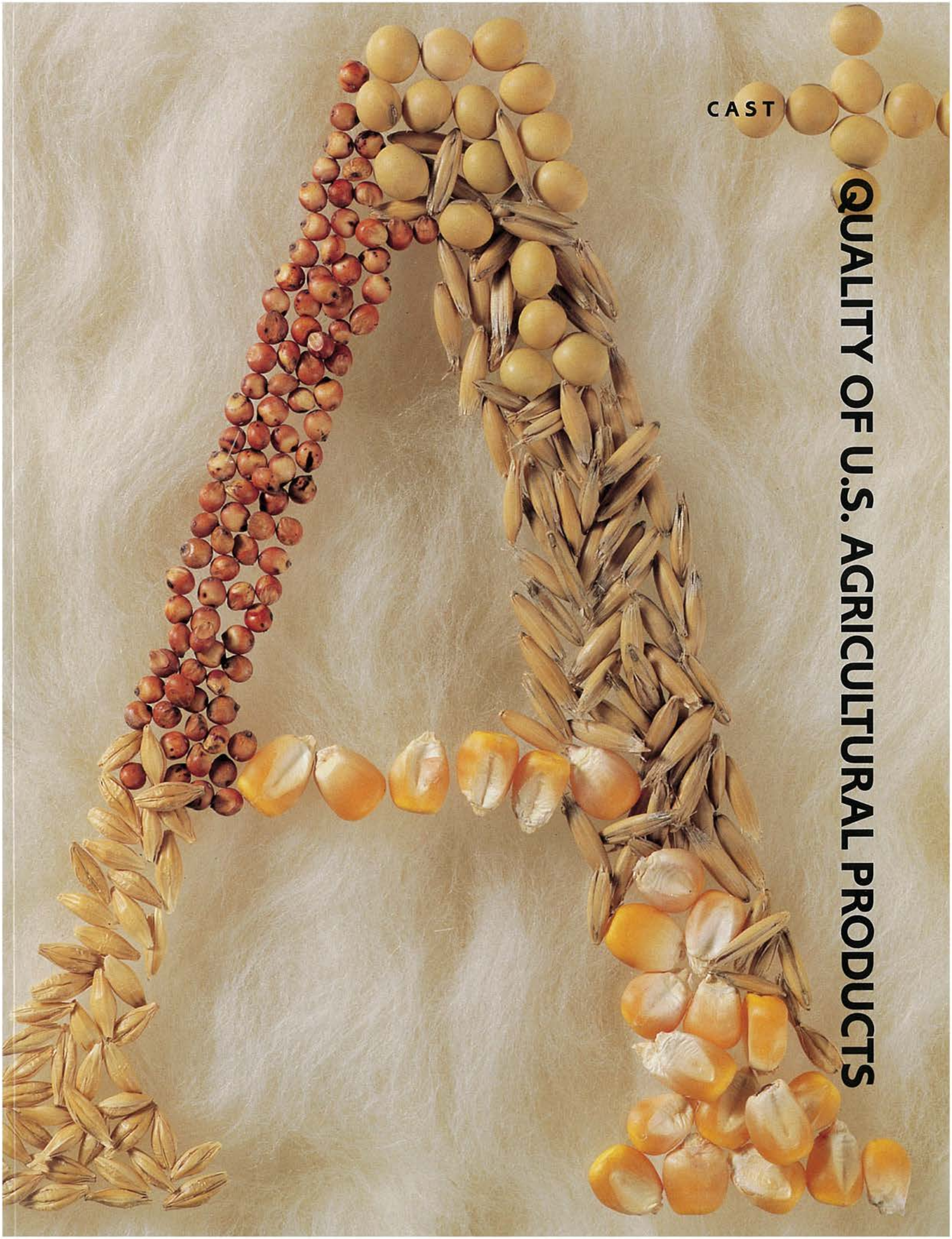
CAST
QUALITY OF U.S. AGRICULTURAL PRODUCTS

The Science Source for Food, Agricultural, and Environmental Issues

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CAST

The Science Source for Food, Agricultural, and Environmental Issues

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The mission of the Council for Agricultural Science and Technology (CAST) is to identify food and fiber, environmental, and other agricultural issues and to interpret related scientific research information for legislators, regulators, and the media involved in public policy decision making. CAST is a nonprofit organization composed of 31 scientific societies and many individual, student, company, nonprofit, and associate society members. CAST's Board of Directors is composed of 50 representatives of the scientific societies and individual members, and an Executive Committee. CAST was established in 1972 as a result of a meeting sponsored in 1970 by the National Academy of Sciences, National Research Council.

The primary mission of CAST is the publication of task force reports written by scientists from many disciplines. The CAST National Concerns Committee screens proposals from all sources and recommends to the board topics for approval as publication projects.

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# Foreword

Following a recommendation by the CAST National Concerns Committee, the CAST Board of Directors authorized preparation of a report on the quality of U.S. agricultural products.

Dr. Lowell D. Hill served as chair for the report. A highly qualified group of scientists served as task force members and participated in the writing and review of the document. They include individuals with expertise in agricultural and consumer economics, agronomy, animal sciences, fisheries, food sciences, grain inspection, plant genetics, rural sociology, and sociology and anthropology.

The task force met and prepared an initial draft of the report. They revised all subsequent drafts of the report and reviewed the proofs. The CAST Executive and Editorial Review committees reviewed the final draft. The CAST staff provided editorial and structural suggestions and published the report. The authors are responsible for the report's scientific content. Because of the report's length and comprehensiveness, some publication delays have been unavoidable. Occasional chapters therefore do not contain the most recent citations.

On behalf of CAST, we thank the authors who gave of their time and expertise to prepare this report as a contribution by the scientific community to public understanding of the issue. We also thank the employers of the authors, who made the time of these individuals available at no cost to CAST. The members of CAST deserve special recognition because the unrestricted contributions that they have made in support of CAST have financed the preparation and publication of this report.

This project was partially funded by the Midwest Agribusiness Trade Research and Information Center (MATRIC), Iowa State University, Ames. MATRIC is supported by the Cooperative State Research Service, U.S. Department of Agriculture under Agreement No. 92-34285-7175. Any opinions, findings, conclusions, or recommendations expressed are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

This report is being distributed to members of Congress, the White House, the Department of Agriculture, the Grain Inspection and Packers and Stockyards Administration, the Centers for Disease Control and Prevention, the Congressional Research Service, the Food and Drug Administration, the Environmental Protection Agency, the Agency for International Development, and the Office of Management and Budget, and to media personnel and institutional members of CAST. Individual members of CAST may receive a complimentary copy upon request for a $3.00 postage and handling fee. The report may be republished or reproduced in its entirety without permission. If copied in any manner, credit to the authors and to CAST would be appreciated.

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# Interpretive Summary

The need for legislation and regulation to improve or maintain the quality of agricultural products depends on the size and geographic distribution of production units, the complexity of the market channel, the volume of commodity consumed in each use, the extent of processing before consumption, the economic organization of firms in the processing and marketing sectors, and the technology available for measuring quality. CAST appointed a task force to evaluate the need for government action to maintain or improve quality for twelve commodities. The task force defined quality as the composite of attributes of the product that have economic or aesthetic value to the user.

Grades provide a technique for combining several attributes into a single-valued descriptor. However, quality may also be described by brand names, label information, contract specification, and personal inspection of each item. The appropriate allocation of responsibilities among government agencies and private firms has been the issue in many public hearings and legislative proposals.

Industry-wide uniform grades improve marketing efficiency by classifying diverse qualities into a few homogeneous categories, by communicating information about value along the market chain, and by providing a means for the market to create incentives and rewards for firms to improve quality.

## Role of Regulation and Public Policy

Not all commodities require a grading system or government regulation. Federal grades are of greatest value for large-volume bulk commodities such as wheat and rice, for which inspection of individual units is not physically or economically feasible. Grades are more important when transactions involve large volumes with diverse characteristics, direct purchase from producers, and assembly into large volume lots for shipping or processing into a limited number of final products. The closer the commodity is to the final consumer, the less need there is for government involvement in nationally uniform grades. Because consumers select largely on the basis of experience, brand recognition, and visual examination, their reliance on government grades is minimal for commodities such as fresh fruits. Grades have minimal value when producers or processors visually select the products item by item at the point of sale. Some commodities that would benefit from federal grades involve so small a volume or so few transactions that the cost of regulation is unjustified. Other commodities have so many different uses with unique quality requirements, that regulated uniform grades are not justified.

When private benefits coincide with private costs, firms can adequately describe quality without relying on government regulations. Increased vertical coordination through contract production or ownership of the producing units reduces the need for government to administer grades and standards, because the benefits of quality classification accrue to the private firm.

## Recommendations for Policy Action

State and federal agencies and legislators should continue to search for means of improving the quality of agricultural commodities without impairing the efficiency of competitive markets. The appropriateness of actions differs among commodities, but certain recommendations are relevant for all commodities.

1. The various agencies charged with developing and implementing regulations related to quality could be combined into a smaller number of units, increasing efficiency and allowing for greater specialization within the combined agency. The secretary of agriculture should instruct the Joint Quality Committee of USDA to review the responsibilities of all agencies that are directly or indirectly involved in quality of agricultural commodities and to evaluate the possibility of placing

these responsibilities under a single unit. The grades and standards for all commodities should be reviewed to determine which require government involvement in grading.

2. The secretary of agriculture, in consultation with the USDA-AMS and the USDA-FGIS, should appoint a small task force for each commodity with members representing the USDA, industry, and academia. They should be charged to develop an ideal system of grades and standards for each of the commodities for which a government agency has responsibility. The task force also should develop a strategy for implementing required changes (if needed) to move industry toward the ideal with minimal market disruption.
3. Congress should review current legislation to ensure that policy guidelines and regulatory authorizations are in place to enable the responsible agencies of USDA to develop grades and standards best meeting the needs of the whole industry. Legislation also should be reviewed with the aim of eliminating impediments to efficient implementation of grades.
4. State and national government agencies should continue to seek policy alternatives to assure national uniformity in measurement technologies and application of grades for all producers and marketing firms. This requires that funds be provided to implement legislation requiring national uniformity such as that contained in the 1990 Farm Bill.
5. Current legislation is adequate to permit regulatory agencies to develop and implement the grades and standards for the various agricultural commodities. Legislation that sets grade limits or minimum quality standards in the market reduces efficiency and market responsiveness.
6. Grades and standards are a public good because they benefit all producers, consumers, and marketing firms. Attempts to transfer the costs of a public good such as federal grades to the private sector by collecting user fees from one segment of the industry will discourage the use of uniform grades. Replacing industry-wide grades with firm-specific grades inevitably will decrease uniformity, increase transaction cost, and limit information available to buyers and sellers.

# Executive Summary

## Summary of Recommendations

The need for action by regulatory agencies and legislative bodies to improve or monitor quality varies with the commodity. In the dairy, fiber, tree nut, fruits and vegetables, poultry products, and catfish industries, present grades administered by the private and public sectors seem adequate. Public agencies should provide periodic reviews to ensure that quality control continues to meet the needs of domestic and foreign buyers. In the oilseeds, feed grains, wheat, red meat, and forage industries, additional regulatory actions are needed to adapt measures of quality to meet consumer demands, to ensure payment according to value, and to accommodate new technologies. These should be flexible and user friendly. These regulatory changes can be made under existing legislation without additional action by Congress.

Perceived imbalance in the influence of producers, marketing firms, processors, and domestic and foreign consumers has spawned legislation to alter the actions or inactions of regulators. But state and federal legislation that limits the range of qualities offered in domestic and export markets, that sets specific numerical grade values, or restricts contractual specifications will increase the cost of marketing, limit consumer choice, and undermine U.S. competitive advantage. The policy changes necessary are those that would facilitate moving regulator recommendations through to implementation.

Legislation should develop the objectives and procedures for regulatory agencies and ensure uniformity and equity in describing attributes that influence market value. Grades and standards for the various agricultural commodities are established and administered by several different agencies and departments within the U.S. Department of Agriculture (USDA).

There is a need for better coordination among these agencies to ensure uniformity in measurement, implementation, and enforcement. Integrating the functions of measurement, standardization, research, and grading for several commodities into a single agency would move agriculture toward a more efficient marketing system and provide consistency among commodities.

## Introduction

*Quality* is an elusive term encompassing measurable characteristics as well as perceptions and preferences. Grades provide a technique for combining several quality attributes into a single-valued descriptor. But personal inspections, labels, brand names, and contract specifications also provide information to buyers and facilitate the process of determining price and communicating information about value. Quality differences (real and perceived) are exploited by sellers through product differentiation, marketing strategies, classification schemes, and allocation among markets under marketing orders. Quality differences expand the choices available to buyers and consumers, but their ability to capitalize on these differences depends on their ability to interpret the available information. Grades simplify numerous attributes into a single descriptive term or number, thereby reducing transaction cost, increasing marketing efficiency, facilitating consumer choice, and providing a means for dissemination of readily understandable market information.

The value of information about quality is increased by widespread adoption of uniform terminology. Especially in bulk commodities, uniformity of quality descriptions facilitates transactions without personal inspection by either the buyer or seller. Uniform grades within an industry provide a standardized homogeneous product. Private labels or brands create product differentiation. Grades usually are established by industry groups or by government agencies with the objective of uniform description and classification for a specific industry and marketing stage. Private labels and contract quality specifications usually are firm specific and designed to increase sales and market share of individual firms.

In addition to their role in assigning values, grades are used in conjunction with marketing orders and agreements to regulate commodity quality moving into different markets. Marketing orders are used primarily for fruits, vegetables, and milk. The USDA Agricultural Marketing Service (AMS) and the secretary of agriculture have the responsibility and authority to enforce grades and other regulations within the marketing orders, including setting minimum quality standards and allocating different qualities to different markets. The balance between producer and consumer welfare sometimes is an issue in marketing order legislation.

Regulations have an important influence on quality, and changes in regulations play an important role in the incentives for decision makers. State and federal legislators continue to explore alternative government actions that will increase the quality and the value of agricultural commodities.

The task force on *Quality of U.S. Agricultural Products* was created to evaluate opportunities for and impediments to improving the quality of agricultural products available to processors and consumers. Impediments include inadequate timely information, inappropriate incentives, and policies or regulations discouraging quality improvement. Changing policies and regulations is one method of creating the economic incentives necessary to motivate firms to change those practices that affect quality. Additional information may be needed to enable farmers, handlers, and processors to respond to economic incentives and to provide the highest quality justified by cost and value.

It is difficult in one study to cover the myriad products, commodities, and consumer goods emanating from this complex agricultural system. We therefore have selected a group of 12 commodities as the focus.[1] Emphasis will be placed on raw commodities, that is, on commodities before they have been transformed through processing. Special characteristics of some commodities required that the analysis be carried through the first stage of processing to the identification and measurement of quality of processed products, e.g., soybean oil and carcass beef, pork, and lamb. A few commodities, such as fresh fruits and vegetables, were carried through to the consumer.

## Definition of *Quality*

*Quality* means different things to different people, depending on products and uses, and also on individual perceptions. For certain buyers, quality is almost synonymous with federal grades. At the other extreme, consumers often base quality evaluation on subjective properties of appearance, supplier reputation, or past experience. In this report, a broad perspective is essential, and the task force has adopted the following definition: "*Quality* is the composite of attributes of the product that has economic or aesthetic value to the user."

The *attributes* in this definition are of several types: physical, intrinsic, sanitary and safety, and nutritional. Although these attributes are not mutually exclusive in all instances, the taxonomy provides insight into some of the policies, issues, and concerns analyzed in this report. *Physical attributes* refers primarily to characteristics that are external and can be physically measured or visually evaluated, e.g., color, foreign material, blemishes, and damaged kernels. *Intrinsic attributes* refers to product components that are of value to the user but are internal and require physical or chemical analysis to evaluate, e.g., fiber strength, protein content, and sugar content. *Nutritional attributes* refers to the endowment of the commodity or product with characteristics important to growth and health of people and animals, e.g., vitamins, minerals, energy, fat, and cholesterol. *Sanitary and safety attributes* also are important to users and include the existence of toxic constituents, microbiological organisms, pesticides, or other residues related to product safety for end use. Grades and standards and the grading process should not be confused with the food safety issue, which centers on whether a particular food or commodity is injurious to human health. Only products considered safe and contaminant free should be included in an official grading system. Because food safety is the central focus of other task force reports, such concerns, unless part of the discussion of consumer perceptions, were excluded from most commodity analyses in this report.

Inherent in the task force definition of *quality* is the recognition that not all quality attributes have been or even can be incorporated into market prices. For example, flavor is a significant quality factor for many fruits and vegetables, but it is a complex combination of many components and sometimes defies chemical analysis. The term *aesthetic value* suggests that some differences in quality may be perceptual. In other words, the product is potentially of great value to consumers simply because they believe it to be, whether or not chemical analysis substantiates that belief. And satisfaction with a product, whether or not supported by scientific analysis, must be taken into consideration in any evaluation of quality. The

[1]The commodities considered by the task force are oilseeds, dairy products, fibers, tree nuts, fruits and vegetables, red meat, poultry products, feed grains, wheat, rice, catfish, and forages.

distinction between "real" and "perceived" differences in quality is a fine line that often is blurred.

Improving quality requires a coordinated approach across all segments of the industry. Changes in grades and standards alone will have little effect. Production practices, location of production units, firm size, industry structure, and government policies all influence quality of the final product. Only by understanding the many facets of the industry and the ways in which they interrelate can industry and government agencies select the most effective means of achieving optimal quality in domestic and export markets. To identify changes required in public policies, regulatory actions, and private decisions, the 12 commodities included in this report are described as a system in which production, marketing, and consumption are related to food and fiber quality.

The commodity chapters focus on the appropriate role of government policy and regulation in providing standards, defining quality attributes, creating grades, and conducting inspections. The involvement of government in quality takes many forms but is of three basic types:

1. Commodities for which the government has responsibility for setting standards, providing legislation relative to implementation of standards, setting grades and making them available throughout the industry, and conducting research and education. The government also may supervise, license, and employ inspectors. Grades in this scenario may be either mandatory or voluntary. In some instances, government grades may be mandatory at certain points in the market channel and voluntary at others.
2. Commodities for which the government provides standards of measurements, defining appropriate units, and setting technical standards. For many commodities, these responsibilities are assigned to the National Bureau of Standards (NBS) (now called the National Institute of Standards and Technology [NIST]). Government agencies may develop grades that can be used as guidelines by industry associations but would have minimal responsibility for implementation or supervision. Private industry in this scenario is responsible for setting grades, inspecting and grading, and communicating information to buyers and sellers. Any discipline of market participants that is required is administered by the market, with buyers and sellers adjusting purchases according to quality preference and prior experience.
3. Commodities for which there is essentially no government responsibility for quality maintenance, grades, or grading. Private trade associations or individual firms provide the quality descriptions needed by buyers and sellers. Government responsibility consists of enforcing fair-trade, anti-trust, truth in labeling, food safety laws and regulations, and providing educational services. None of these responsibilities needs to deal directly with the description of quality or the promulgation of grades.

The appropriate choice among these three options is the focus of the analysis and description in this report. The need for government to develop and to enforce grades and the role of government agencies in describing quality and supervising inspection are influenced by (1) the geographic scope of the market, i.e., whether national or international and the importance of exports; (2) the volume of the commodity or product moving through the market channel; (3) the number of uses and the similarity of requirements among users; (4) the number of buyers and sellers engaged in market transactions; (5) the volume of open market transactions compared with vertical integration or contractual arrangements between buyer and seller; (6) the balance of market power between buyer and seller; and (7) the distribution of benefits. For example, if only a few people benefit from quality information and if total costs can be charged directly to beneficiaries, the requirements for government are different than if there are many nonspecific beneficiaries who cannot be identified for direct recovery of costs.

The appropriate choice among the three alternative roles for government can be deduced from a review of the characteristics of each commodity and the characteristics of the industries producing, processing, and marketing each commodity and derived product.

## Commodities Requiring Government Standards, Grades, and Research

Industries or commodities in this category are composed generally of many small producers selling to a few buyers in open market transactions. Buyers and sellers often are separated physically (as in export or international markets); commodities generally are generic and completely interchangeable for the majority of uses. There is sufficient volume to spread the benefits of government action among many producers, marketing firms, and consumers.

Commodities included in this category are field crops such as corn, soybeans, wheat, rice, and forages; live hogs, cattle, and sheep and their carcasses; some tree nuts at the producer level; and cotton and wool. Fruits and vegetables at the producer and processor level also require grades supported by federal legislation, especially in relation to marketing orders for which uniform enforceable grades are important in the allocation of products among uses.

### Commodities That Can Operate With Minimal Government Involvement

For many commodities, government standards of measurement provide a benchmark for private firms implementing their own grades and quality specifications. Some commodities in this category may meet the requirements of category 1 except that total volume in the market is too small to justify government regulatory costs. Other commodities in this second category may have a diversity of uses with dissimilar quality requirements. Some firms may rely on government grades or standards but add characteristics or qualifications of their own when buying or selling commodities.

Commodities best fitting this description are low-volume field crops such as safflower seed, most tree nuts (especially beyond the point of first sale), poultry and pork products in wholesale and retail trade, and fluid milk other than for sanitary assurances. Government grades are used to allocate milk among various uses, not to describe differences in quality attributes. In the tree nut industry, there are so many different uses for products that uniform grades throughout the industry are an unrealistic goal. But government grades, especially at the producer level, may be used as a benchmark and a basis for pricing. Oilseeds such as sunflower, flaxseed, and safflower do not require government grades: the number of processing plants is relatively small, and total crop volume is quite minor in the total oilseeds industry.

### Industry Characteristics Requiring No Government Involvement in Quality

Private firms and trade associations can provide adequate quality definition and description for products and industries with the following characteristics: (1) few buyers and sellers, with relatively equal market power, (2) markets in which producing and processing firms are coordinated closely through integration or contractual arrangements, and (3) products whose value is judged best by personal inspection.

The commodities belonging in the "no government involvement" category are processed products or commodities for which associations of processors have established grades and standards acceptable to buyers and sellers. Contracts and association rules have been substituted for government grades in these industries. Extensive integration in the broiler industry allows private brands to be substituted for government grades. Fluid milk, at retail, requires no government grades. And retail produce selected by visual inspection requires no government involvement for differentiating or classifying according to grade or quality. The catfish industry is highly integrated, with few buyers and sellers, and requires no government involvement in setting quality standards. Specialty uses for even the major crops, e.g., the snack food industry purchasing of corn, also can operate without government grades. Quality specifications in the contract have replaced industry-wide uniformity for some processed fruits and vegetables and in small segments of numerous other industries.

## Policy Recommendations

State and federal agencies and legislators continue to search for means of improving the quality of agricultural commodities without impairing the efficiency of competitive markets. The appropriateness of actions differs among commodities, but certain recommendations are relevant for all commodities.

1. A task force should be appointed at the national level to review all commodities and to classify each commodity and product into one of the three categories of government involvement. There should be industry, academic, and regulatory representatives on the task force. The task force should include specialists as advisors or consultatins to develop detailed information for each commodity. This activity could be enlarged to reconvene the 1988 USDA Conference on Quality of Agricultural Commodities, with the sole objective being to determine the appropriate role of government in quality control for each commodity. The task force created under recommendation No. 1 would need to include specialists as advisors or consultaints to develop detailed information for each commodity.
2. For commodities classified as categories 1 and 2 (full government responsibility and limited government responsibility for grades), the task force should develop consistent terminology, grading structure, and research strategy. Task force

members must have detailed information about each commodity and an understanding of its markets.

3. The various agencies charged with developing and implementing regulations related to quality could be combined into a smaller number of units, increasing efficiency and allowing for greater specialization within the combined agency. The first step in this direction was completed in 1995 when the Federal Grain Inspection Service (FGIS) and portions of the Packers and Stockyards Administration were combined into the Grain Inspection and Packers and Stockyards Adminstration (GIPSA). In this, and any subsequent reorganization, the agency functions should be focused on quality issues and should be independent of those agencies whose primary functions are research. Research on grades and standards should be conducted by the agency assigned responsibility for grades so that industry needs can be coordinated with resarch priorities.
4. Grades and standards generally are designed to benefit all producers, consumers, and marketing firms. They are therefore a public good. Attempts to transfer the costs of a public good such as federal grades to the private sector by collecting user fees from one segment of the industry will discourage the use of uniform grades. Under the economic pressure of increased user fees, the grain industry already has reduced their reliance on federal grades. Replacing industrywide grades with firm-specific grades inevitably will decrease uniformity, increase transaction cost, and limit information available to buyers and sellers.
5. Measurement technology should be the responsibility of a federal government agency. Measurement of chemical composition, moisture content, and other quantifiable attributes must be uniform throughout each industry and, so far as possible, across industries. Just as the NIST (previously the NBS) sets one standard for weight, length, and volume in commercial transactions, so must there be one standard for measuring moisture, oil, and protein contents in grains and oilseeds. Government legislation should be developed to enforce this uniformity and to fund necessary research and implementation activities. State governments have authority to inspect, license, and monitor many of the weighing and grading activities. While it is important to retain autonomy within states, it is also imperative that rules, regulations, and standards of quantity and quality be uniformly applied in interstate trade. It may be necessary to sacrifice some state autonomy in order to achieve the goal of uniformity.

## Policy Recommendations Specific to Each Commodity

### Feed Grains

The two major feed grains—corn and grain sorghum—are produced on small to large farms and distributed over a wide geographical area. The number of producers is large relative to the number of buyers, and the balance of market power rests with the latter. A large volume of corn and grain sorghum moves through a well organized and efficient market channel, with exporters and processors dominating transactions. Exporting and processing industries are becoming increasingly concentrated, with fewer firms controlling a larger share of the volume in the market.

Grades for feed grains are established by the FGIS in consultation with producing and marketing firms. The U.S. Grain Standards Act requires official inspection of all grains exported, with a few insignificant exceptions. The federal government also is responsible for licensing and supervising the private inspection system throughout the United States, and federal laboratories at regional and national levels conduct appeal inspection and research. Third-party quality determination is an important safeguard for producers, marketing firms, and importers of U.S. feed grains. A system of licensed inspectors that is supervised by a government agency has generated credibility in domestic and export markets for feed grains for more than 75 years.

The importance of quality in the export market and in international competition from other exporting nations provides added incentive for continued scrutiny of grades and standards by those agencies responsible for setting and revising grades. Domestic and foreign buyers are incorporating additional quality specifications in their contracts, indicating the presence of a demand for more information that could be provided most efficiently through grade changes. Regulatory agencies, which have the necessary authority and guidelines on which to base changes in grades and standards, should be encouraged to take a strong initiative in implementing changes that will respond to these demands. The trend toward quality specifications within the contract in addition to grades reflects the inability of current grades to measure important characteristics. Regulatory agencies must conduct the research to find a better measure of end-use value and then act to incorporate those measures into grades. Congress must accept the responsibility for funding both the research and the implementation phases.

## Wheat

The production and marketing characteristics of wheat are similar to those just described for feed grains. The export market is even more important, and the dual use of wheat for feed and for food products adds complexity to the selection of appropriate characteristics for measurement. Much baking-quality wheat is produced in the western Great Plains on acreages usually larger than those typical for corn or grain sorghum. In the market channel, however, wheat and corn exporters and processors are structured similarly and often are owned by the same parent companies.

End-use properties should be given an even higher priority in wheat than in other cereal grains. The proliferation of new cultivars and types and the inability to distinguish end-use characteristics based on cultivar identification are additional impetuses for expanding research to identify attributes correlated with end-use properties and to implement new measurement technology as rapidly as it becomes available. Policy changes are not required, and attempts to control quality through legislation are unlikely to achieve the desired objectives. The role of policy in the case of wheat for feed and for food should be one of funding necessary research on measurement technology and end-use attributes, and of encouraging regulatory agencies to provide up-to-date information about quality characteristics.

## Oilseeds

Soybeans, the primary oilseed in the United States, are produced on many of the same farms that produce corn. A greater proportion of soybean than of corn production occurs in the southern states. As with feed grains, there are a large number of small to medium sized producers. First-handlers are primarily country elevators that deliver to processors, river elevators, and the export market channel. Processors play an important role in the soybean industry, receiving the majority of the soybean supply. Because relatively small amounts of soybeans are used directly for food, there are only two major markets—export and processing for oil and meal.

Government responsibility for grades, inspection, and grading are identical to those for feed grains and wheat. But revisions in soybean grades and standards have been proposed that would improve the ability to describe quality and value. Final action on the proposed changes was delayed from July 2, 1991 until March 7, 1994. The delay in final rule making meant that those changes finally implemented were delayed 3 yr in their effect on quality. In addition, support for many of the 12 proposed changes dissipated over time and potential improvements were rejected. A strategy is needed to expedite changes that have been approved.

Other oilseeds, minor in terms of production volume, such as safflower, flaxseed, canola, and perhaps sunflowers, require no government expenditures to establish quality characteristics desired by processors. The small number of processors and the relative concentration of production in a few geographic areas facilitate the use of private grades and standards for these commodities. Some standards provided by the government, e.g., measurement technology for oil, protein, and moisture, would enable the industry to develop its own grades and specifications without incurring budgetary obligations on the part of the federal government.

The quality of oil and meal derived from oilseed processing is described quite effectively by means of industry standards and grades. The association and organizations comprised of processing firms have achieved national and international uniformity in measuring oil and meal attributes reflecting quality. Additional action by government agencies is unnecessary.

## Rice

Rice is used primarily for food and secondarily for by-products entering the feed industry. The industry is influenced heavily by government policies in terms of price supports, supply controls, and the export enhancement program. Production is concentrated in six states, on relatively few farms with an average acreage larger than that for feed grains. Most farm production moves directly to warehouses that supply relatively few rice mills. Significant vertical integration exists in the market channel, primarily because of the large number of producer cooperatives. Increased differentiation among types, qualities, and uses of rice has exacerbated the need for increasingly sophisticated quality-measurement technologies.

Current grades for rice are adequate for most users in the domestic market, but the cost of delivering a higher quality of rice into the export market has priced the United States out of many of these markets. The economic incentives associated with grades may not reflect true value in end use. Increased user fees for official inspection are shifting marketing firms away from government grades and inspection to private firms. In the long run, these trends may hurt the export market.

Quality control and information on quality in processed and retail transactions are being handled adequately by industry organizations and individual firms. Government regulations related to quality are unnecessary in the rice industry after the first stage of processing.

## Forages

Forage production is distributed widely throughout the United States, but most output is consumed on farms where grown. Very little enters commercial market channels with the exception of exports. Many sales are from small-farm producer to small-farm feeder. End-quality information is difficult to obtain, and buyers often must rely solely on visual appearance to estimate nutritional attributes. Nationally uniform grades would strengthen the basis on which price is established in domestic transactions.

The export market also has been hindered by the lack of uniform grades and measurement technology. Uniform grades would help maintain quality standards in the export market and would provide information to help processors estimate the value of different lots. Government agencies have taken little initiative in developing new measures of quality or technology for measuring the important attributes that influence nutrition.

The lack of national uniform grades reflecting value for feeding purposes is a major impediment to improving quality in the forage industry. Private grades and association grades have developed slowly, in part because of the lack of measurement technology. Government involvement is required in the areas of both research on measurement technology and development of uniform grades for domestic and export markets.

## Cotton and Wool

Cotton and wool are produced on a great number of farms although wool production is concentrated in relatively few states and primarily is a by-product of the meat industry. Cotton is distributed over a much wider geographic area, with significant differences in type from region to region within the United States. The number of firms involved in producing, marketing, and ginning cotton, and in producing textiles is quite large. The complex market channel places heavy demand on the identification of quality by description rather than by direct inspection. The market channel for wool is less complex than that for cotton, with producers delivering to private or to cooperative warehouses in which wool is graded, tested, and stored.

The cotton fiber industry has made significant progress in developing and introducing new objective measurement technologies. Industry-wide use of the HVI system for grading cotton fiber, including fiber strength, led to the designation of HVI as the basis for loan determination starting in 1991. Starting with the 1993 crop, grades that previously combined color and leaf into one factor were divided to reflect the separate influence of the two attributes. New grade charts were introduced and premiums and discounts used in setting government loan rates now reflect the separation into leaf classes associated with each color grade. The use of these grade charts eliminates the averaging rule regarding effect of color and leaf on price, and is a good example of the high-volume instrument system's flexibility in incorporating advanced technology as it becomes available.

Industry participants took a lead role in developing grades and measurement technology. When the government tied grades to the loan program, it accepted the responsibility for refining grades and standards to reflect end-use value in the market and improve accuracy in market signals.

Although the market channel for wool has been slower to adopt more objective, measurable assessments of quality, the impetus for change has been growing, propelled by demands placed on the raw inputs by the yarn spinner and weavers.

Given the structure and the organization of the cotton and wool production sectors and the complexity of the market channel, government must maintain an active role in the development and implementation of grades and standards.

## Fruits and Vegetables

The fruit and vegetable industries involve a diversity of crops, production technologies, marketing channels, and geographic locations. Production units range from small private farms producing for the local farmers' market to corporate entities specializing in a few crops produced on large acreages by means of mechanized harvesting and/or a great number of migrant workers. Integration within either industry takes many forms, from the small producer who also is the processor, packager, and retailer at the local farmers' market, to the more formal vertical integration of major multinational firms integrated from retail through wholesaling, processing, and large-scale production. Farmer cooperatives controlling supply, market channel, and distribution add another dimension to vertical arrangements in the fruits and vegetables industry.

The role of government in establishing quality control differs dramatically from crop to crop and among industry organizations. A completely integrated firm, whether a multinational or the local farmers' market, has little need of government grades and regulations. Grades are of minimal importance at the retail level, where consumers select produce based on use of their senses rather than on classification by quantitative variables. In contrast, marketing orders based on quality characteristics rely heavily on government grades and implementation. Grades for fresh and processed fruits and vegetables at the producer level and at the wholesale level provide an important facilitating function for the market. Grades are important to wholesalers in sorting and classifying even fresh vegetables. They also provide guidelines for processors as they assemble lots from different producers growing crops under a variety of climatic conditions or cultural practices.

Given the increasing importance of organically produced products, government agencies should review current grades to determine their ability to reflect perceptions of quality in the fruits and vegetables industries. The traditional emphasis has been on appearance and condition, and these attributes will continue to be a factor at the retail level. Federal requirements for nutritional information and certification for organically grown crops, tree-ripened flavor, and similar attributes provide for product differentiation that probably will not be captured in government grades. Private firms seeking product differentiation and brand recognition will not wish to rely on a system standardizing all products into a few uniform categories.

Quality is an important issue in exports, and a government agency in conjunction with importers and exporters should review current grades and standards to determine whether the competitive position of the United States could be improved by increasing uniformity and consistency of the quality being delivered. Other exporting nations, e.g., Chile, are working to improve standards and quality uniformity as an export enhancement technique.

United States Department of Agriculture grades are available for 135 fresh and 150 processed fruit and vegetable items. These grades should be reviewed by the regulatory agency to determine whether government regulation is essential in all 285. The allocation of private responsibilities for research and grading of fruits and vegetables needs to be reviewed carefully in the development of policy recommendations.

## Tree Nuts

Producers of tree nuts range from small operations with only a few trees to orchards containing thousands. Economies of size are beginning to eliminate small, part-time producers of tree nuts. The introduction of mechanical harvesting has enabled enlargement of orchards, but the number of producers is small relative to the numbers found in field crops, for example.

The market channel for tree nuts is relatively simple. A grower delivers harvested nuts to the handler of choice. In most instances, this is an independent handler although in some it may be a grower owned marketing cooperative. The first-stage handler assembles a product and enhances its value through cleaning, drying, sorting, sizing, and storing. The handler also may polish and color the shells of nuts to be sold in the shell. Some first-stage handlers also shell the delivered nuts, sort kernels and nut meat pieces according to grades, and package and ship to storage or to buyers. Buyers include wholesalers, retailers, and food processors using nuts in a wide range of food products.

Grades and standards for most of the tree nut industry have been developed with significant industry input. Other than for marketing orders, use of USDA grades is optional and applied at the request of the grower or the handler. For industries operating under marketing orders, e.g., the almond, walnut, and hazelnut industries, official inspection according to USDA grades is mandatory. At the producer level, government involvement in grades provides uniformity across industries and locations. Beyond the first level in the market channel, use of government grades and the role of government in setting standards should be minimal. The diversity of uses and of market channels makes private responsibility a more effective alternative.

The current level of government involvement in the tree nut industry is adequate, and no changes in agency regulation or in the agencies dealing with quality are recommended. A need for government action exists, however, in enhancing the system for collecting and disseminating information about quality. Although quality is important in domestic and export markets, the private sector, emphasizing brand names and product differentiation, provides adequate incentives for quality control.

## Beef, Pork, and Lamb

Beef, pork, and lamb production is widely distributed geographically among a great number of farmers. Although large-scale feedlots have grown in importance, there still are many farmers involved in the production of feeder cattle and in the feeding of small numbers of cattle for market. Pork production has become more concentrated, with average herd size increasing steadily. Sheep production is more concentrated in the western states, with fewer flocks and fewer feedlots specializing in that form of production.

Much of the marketing process still requires classification and descriptive terminology allowing purchase of feeder stock by the use of grades and the classification of slaughter animals into categories facilitating packing plant operations.

Although USDA grades provide the terminology that is in common use in market transactions for feeder stock and finished animals moving into slaughter plants, official grades seldom are used in these sales for hogs. Grades also are valuable in the wholesale beef and lamb markets. The USDA grades often are used for beef and lamb at the retail level, to facilitate selection and advertising. Consumers also rely on retailer reputation and on visual inspection in selecting cuts from the range of qualities available in the store.

The AMS, USDA, has a major responsibility in setting the standards for quality, but many quality attributes related to consumer satisfaction have not been incorporated in official grades. With the technology available, grades could be revised to incorporate more information about composition, nutrition, and eating quality. Changes in grades will require government action, with assistance from processors and marketing firms, to identify relevant attributes.

Quality is an important export issue, and USDA grades are unable to describe all foreign buyers' preferences. Brand naming programs and process verification, however, can enhance the effectiveness of foreign marketing. Many foreign buyers have their own specifications for quality. If the United States wants to be a leader in terms of meat exports, government and industry should start building systems to utilize the International Organization of Standardization (ISO) 9000 principles, establishing international uniformity of quality standards for all meat products. Our foreign markets would be served better with clear specifications concerning quality among all processors and exporters, particularly if global market information is to be collected and disseminated. The export market also would benefit from improved uniformity in quality. Although many changes in grading could be made by private industry, a move toward national uniformity requires leadership from a federal agency with responsibility for setting standards and grades.

## Poultry and Eggs

The poultry industry has become highly concentrated and integrated, and few independent family farms remain. However, there are tens of thousands of family farms operating under contracts with the large integrated firms. The market channel includes very few open market transactions that rely on quality descriptors and classification for setting prices.

Private brands have become a substitute for federal grades in the poultry industry. Most price variations are based on which part of the chicken or turkey is being sold and on the brand name. Table eggs are subject to federal grades and standards, but these have little influence on consumer purchases. In a highly integrated industry, there is little justification for major involvement by government agencies except to ensure sanitation and food safety for consumers. Quality per se is controlled by private firms, from production through retail. With increasing vertical integration in the poultry industry, firms will establish their own price and quality relationships at wholesale and processing levels. Brand names will dominate at retail. Consumers select on the basis of observable criteria and past experience with brands rather than on USDA grades. As with beef, pork, and lamb, retail stores may use grades as a basis for advertising or determining their own niche in a broad and diverse market.

There is little need for additional government involvement in the poultry and egg industry, with the exception of an investigation into the use of quality specifications as a barrier to inter-state trade. This exception does not require the government to set grades and standards but only to control their use as an anticompetitive strategy.

Exports of poultry products generally are based on quality specifications of the importing country. Increased coordination between private firms and government agencies to satisfy the quality requirements of other countries could be a strategy for improving U.S. competitive position in international markets.

### Milk

The number of farmers in the producing sector of the dairy industry has decreased, and herd size has increased. Production per cow has increased concurrently with declining cow numbers. This has created a continuing surplus of milk at prices deemed appropriate by producer organizations and government agencies. Production is concentrated in a few states, with sales controlled under a milk marketing order. Although grades and standards do not affect fluid milk sales at the retail level, they are important in terms of allocating products among uses. Milk marketing orders rely heavily on USDA grades of A, B, and Classes I, II, and III of fluid milk. These grades are important for processed products such as cheese.

There is little need for additional government involvement in establishing quality specifications or grades for milk other than providing more information in response to consumer concerns about nutritional attributes and component pricing. The current system seems to be working well in terms of identifying differences in the quality attributes of milk and other dairy products.

### Channel Catfish

Catfish production is highly concentrated, with 87% of all products coming from the lower Mississippi River flood plain. Seventy percent of total U.S. supply comes from the state of Mississippi. The industry is based primarily on contract production and vertical integration although a few independent farmers have established oral agreements with processing plants to provide them a market. The highly specialized market channel precludes open market operations, and almost all pricing and purchasing activities are conducted directly with processors, who control quality from delivery through retail distribution.

Quality determination under a highly integrated and concentrated marketing system best can be done at the initiative of individual firms. Exports are not a significant factor in the industry, so government grades and standardization are unnecessary except for sanitary and food safety inspections. A label indicating that fish have been processed under government inspection would improve consumer confidence in safety and sanitation aspects of the product, but policy changes are not recommended relative to measurement and designation of quality.

## Glossary

**Intrinsic attributes.** Internal factors such as fiber strength, protein content, and sugar content that are product components valuable to the user but requiring physical or chemical analysis.

**Nutritional attributes**. Factors such as vitamins, minerals, energy, fat, and cholesterol, which are related to the endowment of commodity or product with characteristics important to the growth and the health of people and animals.

**Physical attributes.** External factors such as color, foreign matter, blemish, and damage that can be measured physically or evaluated visually.

**Quality.** Composite of product attributes with economic or aesthetic value to the user.

**Sanitary and safety attributes.** Factors including toxic constituents, microbiological organisms, and other residues related to product safety for end use.

# 1 Quality in Agricultural Products

Lowell D. Hill[2]

## Introduction

Food, fiber, and industrial products, the outputs of a huge complex of industries referred to as the *agricultural sector*, are essential to every society. The quality of these products affects the health and satisfaction of consumers worldwide. Degree of satisfaction is reflected only partly in differences in economic value, but such differences affect prices and profits of farmers and of agribusinesses throughout the world.

Quantity and quality of agricultural products are intertwined. A small quantity of high quality frequently provides greater satisfaction than does a large quantity of low quality. And consumers in affluent societies often are willing to accept reduced quantity to obtain higher quality. Thus, price and value (measured in either currency or pleasure) are linked closely with quality. It follows that producers as well as consumers are potential beneficiaries of improved quality.

But quality improvement frequently comes at the cost either of increased input, labor, or management or of decreased yield. For this reason, producers should compare the cost of improving quality with the additional value created in the market. If improved quality is not commensurate with its cost, economic incentive is absent.

Quality often is associated with price differentials in the commercial market. But many product-quality characteristics that influence consumer satisfaction are subjective and difficult to quantify. Quality is related to human satisfaction, and the characteristics desired in a product depend on the consumer. Even processors of agricultural commodities disagree on which quality characteristics of raw products produce the greatest quantity and value of processed products.

## Opportunity for Improving Quality

Information about quality can be provided through labels, brand names, prices, and grades. Grades classify commodities according to quality characteristics, whereas labels, brand names, and prices link consumer perceptions of a product with the names of private companies.

Quality is controlled by producers and by processors operating within a framework of government regulations and established market rules. Policy therefore influences quality, and regulations can provide incentives for decision makers. Buyers and sellers can improve quality if they are provided with information on value and associated cost and on causes of quality losses. State and federal legislators continually explore means of increasing the quality and the value of agricultural commodities, because incentives for changing quality also can be strengthened by altering the regulatory environment in which decisions are made.

The Council for Agricultural Science and Technology (CAST) task force on quality of agricultural products was created to evaluate opportunities for and impediments to improving the quality of agricultural products available to processors and to consumers. Impediments include inadequate information, inappropriate incentives, and policies or regulations discouraging quality improvement. Changing policies and regulations is one method of creating the economic climate necessary to motivate changes in practices in the industry. Additional information also may be needed to enable farmers, handlers, and processors to respond to economic incentives and to provide the highest quality justifiable in terms of cost and value.

Because it is impossible to describe in one manuscript the myriad products, commodities, and consumer goods emanating from the complex U.S. agri-

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[3]The commodities included in the report are as follows: oilseeds, dairy products, fibers, tree nuts, fruits and vegetables, red meat, poultry products, feed grains, wheat, rice, catfish, and forages.

cultural system, a group of 12 commodities has been selected as a focus.[3] Raw commodities will be emphasized. Unique characteristics of some commodities, e.g., soybean oil and carcass beef, pork, and lamb, will require that the analysis be carried through the first stage of processing to the identification and measurement of quality of processed products. Marketing stages included in the quality analysis will differ among commodities. For example, the section on grains will emphasize transactions between the farmer and the grain processor and will omit price-quality relations at the retail level. In contrast, the most important quality issues regarding fruits and vegetables are at the retail level, where consumers select fresh produce in the supermarket.

## Definition of *Quality*

Depending on product, use, and perception, *quality* can mean many things. For some buyers, e.g., grain processors, quality is almost synonymous with federal grades. At the other extreme, consumers often base quality evaluation on subjective properties of appearance or past experience. In the current report, which requires a broad perspective, the task force has adopted this definition: "*Quality* is the composite of attributes of the product which have economic or aesthetic value to the user."

The "attributes" in this definition are of several types: physical, intrinsic, nutritional, and sanitary and safety. Although not always mutually exclusive, these categories provide insight into some of the policies, issues, and concerns to be discussed in this report. *Physical attributes*, e.g., color, foreign material, blemish, and damage, can be measured physically or evaluated visually. *Intrinsic attributes*, e.g., fiber strength, protein content, and sugar content, are product components valuable to the user but requiring physical or chemical analysis. *Nutritional attributes*, e.g., vitamins, minerals, energy, fat, and cholesterol, are related to the endowment of commodity or product with characteristics important to the growth and the health of people and domestic animals. *Sanitary and safety attributes* include toxic constituents, microbiological organisms, and other residues related to product safety for end use.

Grades and standards and grading itself are distinct from food safety, a concept associated with a food's or a commodity's effect on human health. It is assumed that only products considered safe and free of contaminants are included in official grading systems. Although it is difficult to separate the concept of quality from the issues of product safety, residues, and mycotoxins, these issues are the focus of other CAST task forces and so will be excluded from most commodity analyses in the current report (c.f. Council for Agricultural Science and Technology, 1989, 1992, 1994a, 1994b). Food safety issues will be minimized in most chapters with the exception of an opening overview of the importance of these issues in Chapters 2 and 3. Exclusion requires the drawing of a somewhat arbitrary distinction between quality and safety. The extent of the distinction varies among author and commodity.

Our definition of *quality* recognizes that not all quality attributes have been or can be incorporated into market price. The term *aesthetic value* suggests that some differences in quality are perceived only: in other words, a product is potentially of great value to consumers simply because they believe it to be, regardless of whether chemical analysis substantiates their belief. This type of satisfaction must be considered in any evaluation of product quality. The distinction between "real" and "perceived" quality differences, however, is a fine line.

## Purposes of Grades and Standards

Final consumers of agricultural products often judge quality on the bases of experience and other subjective factors. But an efficient, complex, and sophisticated marketing system requires a method using some form of standardized terminology to describe quality differences. Description and classification enable both buyers and sellers to establish price and value (or preference) before visual inspection or actual consumption. Hence, the basic economic purpose of grades and standards is to communicate information about differences in quality attributes that enables buyers and sellers to establish prices. The objective of a grading system is to sort populations with heterogeneous characteristics into a few categories so that characteristics are relatively uniform. To the extent that uniformity is maintained, grading can constitute a basis for price differentiation. It also can facilitate development of an equitable system in which producers who respond to consumer or buyer preference are rewarded. An effective grading system will decrease transaction cost and increase overall marketing efficiency (U.S. Congress, 1992).

This description of *grades* and *standards* can be expanded to incorporate three purposes: (1) to facilitate trade by providing a limited number of homogeneous categories so that lots within each category can be substituted readily at equal values in the market; (2) to facilitate information exchange in the market system allowing price differentials to influence decisions; and (3) to facilitate establishment of price-value relations among various lots and qualities of a product.

Despite the universality of these purposes, nationally uniform grades and standards are not always the most efficient means of describing quality. For many products, quality is attached to brand name. Private brands and contractual quality specifications are viable alternatives to federal grades and must be considered during evaluation of techniques and strategies for improving agricultural product quality.

The diversity evident in any list of quality attributes for different commodities underscores the difficulty of creating a single system for measuring and describing quality in the marketing system. Each consumer and processor may view quality characteristics uniquely. Developing uniform grades and standards requires both identification of factors common to the quality specifications of most users and compromise in the event that preferences differ among buyers.

The importance of a specific quality characteristic depends on commodity and use. Unanimity among different end-users regarding either the best structure for nationally uniform grades or the most important factors to include if they are accepted is rare. For example, nutritional characteristics are an essential aspect of quality for commodities used in animal feed; for other commodities, such characteristics are of minor concern. Food processors purchasing raw agricultural commodities emphasize intrinsic, sanitary, and safety attributes. Products sold directly to consumers are evaluated with a careful consideration for physical and cosmetic properties and for safety, sanitary, and nutritional characteristics.

Given such differences among commodities and among users of the same commodity, obviously no one set of rules and regulations or of grades and standards will serve equally well for all industries. Cutting across commodity lines, however, are principles able to serve as guidelines for policymakers and for industry advisory groups. These principles will be developed from detailed analyses of 12 commodities. Common themes will be summarized in the concluding chapter of this report.

## Quality's Role in Competitiveness

Quality issues, especially those affecting grains and oilseeds, recently have received considerable attention in international markets. Legislation related to quality and to grades often has been based on the assumption that export of poor quality commodities has caused losses in the export market, quality's role in international trade often is misunderstood.

Because quality, quantity, price, and value are intertwined, professional merchandisers in international trade must evaluate accurately the tradeoff among these four attributes in any shipment. A processing plant converting soybeans into oil and meal can determine with precision the increased value obtained from Brazilian soybeans with a high oil content and can adjust price accordingly. Wet millers in Japan can use the relative yields of products to calculate the premium that they are willing to pay for South African corn above the price for U.S. No. 3.

Most exporting countries are committed to exports as sources of foreign exchange. Competitive market shares are maintained by adjusting prices to the levels necessary to move products or commodities into international markets. Although countries exporting large volumes may act as price leaders and force competitors to match prices so as to maintain market share, all exporters face the same world market forces.

As indicated, there is a tradeoff between price and quality. When quality is evaluated by the buyer in terms of the yield and value of products and the profitability of processing, a higher quality for the same price is equivalent to a lower price for the same quality. Thus, a quality increase without a price increase in one country necessarily will be offset by a lowering of the price (or an increasing of the quality) in competing countries. In short, changes in quality will not prevent competitors from exporting their surpluses.

High-quality or unique quality characteristics may capture markets with specific quality requirements or specifications, but total volume of the commodity produced must be moved into the export market, the domestic market, or storage. Grade changes may increase information but will have little effect on volume sold in either domestic or export markets unless the change also results in increased quality at competitive prices (Hill, 1991a).

The same principles can be applied with respect to regional differences. Quality differences among regions may generate value differences reflected in price. To the extent that such price differentials alter both returns/acre (a.) and profitabilities of alternative resource uses, quantities produced among regions may shift. In general, differences in quality values are small compared with those in productivity or in input cost. Among regions, small-volume production of specialty crops may shift in response to quality differences, but major changes in land use are unlikely to result from differences in either quality or grading procedures.

Competition among firms often is based on product differentiation. Uniform grades and standards and uniform measurement methods increase marketing efficiency for the entire industry but do not improve competitive advantage for individual firms. Thus, to gain price advantage or market share, firms may prefer to bypass grades and to rely on a reputation for superior quality. Uniform grades are advantageous from an industrywide perspective because they improve efficiency, but individual firms logically may oppose uniform grades because private brands provide opportunities for private gain.

## Private and Government Grades

The need for uniform grading throughout the industry is related to the distinction between private label brands and uniform descriptive terminologies. Uniformity in definition, measurement technology, and grade name is needed to enhance communication and efficient exchange in the marketplace. This uniformity can be achieved by state or federal legislation or by the initiative of private trade organizations. Although government grades have been mandated for use in export or interstate trade for a few commodities, most government as well as private grades are adopted voluntarily by buyers and sellers in an industry. The value of uniform grades is enhanced by widespread adoption and use. The involvement of government in developing and disseminating grades increases their acceptability.

In many industries, allowing all firms access to grading information has encouraged widespread participation. But voluntary standardization makes deviation from standards possible. For example, experience in the grain industry during the last half of the nineteenth century clearly demonstrated that voluntary adoption did not result in uniformity (Hill, 1990). Even state governments were unable to generate standards and definitions whereby grade names and factors meant the same thing to all buyers and sellers. In contrast, a majority of firms in the edible oil and the catfish industries have implemented voluntary standards seeming to constitute a basis for efficient communication; and U.S. Department of Agriculture (USDA) grades for beef, pork, and lamb are used widely on a voluntary basis.

## Measurement Cost and Information Value

Kind and amount of information provided by grades and standards differ greatly among industries and even over time within the same industry. Obviously, every biological product can be described by a nearly infinite number of characteristics. There also are a nearly infinite number of grades or classes and subclasses into which biological products can be divided. The number of characteristics included in grades (either voluntary or mandatory) must reflect information cost as well as its value. The value of information to the individual firm and to the industry as a whole should exceed the costs of measuring and reporting.

Whereas evaluation of many characteristics may provide useful information, cost and time required to obtain such information may make developing the necessary technologies and procedures impractical or uneconomical. For example, if the baking characteristics of wheat were known at the time of harvest, truckloads of wheat could be segregated according to the quality essential for given food products. But time and expense required to conduct baking tests preclude such an analysis at the first-handler level, when farmers are delivering grain from their combines. Even the next level in the market chain would find it prohibitively expensive to provide information about baking characteristics.

One of the challenges of using grades and standards is that of finding readily measured proxy variables to indicate a value for each product use. Identifying the necessary information provides the incentive to develop economically feasible technologies and evaluation procedures. Justifying the cost of some information never will be possible; in other instances, measuring important characteristics will require development of new technology.

## Distributional Impacts of Quality Identification

If quality characteristics are identified and are associated with price differentials, the grading system allows the market to increase prices of superior-quality products and reduce prices of inferior-quality products. To the extent that quality characteristics can be controlled by management practices, managers will respond to reduce discounts. Price differentials generate incentives for improving quality. Yet in many instances quality differences are inherent within a geographic region or dependent on annual climatic conditions. These relationships are less true for livestock and livestock products than for crops.

The argument sometimes is raised that grade factors penalizing a certain region of the country or a certain crop year are unfair. But the purposes of grades and standards are to describe qualities existing for each lot of a product and to allow the market to determine value. Some farmers, regions, and crop years inevitably will be disadvantaged in the process of establishing true value of each lot of a commodity for each producer.

Competitive market prices will differentiate among commodities and locations according to transportation cost, local supply and demand, and quality. Detailed commodity grades facilitate accurate estimates of value by buyers. It is difficult to argue that all farmers should receive the same price, regardless of crop value. Analogous is the assertion that all farmers should receive the same price for a product no matter how far they are located from the marketplace regardless of the transportation cost.

Efficient allocation of resources and equitable treatment of producers require adherence to the principle of "price differentials based on differences in value." This principle applies not only to value in terms of product location, seasonal demand and supply, and storage cost, but also to differences in form and quality. Top milling-quality wheat should not receive the same price as feed wheat. This conclusion is transferred easily to quality differences relating to all users for all products and commodities. Price *differentials* must be allowed to respond to demand and supply of quality, just as price *level* must be allowed to respond to demand and supply of quantity.

## Public Goods Attributes of Grades and Standards

Information about product quality often is provided by processors or sellers who are not relying on government grades or standards. If buyers accept the reliability of their information source, they can set specifications via contract and obtain, without use of government grades, commodities with adequate levels of important attributes. At the retail level, consumers rely on private labels and names to ensure desirable quality attributes. At the production level, buyers of raw commodities often set quality standards, and producers must accept price-quality relationships established in the market.

Successful use of private grades requires that quality control be realized by users, who can then be charged for costs of quality measurement and control costs. Although some firms can retain all the benefits of quality measurement for their products, the purposes of industrywide uniform grades and standards demonstrate that many related benefits accrue to a much broader public than to simply buyer and seller. The benefits of marketwide information, uniform terminology for negotiating prices and contracts, marketing efficiency, objectivity, and industrywide incentives all extend beyond individual firms.

Measurement standards clearly are the responsibility of an objective third-party agency responsive to society in general. A commercial world in which each firm or even groups of firms are allowed to define the length of a yard or the weight of a ton is inconceivable. These clearly are public goods for which costs cannot be allocated to individual users. Many quality measures also fall into the category of public goods. User charges assigning the full social benefits from uniform grades and standards to a few buyers and sellers of the commodity discourage use of uniform grades.

All buyers, sellers, and consumers benefit from uniform grades and standards, but the extent of the division between private and public benefits depends on the commodity. In grain, the trend of increasing user charges to grain firms in order to recover full cost of inspecting, grading, and standardizing encourages the development of private-firm grading. If this trend continues, the industry could be revisited by the chaos and the abuses of the 1800s, during which one study identified "338 names or grade titles" for grains (Hill, 1990). Government grades in grains were created because Congress considered them a public good.

Government grades for other commodities have a similar justification, and the concept of a public good whose benefits are spread among a great number of diverse sectors must be included in any evaluation of the government's role in setting and implementing grades.

## Achieving Uniform Nomenclature

Most grades and standards—private as well as government—have developed gradually, often in response to real or to perceived needs. Consequently, it is to be expected that terms and definitions are inconsistent among commodities. For example, the term *foreign material* is defined differently for the four feed grains. In many instances, the characteristics desired in one commodity are sufficiently unique not to appear in the quality specifications of other commodities. But when there are similar concepts, especially for closely related commodities such as grains, uniform definitions are advantageous.

At this point, no systematic effort has been undertaken to generate such uniformity. Even a characteristic as common as moisture content is defined differently for different products in different countries. Thus, when comparisons among countries, importers and exporters, and different commodities are attempted, confusion results.

Total uniformity probably never will be achieved and may not be desirable. Establishing criteria by which to organize the most frequently used terms, however, would enhance communication. A recent corn and soybean workshop brought together experts from 16 countries to begin identifying uniform grades and standards (Hill, 1991b). It is hoped that this process will continue and eventually will provide criteria for defining common terms used for more than one commodity, as well as uniform definitions for these terms.

## An Industrywide Approach

Improving quality requires a coordinated approach across all segments of an industry. Changes in grades and standards alone have little effect. Production practices, production unit location and size, market structures, and government policies all influence quality of the final product. Only by understanding all essential elements of an industry and relationships among these elements can industry and government agencies select the most effective means of achieving optimal quality in both domestic and export markets. To evaluate changes required in public policies, regulatory actions, and private decisions, the 12 commodity chapters that follow describe each industry as a system within a context of food and fiber quality.

## Glossary

**Agricultural sector.** A huge complex of businesses producing food, fiber, and industrial products.

**Intrinsic attributes.** Internal factors such as fiber strength, protein content, and sugar content that are product components valuable to the user but requiring physical or chemical analysis.

**Nutritional attributes.** Factors such as vitamins, minerals, energy, fat, and cholesterol, which are related to the endowment of commodity or product with characteristics important to the growth and the health of people and animals.

**Physical attributes.** External factors such as color, foreign matter, blemish, and damage that can be measured physically or evaluated visually.

**Quality.** Composite of product attributes with economic or aesthetic value to the user.

**Sanitary and safety attributes.** Factors including toxic constituents, microbiological organisms, and other residues related to product safety for end use.

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# 2 Consumer Opinions of Food Quality

Stephen G. Sapp[4]

## Introduction

Consumer evaluations of food quality reflect perceptions of sensory, nutritional, and safety attributes. The nature of both scientific and general literature on sensory and nutritional attributes, however, hinders discussion of quality perceptions at the commodity level. Documentation of sensory attributes, for example, would be quite tedious for any reasonable list of food products and would have limited utility for commodity-level policy decisions. Likewise, nutritional considerations can offer only general criteria for policy decisions, such as establishing meat grades and standards rewarding reduced fat content. Certain foods are selected, for example, precisely because they have little nutritive value, but taste good.[5] Thus, sensory and nutritive attributes provide overly specific criteria for a policy-relevant presentation of consumer perceptions of the quality of the U.S. food supply.

Food safety issues, on the other hand, affect consumer opinions of food quality across all commodities. Furthermore, scientific journals, consumer magazines, and newspapers contain many food safety articles directed to the topic of quality. This discussion, therefore, will address consumer perceptions of quality from the perspective of consumer food safety issues.

Consumer concerns about food safety are increasing. Annual surveys conducted by the Food Marketing Institute (FMI) show continuing levels of concern about pathogenic contamination, chemical residues, additives, and irradiated foods. Consistently, in recent years, approximately one-fourth of FMI survey respondents have expressed complete confidence in the overall safety of foods purchased at the supermarket. A recent survey indicates that 74% of respondents consider pesticide and herbicide residues serious health hazards and that more than 52% consider antibiotics and hormones used in livestock production serious health hazards (Council for Agricultural Science and Technology, 1995; Food Marketing Institute, 1995). High-technology procedures aimed at reducing risks have failed to alleviate consumer concerns (Lee, 1989; National Dairy Council, 1987). Indeed, to some degree, consumer concerns are heightened by the increased technological abilities to detect and to eliminate risk (Segal, 1990).

Unlike consumers, food scientists express strong confidence in the safety of the food supply (Young, 1989). Food scientists and consumers differ also in their ranking of hazards. Extensive research shows that consumers consider chemicals and additives the most important food safety hazards, and microbial contamination the least important. But food scientists consider microbial contamination the most serious hazard and consider long-term health risks from ingesting chemical residues or additives negligible (Council for Agricultural Science and Technology, 1994; Young, 1989).

Responsibility for food safety regulation and monitoring is shared by a combination of federal, state, and local agencies (Middlekauff, 1989; Young, 1988). The FDA is responsible for ensuring the safety of all foods except meat, poultry, and eggs. For these products, the USDA, through inspection and grading systems, enforces standards of quality. The Animal and Health Inspection Service (APHIS) regulates entry into the United States those pests that compromise food safety. The Bureau of Alcohol, Tobacco, and Firearms enforces regulations governing production, distribution, and labeling of alcoholic beverages. The Centers for Disease Control (CDC) enters the food safety arena during large-scale outbreaks of food-borne disease. The Department of Justice seizes food in violation of federal law and prosecutes violators of food safety laws. The Environmental Protection Agency (EPA) regulates pesticides and their use and establishes water-quality standards. The Federal

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[5]Selection of foods providing a wholesome overall diet requires accurate food content information. In 1993, the U.S. Food and Drug Administration (FDA), in response to requests by both consumers and nutrition educators began enforcing the Nutrition Labeling Education Act passed in 1990.

Trade Commission regulates the advertising of foods. The National Marine Fisheries Service (NMFS) regulates seafood quality. State and local governments and foreign governments cooperate with federal agencies to ensure food safety. The system obviously lacks uniformity and is a source of confusion to consumers.

Government agencies have been criticized strongly for failing to ensure a safe food supply (Leonard and Turner, 1986). The first comprehensive criticism of America's food safety net—*The Chemical Feast*—was prepared by a Ralph Nader study group (Turner, 1970). This report, based on extensive reviews of FDA files and interviews of previous and then-current FDA officials, claimed, among other things, that the agency was controlled in large part by special interest groups working on behalf of powerful food industry firms, conducted shoddy investigations, relied on inadequate scientific analysis, yielded to political pressures from both within and without the agency, and enforced regulations deferentially. According to the Nader report, the agency thus administered actually worked against food quality. Now 25 yr old, the attack lingers as a persuasive indictment of one government agency's inability to regulate food safety or to enforce related regulations.

This section reviews food safety issues facing the American public and describes a number of perspectives on these issues. It also presents a conceptual framework in which to interpret the food safety controversy and describes recent programs promoting effective risk communication.

## Food Safety Issues

The food safety controversy focuses on the use of pesticides, additives, antibiotics, and hormones in food production; the incidence of microbial contamination; the potential use of food irradiation in postharvest processing; and biotechnology. A review of these and other issues indicates the complexity of food safety problems facing the American public.

### Pesticides

The FDA and the EPA extensively test potential long-term health effects of food produced in conjunction with pesticide applications (Young, 1989). The National Coalition Against the Misuse of Pesticides (NCAMP) and the Natural Resources Defense Council (NRDC) note, however, that neither agency tests for many pesticides potentially present in food and claim than neither samples randomly or, in its assessment of quantitative risk, makes reasonable assumptions about the volume of food eaten (Durner, 1987; Lefferts, 1989; Montgomery, 1987).

Officials of the EPA and the FDA agree that current regulatory procedures are outdated (Benbrook, 1986; Reilly, 1990; Russell, 1990). For example, carcinogenic risk standards, i.e., the Delaney Amendment, prohibit the use of pesticides and additives posing any risk of cancer. This proscription, although unambiguous in meaning and intent, creates significant problems in practice: technological advancements occurring since the adoption of the Amendment provide exceedingly sensitive means of detecting such risk (*Consumer Reports*, 1989). Thus, regrettably, the EPA must withhold approval of new pesticides that are actually less carcinogenic than pesticides approved before improved test-sensitivity (Council for Agricultural Science and Technology, 1992; U.S. Environmental Protection Agency, 1990; Young, 1989).

It also is true that all plants produce natural pesticides for protection from predators; approximately 30% of these pesticides are carcinogenic, almost as great a percentage as that of commercially produced pesticides (Ames, 1989). For this reason, too, regulations aimed at eliminating carcinogenic agents may prove unenforceable.

Other problems arise in attempts to reevaluate previously approved pesticides. The General Accounting Office (GAO) estimates that the EPA could not complete such a review until the year 2024. Furthermore, once toxic products are determined to be unsafe, it may take a long time for them to be removed from use (Rowen, 1989).

In response to the need for streamlining and standardizing current regulatory law, several proposals with different degrees of support by environmentalists and by the EPA now are before Congress. The Waxman Committee submitted the Pesticide Reform Act (HR4091) in 1994. One proposed legislation would allow the FDA to rely on negligible-risk standards when approving pesticides. For carcinogens, *negligible risk* would be defined as involving, at most, one additional case of cancer in 1 million persons over a 70-yr lifetime of ingesting residues of the cancer-causing chemical in food (Young, 1989). For health effects other than cancer, such risk would be defined as a "100-fold margin of safety," meaning that a standard would be set at least 100 times lower than the highest dose at which the chemical causes no ill effects in animals.

Some claim, however, that even "negligible risk" is excessive and call for a phase-out of cancer-causing pesticides (Epstein and Feldman, 1989). And a significant number of consumers, for example, have turned to organically grown produce to avoid potential problems with pesticides (Jolly et al., 1989; Zind, 1990).

Concerned consumers in California have implemented legislation aimed at curtailing the use of carcinogenic pesticides. The California Safe Drinking Water and Toxic Enforcement Act, a.k.a. Proposition 65, prohibits businesses from knowingly exposing individuals to cancer-causing chemicals. A "bounty hunter" provision to the act rewards individuals or agencies able to win suits against violators of the law (Stone, 1988).

The Grocery Manufacturers of America, however, has pointed out that virtually all foods contain naturally occurring carcinogenic toxins and suggests that an estimated 15,000 items currently on supermarket shelves would have to be removed (Abelson, 1987). In response, the law exempts items that pose "no significant risk" for causing cancer. This exemption, however, allows for differing evaluations of testing procedures and results—and the testing procedures themselves are based on differing opinions about what constitutes safety.

Controversy surrounding the banning of Alar, a pesticide used in apple production, underscores the intensity of the food safety debate. The safety of Alar was called into question in a report by the NRDC (1988), which claimed that the chemical posed an "intolerable risk" to consumers. Then a February 26, 1989 broadcast of CBS's "60 Minutes" stated that "the most potent cancer-causing agent in our food supply is a substance sprayed on apples to keep them on the trees longer and make them look better." Within a week, the celebrity Meryl Streep testified before the Senate subcommittee on Labor and Human Resources regarding her concerns about the safety of the U.S. food supply. Subsequently, the EPA, under pressure from concerned citizens and consumer interest groups, banned the use of Alar.

Yet the NRDC report and the "60 Minutes" broadcast have come under sharp criticism by government and scientific agencies. Then-FDA commissioner Frank Young stated that "this is one of the worst instances of where statements were made without the benefit of scientific review" (Fumento, 1990). Sixty-five food scientists protested the ban on Alar by sending to three newspapers an open letter stating that "Our Food Supply is Safe" (Dolan, 1989). Officials from the EPA pointed out that the NRDC report cited tests since discredited and that it ignored more recent tests indicating Alar's safety (Moore, 1989). Research by Bruce Ames, a biochemist and leading figure in food safety research, showed that the "index of possible hazard" of Alar is less than 1/20 the risk of common municipal tap water (Ames, 1990; McAuliffe, 1987).

Currently, no recognized group of toxicologists or medical experts supports claims that pesticide residues in fruits and vegetables pose important health hazards (Council for Agricultural Science and Technology, 1990). Industry economists estimate losses to apple growers due to the banning of Alar at between $60 million and $140 million.

## Food Additives

For purposes of FDA regulation, chemicals added to food fall into four categories: food additives, generally-recognized-as-safe (GRAS) substances, prior sanctioned substances, and color additives (Young, 1988). The FDA procedures for approving food additives have come under much criticism from consumer advocacy groups. Government and industry officials agree that current testing protocols can be ineffective and are evaluating alternative approaches (Kirschman, 1983).

Advocacy groups claim that FDA approval of aspartame, i.e., NutraSweet, failed to resolve significant questions about its safety and that the FDA commissioner failed to act on numerous recommendations to keep the substance off the market. Studies conducted and submitted to the FDA by G. D. Searle, aspartame's creator, show that the additive may cause tumors in rats. And "court documents, documents gathered by attorney and food-safety advocate James Turner, and interviews with FDA policymakers and scientists show that the [Searle] safety studies were carelessly executed and yielded contradictory results" (Farber, 1990). Aspartame was approved in 1981, and by July 1988 the FDA had received more than 6,000 complaints of side effects from the sweetener (Farber, 1990).

"Unintentional" additives include mycotoxins, antibiotic residues, and chemical contaminants. Mycotoxins are fungal toxins occurring in a great variety of foods and feeds. Exposure to mycotoxins occurs through consumption of infected food, and the technology does not exist to prevent such exposure. Consumption of foods with high levels of mycotoxin contamination has resulted in large-scale food poisoning (Council for Agricultural Science and Technology, 1989b).

Drought conditions in the Midwest in 1988 caused significant increases in contamination of the corn crop with aflatoxin. The FDA subsequently asserted that plentiful clean corn remained for consumption by humans. But concern is aroused by reports that contaminated corn still is being purchased by owners of certain grain elevators, who, to escape detection by state health officials, may mix this corn with uncontaminated corn (Council for Agricultural Science and Technology, 1989; Kilman, 1989).

Both GRAS and prior sanctioned substances such as cyclamates can be removed from use if new scientific evidence shows them unsafe. The FDA also has come under criticism for its regulation of substances in these categories. Controversy surrounding the use of cyclamates, for example, is documented in *The Chemical Feast* (Turner, 1970), which states that the FDA was warned repeatedly about the dangers of cyclamates over many years but ignored warnings until intense public pressure led to new studies and ultimately to a ban. *The Chemical Feast* documents a similar case history for saccharin, which the FDA removed from the GRAS list but which continues to be used because of a special exemption from Congress (Young, 1988).

Color additives must be subject to premarket testing. Some in use for many years, such as red dye No. 2, have been banned because of failure to pass current safety tests.

## Antibiotics and Hormones

The use of antibiotics and hormones in animal production has increased dramatically with advances in technology and in farmers' understanding of these technologies. Concern exists that continued heavy use of antibiotics may create drug resistant bacteria transferrable to humans through consumption of animal products. Studies conducted by the NDC (National Dairy Council, 1987) have implicated hamburger meat as a source of drug-resistant salmonella bacteria. But food safety authorities state that current evidence is inconclusive and insufficient to ban the use of subtherapeutic levels of antibiotics.

Concern exists, too, about the use of hormones in animal production (Grunewald and Field, 1991; Herman, 1989; Schell, 1984). Currently, the United States and the European Community (EC) are involved in a debate about the safety of hormones in beef production. This debate is posing significant problems for General Agreement on Tariffs and Trade (GATT) negotiations. Although consumers enjoy the benefits of leaner meat produced with hormones, because of safety concerns they are hesitant to accept this product (Florkowski, 1989). Scientific agencies, however, find no evidence that consuming products produced with hormones poses a risk to human health (Council for Agricultural Science and Technology, 1991a).

## Microbial Contamination

Although much consumer and media attention focuses on the safety of pesticides, additives, antibiotics, and hormones in food production and processing, food scientists consider microbial contamination the greatest food safety hazard (Council for Agricultural Science and Technology, 1994). Currently, the FDA has placed microbial safety of foods among its highest priorities.

The FDA estimates that microorganisms cause as many as 81 million cases of diarrheal disease and that between 400,000 and 4,000,000 humans contract salmonellosis each year (*Consumers' Research*, 1989; Young, 1989). Outbreaks of food poisoning from microbial contamination have affected hundreds of thousands during the past decade (Segal, 1988). Costs incurred from direct medical expenses, lost wages and productivity, and industry losses through recall, embargo, and destruction of contaminated products are estimated at between $1 billion and $10 billion annually (Segal, 1988).

Part of the escalating incidence of foodborne illness can be attributed to improved detection methods. Improved abilities to differentiate foodborne disease from the "flu," for example, have altered the statistical recording of disease causes (McAuliffe and Lennon, 1987). Increased numbers of foodborne illness, however, are not purely actuarial. Increased concentration of the food industry, wherein one mistake can affect millions of people, combined with increased away-from-home food consumption, contributes to increased incidence of food poisoning (Institute of Food Technologists Symposium, 1986).

The FDA likely will increase efforts to prevent foodborne disease (Young, 1988). Prevention, however, still rests largely on the consumer or the food-service provider. Publications from the FDA (Young, 1989), science and industry (National Dairy Council, 1987; Snyder, 1985), and consumer advocates explain to both consumers and food-service personnel proper food handling methods.

## Food Irradiation

No food safety issue is spawning such voluminous literature or intense debate as food irradiation is. Irradiation promises to increase the safety of foods greatly by limiting harmful bacteria and parasites responsible for foodborne diseases. The process can extend significantly the shelf life of foods, an advantage with implications for both domestic and export markets. The FDA approves food irradiation for spices, produce, pork, chicken, and wheat. The process also has been endorsed by the American Medical Association and by health authorities worldwide (Council for Agricultural Science and Technology, 1985; 1989a; 1991b).

Irradiation faces strong opposition, however, from certain national-level consumer groups. As a result of such opposition, the sale of irradiated food has been banned in Maine, New York, and New Jersey, and seven additional states are considering a ban. Consumer groups opposing irradiation also have been successful in petitioning pork and poultry commodity groups and major food companies. In 1988, food companies were unwilling to risk having their brand names associated with irradiation (Hayes et al., 1988), and pork and poultry commodity groups fund no projects on consumer acceptance of food irradiation.[6]

## Additional Food Safety Issues

In response to changing tastes and nutritional concerns and to improved production and processing techniques, consumption of seafood has increased markedly during the last decade. But with rising consumption has come increased attention to potential safety problems occurring as a result of contamination from polluted water or inadequate inspection, harvest, transport, preparation, or sale. The FDA has been prompted to appoint a special task force to evaluate its seafood safety efforts (Miller, 1991; Modeland, 1989).

Since the early 1970s, food imports nearly have tripled to 30 billion pound (lb)/yr, with a value of greater than $20 billion (Ingersoll, 1989). Yet the FDA checks only a small percentage of food products entering this country. Only about 10% of all products is inspected, and only about 2% tested for microbial contamination. No approval process exists for importers of canned goods, and the FDA seldom sends inspectors overseas to inspect foreign processing plants (Ingersoll, 1989). The FDA says, in fact, that a limited staff, which often must respond to emergencies, cannot provide the protection needed for imported goods.

The widespread use of microwave ovens at home and in food services has created concerns about the safe reheating of foods. Results from microwave reheating depend on the geometry of menu size and placement, the type of container, the length of heating cycle, and the location of food in the oven (Dahl, 1982). Foods may be reheated at inadequate temperatures and with improper containment and placement in microwaves (Mathews, 1985).

Advances in biotechnology promise improvements in the yield and nature of foods. Concerns remain, however, about the potential negative impacts of biotechnology on the nutritive value of food and on the interaction of such technology with chemical residues, nitrates, and naturally occurring toxins (Doyle, 1986).

Finally, consumer advocates are concerned that efforts to "harmonize" chemical-residue and food safety standards among nations wishing to expand trade may undermine comparatively more stringent standards for safety in the United States (Anthan, 1991). Recent trade agreements may allow importation of foods treated with dichlorodiphenyltrichloroethane (DDT), which was banned from use in the United States many years ago.

[6]Personal communication with research representatives of commodity organizations.

# Glossary

**Negligible risk.** Allowable level of a hazard. For carcinogens, at most, one additional case of cancer in 1 million persons over a 70-year lifetime of ingesting residues of a cancer-causing chemical in food (Young, 1989). For health effects besides cancer, defined as a "100-fold margin of safety," meaning that a standard would be set at least 100 times lower than the highest dose at which the chemical causes no ill effects in animals.

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# 3 The Food Safety Dilemma

Stephen G. Sapp[7]

## Introduction

"Today's consumer environment can be summed up in three words: fear, confusion, and frustration" (McKinney, 1990). Consumers hear repeatedly that the foods they eat are unsafe, that the FDA and the EPA are failing in their responsibilities to the public, that representatives of big industry exert disproportionate influence so as to protect profit rather than safety, and that current scientific evidence is faulty, inadequate, or misleading. Although both food scientists and government authorities recognize problems with the existing food safety net, they conclude that the American food supply is the "safest in the world" and that the public runs negligible risk from exposure to pesticides, additives, antibiotics, and hormones (Russell, 1990).

The resulting dilemma is that food safety decisions, and even protocols for making them, have become a matter of uncertainty and debate. Conflicting food safety messages may create adverse effects, in themselves, among frustrated consumers (Dullea, 1989). Milton Russell, a former EPA official, states that frustrated consumers may react with either constant anxiety or defensive indifference (Abelson, 1987). Expectations of absolute safety in a world of increasing technological sophistication can cloud discussion of how best to achieve maximum safety when no guarantees are possible (Watts, 1989). Additionally, food-risk perception can be skewed by "outrage factors" (Sandman, 1988) such as doubts about voluntariness, control, fairness, and morality in hazard avoidance and food safety decisions.

The American Council on Science and Health (ACSH), a consortium of food scientists and practitioners, seeks to alleviate consumer anxieties through its support of the existing food safety net. But NRDC representatives have criticized the ACSH for making overly optimistic statements about food safety and have questioned the organization's credibility in light of its financial support by food corporations.

On the other hand, the NRDC acquires members, publicity, and income from emphasizing hazards (Koshland, 1989). As Fumento (1990) points out, "If it's true that ACSH gets ten percent of its money from pesticide companies like Uniroyal, it's also true that the NRDC gets 100 percent of its money by convincing donors that chemical companies like Uniroyal are poisoning the environment."

Consumer advocacy groups and the media also have been called into question concerning their food safety accusations. Phelps (1986) notes that, in regard to what they can say about food safety, scientists, industry representatives, and government officials are constrained by numerous factors including critical review, whereas critics are bound by no "discipline of responsible participation in the process." He states that food safety issues require open public debate, not criticism and sensationalism.

## Suggestions for Alleviating the Food Safety Dilemma

Improving food safety involves activity on the part of three groups: consumers, scientists, and food safety authorities.

### What Consumers Should Do

The media inform consumers about how to limit exposure to unsafe food. Consumers receive instructions in such matters as proper seafood selection and preparation, internal temperature for red meat and poultry, food storage, food handling, and identification of risky foods (Gershoff and Whitney, 1990). In addition, the FDA has established a popular telephone hotline to answer food safety questions (Lecos, 1988).

Advocacy groups urge consumers to become members; to take active roles in addressing food safety problems; to contact federal, state, and local agencies about suspected food safety problems; to demand immediate bans on suspected toxic products (Rowen,

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1989); to buy organic produce (Durner, 1987); and to volunteer as food safety activists (Montgomery, 1987).

Government agency representatives urge consumers to maintain a perspective on relative risk and to sort sense from nonsense. Educators are urged to communicate science at all levels, and the public is urged to hold "purveyors of nonsense" legally responsible for economic damage (Lee, 1989).

### What Scientists Should Do

The Institute of Food Technologists (IFT) offers suggestions for improved communication of risk to consumers. The IFT recommends studies to determine how public perceptions are formed and how best to communicate with the public. These studies should be followed by programs to communicate food safety issues (Kolbye et al., 1985).

Scientists may begin with the assumption that consumers are irrational in their reactions to and wrong in their conclusions about claims by consumer groups. But some observers, who believe that researchers' and officials' ignoring consumer fears add to the food safety controversy, urge respect for the consumer perspective (McNutt, 1988). Scientists are urged to listen to consumers; to recognize their intelligence; to take their concerns into account; to be honest about real risks; to make as much information available as possible; to refrain from giving pat responses, e.g., "we have the safest food supply in the world"; to allow common sense into the reasoning processes; and to show respect (Council for Agricultural Science and Technology, 1995; McNutt, 1988).

### What Food Safety Authorities Should Do

The American Dietetic Association cites a need for coordination between federal and state regulatory bodies; a unified voice from federal agencies; consistent food regulations among states; research on pest-resistant crops to reduce the need for chemical pesticides; education for the public; and funding for inspections of meats, imported food, and seafood (American Dietetic Association, 1990).

Similarly, agricultural interest groups are urged to respond to consumer concerns. Byal (1989) recommends that these groups cultivate understanding of consumer fears, which can be influenced greatly by sensationalist journalism.

## Risk Communication Strategies

The marked differences among these suggested solutions result from equally marked differences in food safety philosophies. Consumer advocacy groups suggest increased public awareness and participation. Others, however, in response to what they perceive as overreaction to safety issues, call for action in response to criticisms of the food safety net.

Economic analysis, which identifies costs and benefits of information dissemination by scientific and industry representatives, can help identify the determinants of information acquisition and use by consumers, producers, and others. When safety information is unreliable and disseminated asymmetrically, the economic approach also can clarify potential impacts on market conditions (Kramer, 1990).

A common suggestion by food scientists and by food safety authorities is increased consumer education whereby the consumer will be able to improve understanding of the nature of food science and presumably of the safeguards of the food supply. Recommendations that consumers study quantitative risk assessment, food inspection and regulation procedures, and scientific studies of food hazards appear in numerous scientific and government publications addressing consumer concerns (Council for Agricultural Science and Technology, 1995).

Educational messages alone, however, cannot be expected to alleviate food safety concerns because what scientists consider "educational" differs from what consumer advocacy groups do. Consumers receive educational messages about the safety of current production and processing practices and also about the faults of the current system. Further, educational messages can heighten concerns while attempting to explain the complex and technical nature of food safety regulations.

Most important, consumer education messages are delivered within a social context of conflicting values and attitudes regarding appropriate food safety technologies. "At the core of the food safety issue is a clash of values," states *The Chemical Feast* author, James Turner (*Prepared Foods*, 1986, 228). Different conceptual approaches to risk yield different conclusions about potential hazards and suggest different solutions (Rodale, 1990).

Bradbury (1989) distinguishes between risk as a physically given and as a socially constructed attribute. The former permits objective, quantifiable definitions. This technical conceptualization of risk implies an education policy through which the consumer receives the technical information needed to recognize the true nature of risk. Similarly, psychometry views consumer education and media control as central to alleviating food safety concerns.

The socially constructed notion of risk assumes that truths do not exist independently of people, who make value judgments, educated guesses, and politically expedient decisions at all phases of the risk identification and assessment process (Otway and Thomas, 1982). This conceptualization of risk implies the appropriateness of policy structured in terms of negotiating among alternative belief systems held by technicians, policymakers, consumers, consumer advocates, and media practitioners (Rayner, 1984; Rogers and Kinkaid, 1981).

Proponents of the social process approach state that risk communication must involve citizen participation in policy decisions (Fischhoff et al., 1981). Scherer and Juanillo (1990), for example, state that risk communication should be judged in terms of the extent and the quality of public involvement in risk assessment and policy formation and that scientific and lay opinions must enter into risk identification, assessment, and communication. Furthermore, communication about risk should dispel the myth that scientific expertise is based on hard facts, is more reliable given its consensus by experts, and is the only source of information admissible in decision making. Likewise, consumer opinion should be considered one of several sources of risk information.

A Cornell University-sponsored workshop (Scherer, 1990) has incorporated the socially constructed perspective of risk into strategies for effective risk identification, assessment, and communication policy. Workshop materials stress that risk policy should be a process wherein all participants—representatives of government, science, industry, mass media, consumer advocacy groups, and lay communities—exchange information and philosophies. Such a strategy is thought to respect the credibility of all participants, to provide mechanisms for all to learn from one another, to develop systems for identifying information needs, to provide the nonscientific community with analyzed data and methods for their interpretation, to enable mass media practitioners to recognize and to deal with conflicts among participants, and to develop systems providing practitioners with accurate and complete information for publication. Thus, possible mechanisms for enabling effective interaction include promoting active involvement by citizens groups, conducting interactive public hearings, setting forth political initiatives, and conducting scientific public surveys to assess public opinion accurately.

# Conclusions

The United States faces a food safety dilemma characterized by mistrust of a net too often unable to protect the public from unnecessary risk. Frustration with the impacts of this mistrust on legitimate attempts to improve food safety also is characteristic. The broad range of debate on the safety of pesticides, additives, hormones, microbes, and high-technology processing underscores a fundamental conflict in philosophical perspectives on food production and processing.

Technical or psychometric approaches to ameliorating the food safety dilemma, because they assume an objective standard of safety, are unlikely to elicit productive risk identification, assessment, or communication strategies. The socially constructed perspective of risk, because it recognizes that each participant has a unique set of values and because it considers all participants credible, regardless of value orientation, can promote effective risk policy through strategic interaction and dialogue.

Food safety is a public-policy issue. If absolute safety is impossible, then the public must decide how much safety it wants at what cost. Scientific inquiry conducted expertly and honestly must be recognized for its contributions to the safety of food products. But the limits of science in method, measurement, and philosophy also must be recognized and appreciated (Council for Agricultural Science and Technology, 1992). Strategies promoting legitimate interaction and dialogue within a context of competing value structures offer the best means of providing the consumer with desired levels of food safety.

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# 4 Exploring the Limits of Measurement Technology

Donald E. Koeltzow[8]

## Introduction

Measurement of quality requires both a quantifiable definition and compatible equipment. Definitions and technologies are interdependent. New measurement technology or methodology has identified relatively stringent limits in defining quality, as can be seen with aflatoxin. The importance of the quality attribute "corn breakage susceptibility," for example, has stimulated a search for measurement technology.

Technology and standards must progress simultaneously. As Near-Infrared (NIR) transmittance technology improved in speed and reliability, measurement of oil and protein contents of soybeans became requested in the export market. Use of NIR technology usually depends on the degree of correlation with another method. New equipment for measuring fiber strength in cotton allowed the cotton industry to quantify these attributes and to incorporate them into grades and world prices.

Technical capability, however, differs from economic feasibility in quality determinations. Many analytical techniques provide useful information about quality and value but must be transferrable from the laboratory to the commercial marketplace before they are useful in price negotiations. This adaptation is accomplished more easily for some commodities than for others. Time and cost are essential considerations in commercial transactions. Continued research and development (R & D) are moving an ever increasing number of quality measurements from the laboratory to the marketplace.

## Factors Affecting Measurement Technology

Few factors have so great an ability to change the definition of *quality* applied to agricultural commodities as the current revolution in measurement technology does. With the exception of weight, early measures, e.g., appearance, color, and odor, were predominantly subjective. The few chemical tests available for measuring constituent levels in commodities usually required elaborate equipment, experienced personnel, and much time.

Today, wet chemical techniques are being replaced by faster, more reliable, and more accurate instrumental and immunochemical methods. Detection limits in the parts-per-thousand and sometimes in the parts-per-million ranges have been lowered to the parts-per-billion (ppb) and even the parts-per-trillion ranges. Analysis times have decreased from hours to minutes, and the levels of technical expertise and the types of equipment required for many analyses now permit testing in the field. Additionally, subjective observations are being replaced by objective tests.

These new test methods derive from two primary forces. One force is the market, which drives efficiency; the other is heightened consumer expectation or demand for reliability and safety. In the first instance, streamlined methodology decreases analysis costs by decreasing labor requirements. Increasing accuracy decreases both the number of tests and the number of reanalyses needed for a specific level of analytical confidence.

For example, in 1989, the USDA Federal Grain Inspection Service (FGIS) selected new NIR transmittance instruments for protein and oil analyses in soybeans. These instruments require less sample preparation than the older reflectance machines do, and the agency saves approximately $27,000/instrument/yr in labor costs. Additionally, the availability of inexpensive, reliable testing for specific constituents in commodities may provide producers and exporters with a competitive edge or with premium revenues. High-protein milk and wheat, high-oil sunflowers, and low-fat meat are examples of commodities that

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may yield higher prices because of constituent contents.

As faster and cheaper test methodologies are devised, a larger portion of the commodity moving through the market channel will be tested. This increased sampling and analysis provides the market with the information needed to establish new quality parameters and to segregate the commodity into high, medium, and low quality portions. For example, after the USDA–FGIS made available the faster, more economical means of measuring protein and oil in soybeans, requests for analyses increased. Soybean quality definitions now include protein and oil contents. This information, in turn, is used by both plant breeders and producers to maximize constituent levels. Eventually, the quality of U.S. soybeans will improve in terms of these two constituents.

Economic concerns affect the development of new analytical techniques in another important way. As mentioned, the factors used to define the quality of any commodity usually are limited by the technology available for measurement. But developing new analytical technology is quite expensive. If, in addition, market potential for the technology is limited, then the economic risk of development increases with the difficulty of recovering development costs.

Instrument and analytical method manufacturers are willing to develop new analytical techniques if such techniques will become part of the mandatory quality tests used to grade agricultural commodities. On the other hand, a guarantee cannot be provided by buyers, sellers, or inspectors of commodities until the analytical methods have been shown to provide useful marketing information. Research funds from federal and state governments and from various producer and marketing organizations therefore are vital to the creation of new quality measures.

In the second instance, heightened consumer expectation and demand increase the need for accurate quantitative, objective tests; and product safety is a central quality issue. Consumers are concerned about the levels of bacteria in poultry products; of antibiotics and hormones in meat and milk; of mycotoxins in milk, meat, and grain; and of pesticide residues in fruits, vegetables, and grains. In addition, demand increases for meaningful objective measure of "end use" quality factors such as the gluten strength in wheat protein as related to flour baking-quality or the nutritional constituents in meats, feed grains, fruits, and vegetables. These factors are becoming increasingly important to the customer, and fast, accurate, economical methods of measurement are necessary if the factors are to be useful marketing tools. Again, as objective analytical information is made available, the parameters defining quality change.

There is a significant difference between the two driving forces of economics and objectivity. The main goal of objective testing is greater accuracy and reliability and truer representation of commodity quality. The market drives efficiency, sometimes at the expense of accuracy and reliability. Thus, cost and accuracy always must be balanced in the development of new inspection techniques.

## Development of Analytical Techniques

The development of two different analytical techniques has played an important role in the expansion of measurement capabilities in agricultural commodities. The first technique is NIR spectroscopy for constituent measurement; the second, enzyme-linked immunosorbent assays (ELISAs).

In the 1950s, Karl Norris, USDA–ARS, Beltsville, Maryland, began experimenting with light scattering. His work led to the development of a computerized NIR spectrophotometer, which was used to analyze meat in the late 1960s. Commercialization of NIR instruments was made possible by improvements in instrument optical systems and by availability of faster, cheaper computers.

In NIR reflectance instruments, light from the NIR region of the spectrum is focused on the sample. As this light penetrates the sample, different portions are absorbed because of the presence of specific chemical constituents. After the light reflected by the sample is analyzed, those portions absorbed by the sample are used to calculate the levels of specific constituents. Often, to prepare a uniform surface for analysis using this technique, the researcher must grind the sample to a fine powder before loading it into the analytical cell.

Typical analyses can be accomplished in a matter of minutes, including sample preparation time, and results frequently are more reproducible than those obtained with standard analytical methods. Instrumentation is relatively cheap, and techniques for analysis are easy to learn and to use. But because NIR spectroscopy is an indirect measurement technique, results always must be correlated with analysis for each constituent obtained using standard chemical methods. Keeping the instrument adjusted to these chemical results presents a challenge to regulators, users, and developers of the technology.

In the late 1980s, a new type of NIR instrument was developed that measured the amount of NIR light transmitted through the sample rather than the light reflected by it. Frequently, NIR transmittance instruments do not require that the sample be ground to a powder before analysis; thus, labor costs are reduced greatly.

Both reflectance and transmittance instruments are being used for a wide variety of constituent analyses of a great number of commodities. The list of constituents and of other properties measured includes moisture, protein, oil or fat, starch, fiber, kernel hardness, textile strength, and forage digestibility, to name a few. Commodities being tested include those covered by this report, as well as many others. The major limitations to analyses using this technique are that the level of constituent content should be above 1% and that great effort is required to adjust the instrument.

In the case of the second important analytical development, i.e., the commercial production of ELISAs, the assays contain specific antibodies coupled with enzymes that produce visible colors. Commercial production of these assays has been dependent on discoveries made during investigations of the immune defense mechanisms of mammals.

In a typical ELISA, the constituent being analyzed is extracted from the sample. Next, this extract is added to an assay system component containing antibodies that react specifically with the constituent. All other materials are washed away. Finally, an enzyme system is added to the antibody-constituent mixture. The enzyme works as a catalytic amplifier, producing great amounts of visible color if very little constituent is present. Most ELISA tests are semiquantitative in that they are adjusted to detect the presence of the constituent at a preset level. Typical is the corn aflatoxin ELISA test, which normally is adjusted to produce a negative result for aflatoxin levels at or below 20 ppb and a positive result for levels above 20 ppb.

The ELISA methodology can be modified to analyze practically any constituent. All that is required is development of a specific antibody for the constituent. Now ELISAs are available commercially for the measurement of different bacteria, numerous antibiotics and hormones, pesticide residues, several mycotoxins, and insect infestation levels in a wide variety of commodities. Because of the amplification provided by the enzymes in these assays, detection limits can be in the ppb range or, on occasion, in the parts-per-trillion range. New assays are taking advantage of all or part of the ELISA technology, and faster, more accurate quantitative tests are being devised. A number of immunodependent assays providing the aflatoxin concentration in ppb are available commercially.

## New Measurement Technologies

Among the several new methods of analysis being developed that have the potential to improve greatly the ability to measure quality factors of real or perceived value are image analysis, odor detection, acoustical detection, and robotics. Probably the most significant is the first, which uses color video cameras to record sample inspection. The information recorded is transferred to a computer for analysis. Questions about the commodity, e.g., whether it is the correct size, color, or shape and whether it has insect, heat, or mold damage, can be answered in a few microseconds.

Color video cameras already are being used to sort and to grade many kinds of fruit and other produce. This equipment is fast enough to be used on-line as the product is being cleaned and packaged.

Development of image-analysis systems depends greatly on the commercial availability of computers able to process great amounts of information rapidly. In addition, software innovations such as neural networking and expert systems have simplified production of the computer programs needed to control image-analysis systems. Current study of their use in inspection of agricultural commodities centers on determining what visual information is needed to make quality determinations and how this information should be processed. Eventually, a form of image analysis likely will be used to inspect all agricultural commodities.

Odor is an important quality parameter for most commodities, and a second area of significant analytical development is in odor detection. For example, the U.S. Grain Standards use odor as a grade determining factor for most grains. Odors also are quite important in the catfish industry. Current methods of odor detection are subjective evaluations made by inspectors. But smells detected by the nose are affected by a wide variety of factors such as illness or allergy. Research therefore is being directed toward the production of objective tests for the presence of specific odors in grains and other commodities. Additionally, numerous studies of odor perception are being conducted by the cosmetic and the food industries. Results from all relevant research will be used to produce instrumentation able to detect specific odors.

A third innovative technique involves acoustic detectors. Many agricultural commodities are subject to attack by insects, and infestation frequently is invisible to inspectors because it occurs inside individual products such as kernels, bags, or packages. Acoustic detectors capable of quantifying the level of infestation by analyzing the sound made by insects as they feed and move are being tested by the ARS.

A fourth area of development is automation, in which a robotics revolution is taking place. All procedures described in this section can be automated. For example, at the 104th Annual Meeting of the Association of Official Analytical Chemists (AOAC) in 1990, a paper describing the automation of an immunochemical analytical system for the measurement of aflatoxin in corn was presented (Carman, pers. com., 1990). Much measurement technology probably will be automated by the twenty-first century.

Inspection laboratories of the future will be quite different from those of today. They will be staffed by fewer people, who will be trained in constituent analysis, computer operation, and robotics, and will measure a wider variety of constituents and end-use quality factors. As research provides additional information about the constituents that are important quality parameters, the list of items analyzed will continue to increase. Many determinations may be made on line, as commodities are processed. Such online analysis will eliminate the need for collecting specific representative samples and will permit the inspection of much larger portions of the commodity.

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# 5 Feed Grains

Lowell D. Hill[9]

## Introduction

Although the various industries using feed grains have common quality concerns, each industry seeks a set of specialized quality characteristics.

Crops included as feed grains constitute neither a unique nor a fixed set. Several cereal crops must be included in the feed grains category because at the appropriate prices, as dictated by supply and demand, many grains classified as food grains can be used for feed. Moreover, the traditional feed grains, e.g., corn and grain sorghum, may be processed for food and industrial uses. Depending on both prices and price substitutes in the various processing industries, certain grains may be classified as either feed grains or food grains.

For the purposes of this report, *feed grains* include corn, grain sorghum, barley, and oats. Although representing a small fraction of total feed grains, barley and oats will be discussed briefly. Wheat also is used, depending on relative prices, for livestock feed but will be discussed in a separate chapter.

## Consumption Patterns

Feed grains are used for many products in addition to livestock feed, products ranging from breakfast cereals to industrial alcohol. For numerous products, there is significant substitution among grains, but the specialized corn processing industries have exerted a strong influence on quality control. The products obtained from each grain and its characteristics influence quality requirements and related issues. Brief descriptions of the primary uses for each grain will facilitate the discussion of quality problems.

### Corn

During the 1993–1994 crop year, approximately 19% of U.S. production was exported. Less than 40% was fed on farms where the corn was produced.[10] The remainder entered the domestic market channel for use in feed, food, or industrial processing industries. The volume of corn used for food and industrial products such as starch, sweeteners, and alcohol has increased in recent years, with 1993–1994 consumption surpassing the quantity exported. (Table 5.1.) Each of the major uses has unique quality requirements and problems, but quality as indicated by grade was especially important for the 2,805 million bushel (bu) dedicated to milling and to export during the 1993–1994 crop year. Quality also is important in the feed industry and for on-farm use; numerical grade is less so.

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[10]The data series "used for feed or farms where grown" was discontinued in 1979. The 5-yr average from 1975 through 1979 was 38.5%, with a generally downward trend.

**Table 5.1. Corn: Marketing year supply and disappearance (million bu) (U.S. Department of Agriculture, 1994)**

| | Supply | | Domestic use | | | | | |
|---|---|---|---|---|---|---|---|---|
| Marketing year | Production | Imports | Food, alcohol, and residual | Seed | Feed and residual | Total | Exports | Total disappearance |
| 1989–1990 | 7,525.5 | 1.9 | 1,337.0 | 18.9 | 4,389.2 | 5,745.1 | 2,368.2 | 8,113.4 |
| 1990–1991 | 7,934.0 | 3.4 | 1,353.7 | 19.3 | 4,663.0 | 6,036.1 | 1,724.6 | 7,760.7 |
| 1991–1992 | 7,475.5 | 19.6 | 1,433.8 | 20.2 | 4,877.9 | 6,331.9 | 1,584.1 | 7,916.1 |
| 1992–1993 | 9,481.7 | 7.1 | 1,492.7 | 18.7 | 5,301.4 | 6,812.8 | 1,663.3 | 8,476.1 |
| 1993–1994 | 6,344.0 | 20.8 | 1,568.1 | 20.1 | 4,711.2 | 6,299.4 | 1,328.3 | 7,627.7 |

## Grain Sorghum

Most grain sorghum is used as feed in domestic and foreign markets. Less than 40% of total grain sorghum produced in 1993–1994 was consumed on the farms where it had been grown.[11] Approximately 60% moved through the traditional market channel where grades provide information about value. Thirty percent of total annual consumption was exported; seventy percent was used for feed. Only 1% was used for food, alcohol, and seed. The volume of sorghum exported ranged from 202 million to 303 million bu over the past 5 yr, with a general declining trend (Table 5.2). Industrial use is limited primarily to wet milling for starch and for industrial alcohol. Numerical grades are important to the export market but provide little information about nutritional value for feed use.

## Barley

Barley produced in the United States is used primarily for malting or livestock feeding. During 1993, approximately 400 million bu of barley was produced, of which approximately 163 million bu was used for malting and brewing and approximately 250 million for feed. Barley can be ground and mixed with concentrates and other grains to produce feed or can be steamed and rolled to produce flakes. Pelleting of barley increases its palatability and efficiency as a feed for hogs. Malt sprouts, brewers' grains, and distillers' grains are by-products of the malting, brewing, and distilling industries, respectively, and are used in mixed feeds—primarily for dairy cattle. The quantity used for food and alcohol stabilized in the 1990s and remained lower than the quantity used for feed (Table 5.3).

Barley exports from the United States have fluctuated widely over the past three decades, ranging from 10 million bu in 1969–1970 to 134 million bu in 1986–1987. Exports have fallen from this peak to a low of 66 million bushels in 1993—approximately 14% of total disappearance. Grades are of minor importance to livestock feeders and are supplemented with variety-specific contracts in the malting industry.

## Oats

The quantity of oats consumed in the United States has averaged just over 350 million bushels since 1989–1990. Food and industrial uses for oats have remained fairly constant throughout this time period. Declining domestic production has been offset by in-

[11]The data series "used for feed or farms where grown" was discontinued in 1979. The 5-yr average ending in 1979 was 39.5%, with a generally downward trend.

**Table 5.2. Sorghum: Marketing year supply and disappearance (million bu) (U.S. Department of Agriculture, 1994)**

| Marketing year | Supply | | Domestic use | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Production | Imports | Food, alcohol, and residual | Seed | Feed and residual | Total | Exports | Total disappearance |
| 1989–1990 | 615.4 | 0.2 | 13.6 | 1.3 | 517.3 | 532.2 | 303.2 | 835.4 |
| 1990–1991 | 573.3 | 0.1 | 7.3 | 1.4 | 409.6 | 418.4 | 232.2 | 650.5 |
| 1991–1992 | 584.9 | 0.0 | 6.8 | 1.7 | 374.0 | 382.5 | 291.7 | 674.3 |
| 1992–1993 | 884.0 | 0.0 | 6.1 | 1.4 | 477.5 | 485.0 | 277.2 | 762.2 |
| 1993–1994 | 567.9 | 0.0 | 6.2 | 1.3 | 486.3 | 493.8 | 201.6 | 695.3 |

**Table 5.3. Barley: Marketing year supply and disappearance (million bu) (U.S. Department of Agriculture, 1994)**

| Marketing year | Supply | | Domestic use | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Production | Imports | Food, alcohol, and residual | Seed | Feed and residual | Total | Exports | Total disappearance |
| 1989–1990 | 404.2 | 13.1 | 162.0 | 13.5 | 193.3 | 368.8 | 84.0 | 452.9 |
| 1990–1991 | 422.2 | 13.5 | 161.1 | 14.6 | 204.8 | 380.5 | 80.6 | 461.1 |
| 1991–1992 | 464.3 | 24.5 | 163.3 | 12.9 | 224.9 | 401.1 | 94.5 | 495.6 |
| 1992–1993 | 457.4 | 11.4 | 158.4 | 13.2 | 194.9 | 366.5 | 80.3 | 446.7 |
| 1993–1994 | 400.2 | 71.5 | 162.9 | 12.1 | 243.0 | 418.0 | 66.1 | 484.0 |

creased imports of oats. Imports comprised more than 33% of total domestic use in 1993–1994.

### Summary

Quality issues in the feed grains industries are important primarily for those grains moving into the market channel, especially for those destined for the food processing industries or the export market. The latter absorbs 15 to 30% of annual use of corn, barley, and grain sorghum. Oats exports are insignificant. Most oats are fed on the farms where grown; most corn, grain sorghum, and barley move through the commercial market channel. Issues related to grading, pricing, and transporting for the most part are relevant to grain moving in commercial markets. Because of the emphasis on competitiveness and on trade balance, the portion of the crop exported is subject to even greater scrutiny with respect to quality than the portions used for feed, food, or industrial products.

## Production Description

Feed grain production occurs in every state; individual grains, however, tend to be concentrated in different geographic regions, depending on soil, climate, and market condition. Local demand and transport costs also influence production location through their indirect effects on prices.

### Corn

Corn is grown in nearly every state in the continental United States. The Corn Belt, however, covers approximately 12 states. Iowa, Illinois, Nebraska, and Indiana accounted for 58% of total U.S. production in 1992. Average corn acreage/farm in these Corn Belt states was 132. Average size of production was greatest in Nebraska—175.4 a. (Table 5.5).

### Grain Sorghum

More drought tolerant than corn, sorghum is produced mainly south and west of the Corn Belt. Production is concentrated in four states (Texas, Kansas, Nebraska, and Missouri), which accounted for 83% of U.S. production in 1992. The average acreage of sorghum/farm (U.S. Department of Commerce, 1989) in these four states was 114 (Table 5.5).

### Barley

Barley ranks third behind corn and sorghum as the principal feed grain produced in the United States. Production is concentrated in the northern Great Plains and in the Western Coastal States, with four states (North Dakota, Idaho, Montana, and Minnesota) accounting for 72% of U.S. production; North Dakota supplies more than 37% of total barley consumed (Table 5.5). Feed barley cultivars predominate in the Western States; malting cultivars, in the Great Plains, primarily in North Dakota. During 1992 only 21 states reported average barley production greater than 1 million bu. In contrast, corn production is distributed widely among 47 states.

Average acreage/farm in the four most important states in terms of volume produced was 120 a. in 1989 (U.S. Department of Commerce, 1989). Montana recorded an average of 198 a./farm (Table 5.5).

### Oats

Oats production is concentrated in the northern Corn Belt, with South Dakota, North Dakota, Minnesota, and Wisconsin accounting for 50% of total production in 1992. Average acres/farm for these four states was only 30, reflecting the minor role of oats in grain farm rotations. The largest production units were in South Dakota, with 68 a. planted to oats/farm (Table 5.5).

**Table 5.4. Oats: Marketing year supply and disappearance (million bu) (U.S. Department of Agriculture, 1994)**

| Marketing year | Supply | | Domestic use | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Production | Imports | Food, alcohol, and residual | Seed | Feed and residual | Total | Exports | Total disappearance |
| 1989–1990 | 373.6 | 66.4 | 91.6 | 23.4 | 265.6 | 380.6 | 0.8 | 381.4 |
| 1990–1991 | 357.5 | 63.4 | 100.9 | 19.1 | 286.0 | 406.0 | 0.6 | 406.6 |
| 1991–1992 | 243.5 | 74.8 | 107.2 | 17.8 | 234.8 | 359.8 | 1.9 | 361.7 |
| 1992–1993 | 294.8 | 55.0 | 107.2 | 17.8 | 233.6 | 358.6 | 5.7 | 364.3 |
| 1993–1994 | 206.4 | 106.8 | 109.8 | 15.2 | 192.9 | 317.9 | 3.0 | 320.9 |

**Table 5.5. United States production and acreage of feed grains in selected states, 1992**

| Grain | Rank/state | Production[a] (1,000 bu) | Production[a] Percent U.S. | Acreage[b] | Farms[b] (No.) | Average acreage/farm[b] |
|---|---|---|---|---|---|---|
| Corn | 1 Iowa | 1,903,650 | 20.08 | 10,147,051 | 83,301 | 122 |
| | 2 Illinois | 1,646,450 | 17.37 | 9,162,711 | 66,600 | 138 |
| | 3 Nebraska | 1,066,500 | 11.25 | 6,090,669 | 34,717 | 175 |
| | 4 Indiana | 877,590 | 9.26 | 4,884,114 | 45,383 | 108 |
| 4-state total | | 5,494,198 | 57.96 | 30,284,545 | 230,001 | 132 |
| U.S. total | | 9,478,914 | 100.00 | 72,144,000 | 627,602 | 94 |
| Sorghum | 1 Texas | 279,000 | 31.56 | 2,665,257 | 15,935 | 167 |
| | 2 Kansas | 244,000 | 27.60 | 3,399,564 | 32,492 | 105 |
| | 3 Nebraska | 143,800 | 16.27 | 1,300,713 | 12,576 | 103 |
| | 4 Missouri | 69,840 | 7.90 | 625,047 | 9,258 | 68 |
| 4-state total | | 736,640 | 83.33 | 7,990,581 | 70,261 | 114 |
| U.S. total | | 884,010 | 100.00 | 12,150,000 | 89,642 | 109 |
| Barley | 1 North Dakota | 172,250 | 37.75 | 2,690,972 | 20,825 | 129 |
| | 2 Idaho | 54,000 | 11.83 | 833,225 | 7,842 | 106 |
| | 3 Montana | 52,800 | 11.57 | 1,300,275 | 9,621 | 198 |
| | 4 Minnesota | 50,625 | 11.09 | 807,374 | 8,412 | 96 |
| 4-state total | | 329,675 | 72.24 | 5,631,846 | 46,700 | 120 |
| U.S. total | | 456,348 | 100.00 | 7,309,000 | 89,948 | 102 |
| Oats | 1 South Dakota | 42,900 | 14.56 | 919,997 | 13,558 | 68 |
| | 2 North Dakota | 37,400 | 12.70 | 544,907 | 25,398 | 21 |
| | 3 Minnesota | 35,000 | 11.88 | 730,864 | 25,984 | 28 |
| | 4 Wisconsin | 34,410 | 11.68 | 679,203 | 31,085 | 22 |
| 4-state total | | 149,710 | 50.82 | 2,874,971 | 96,025 | 30 |
| U.S. total | | 294,604 | 100.00 | 4,492,000 | 206,192 | 29 |

[a]U.S. Department of Agriculture, 1993.

[b]U.S. Department of Commerce, 1989.

## Summary

Production of corn, grain sorghum, and barley is highly concentrated on relatively large farms with only three or four states producing over half of U.S. production. Although some grains are fed directly to livestock on the farm where the grains have been grown and do not enter the market channel, a significant proportion is sold off of the farm and enters domestic and export market channels. The volume moving in the market channel requires a system of quality measurement to establish value. The allocation of responsibility for measuring quality and for administering grades differs with the structure and organization of the market channel and with the type of firms engaged in buying.

# Organization of the Marketing System

## The Market Channel for Feed Grains

Most feed grains entering the market channel follow a similar path from farm to final buyer. Country elevators receive grain delivered by farm trucks and wagons from farmers' fields or storage bins. The greatest volume, of course, is received at harvest. As the first-handler, the country elevator provides many of the drying, storing, cleaning, grading, and merchandising services that the market requires. Through storage, the country elevator absorbs the seasonal surge in volume and moves the grain to users as demand requires.

The country elevator generally ships the grain by truck to river and inland subterminal elevators and to processors. The subterminals assemble large-volume shipments to take advantage of low rail and barge rates to distant processors or to port elevators. Export elevators must deliver the quality and the quantity of grain on board the ocean vessel according to the time schedules and the quality specifications set by international processors. A sophisticated marketing system matches the time of delivery with arrival. Grains are purchased from many sources, transported to ports, and loaded on ocean vessels. This requires a sophisticated marketing system to enable shippers to match the time of delivery with arrival of the vessel. The export elevator also must match loaded quality with contract specifications by blending, cleaning, and selecting origins. Such matching is accomplished despite the variability of quality in grain received from widely distributed origins.

Most export contracts for feed grains are for one grade lower than that sold on the domestic market, e.g., No. 3 export and No. 2 domestic. This practice allows for quality losses such as increased breakage and damage levels common during transport and handling. Few exporters provide drying and storage, but many find it necessary to clean the grains to remove broken kernels and foreign material that otherwise would exceed limits. All export grain must be given an official grade, which usually is determined during loading by federal employees using automatic mechanical sampling devices. The few exceptions to mandated official export inspections have been ignored in this more general discussion. The USDA–FGIS is responsible for verifying that any grain loaded on the ship meets the specifications of the contract. Ship loading plans and inspection strategies are developed based on statistical principles to assure buyer and seller of equitable treatment in establishment of quality and value.

Small feed-processors may buy grain directly from farmers or country elevators and distribute it to local livestock producers. Large feed-manufacturers may buy grain through the structured market channel described. The large proportion of corn and grain sorghum production that is exported has generated a storage and transport system focused on serving ports. Domestic processors must draw grain from this system or develop an alternative, more direct channel. Some processors of food and industrial products receive grain directly from farmers.

Transportation from farmers to first-handlers uses farm trucks and wagons. From the country elevator, grain moves by truck and rail. Inland subterminal elevators shipping to processors or to port elevators primarily use rail. River subterminals primarily use barge transport outbound and truck transport inbound although some grain also is shipped in rail cars and trucks from river elevators.

A 1985 study reported that 21.2% of domestic shipments of corn moved by truck, 46.8% by train, and 32% by barge. Of corn moving to ports, 55.7% was transported by barge, 38.8% by train, and 5.6% by truck.

The pattern for grain sorghum was slightly different, especially in terms of the greater proportion shipped by truck to ports. Of domestic shipments of grain sorghum, 32.5% was distributed by truck, 47.7% by train, and 19.8% by barge. Shipments to ports were distributed as follows: 16.9% by truck, 36.4% by train, and 46.7% by barge.

The transportation pattern for oats was unique because of the influence of imports. Oat shipments to domestic points (receipts from all origins) were moved primarily by truck (57.7%); 27.3% was moved by rail, and 15% by barge.

Barley was not included in the 1985 study, but data from a 1977 study indicated that 68% of interstate receipts were transported by rail, 28% by truck, and 4% by barge. In contrast to domestic shipments, shipments to ports were nearly equally distributed between truck and rail—46.9% by truck, 48.2% by rail; a very minor share (4.9%) was transported by barge. This transportation pattern contrasts sharply with that of either corn or grain sorghum.

## Pricing Practices and Strategies

The general price level for feed grains is set on the Chicago Board of Trade (CBOT), by forces of supply and demand. Grain handlers (including merchandisers, elevators, and processors) of feed grains rely heavily on organized grain exchanges and futures markets for price discovery and information. Nearly all buyers in the commercial market channel base their purchase prices for corn and grain on daily prices at the CBOT and on price expectations heavily influenced by organized futures markets. The futures markets also provide the institution for forward contracting and hedging. Contracts on the CBOT include quantity and quality specifications, with standard discounts for quality less than contract grade. Contract grade and discountable factors are based on official U.S. grades for grain.

Daily price information is distributed rapidly over a wide geographic area to market participants, including farmers. Central price minus transportation cost and marketing margin provides a base price offered by buyers at each stage in the market channel.

Competition in the local area results in additional adjustments to the prices paid producers. This competition may take several forms. In addition to offering higher prices, elevators also may compete on the basis of service, customer loyalty, or quality-related price differentials. In most instances, discounts are applied to adjust for quality differences at each point in the market channel.

First-handlers post their bids to farmers in an open market environment in which all producers have equal access to price information. Bids to farmers by country elevator owners usually are backed by a previous sale at a fixed price or by an offsetting transaction in the futures market. Thus, much of the risk of changes in price level over time is shifted from the individual buyer to the organized futures markets. There is little opportunity for market participants to shift risks related to changes in quality or errors in measurement of quality.

In most instances, a base grade for pricing is established (usually No. 2 corn and No. 2 grain sorghum) using U.S. official grades to identify relevant quality factors. Deviations from this base generally are discounted, with discounts determined by competition in the market. Country elevators usually match their discounts to those used by buyers of their grain. This same system of base price and discount is used throughout the market channel as grain is bought and sold by farmers, merchandisers, processors, and exporters.

Whereas No. 2 is the most frequently used base for domestic purchases and sales of corn and grain sorghum, No. 3 is the most frequently used base for the export market. Normal handling and storage procedures can lower the quality of grain by one grade level. To meet the limits of export contract grade, sellers also blend grain with different quality characteristics to achieve an acceptable average quality.

Buyers in the domestic and the export markets are free to select any quality and to adjust prices within the limits allowed by competition. The distribution of corn export sales among grades illustrates the range of quality preferences exhibited by buyers (Table 5.6). Prices and premiums often are set by contract between producers and purchasers of malting barley and specialty corn. The premium is the price necessary to elicit the required supply and frequently is tied to price at the CBOT. Farmers make their decision to enter into a production contract on the basis of the premium and the profitability of alternative crops or market outlets. In nearly all instances, before adjusting the prices paid to farmers, the first-handler considers the quality characteristics identified by buyers as important in pricing strategies. Discounts frequently are tied directly to those factors in the official grades for feed grains, but each buyer is free to add specifications or to ignore grading factors.

Prices and price discounts are competitive strategies for buyers of feed grains, who are free to adjust prices within the limits that competition will allow. Competition from other firms in the market channel places effective restrictions on the range within which price and quality differentials can deviate from the average or the norm in a market region. This competitive pressure exists throughout the market channel, including foreign buyers in the export market. Price differentials (premiums or discounts) respond, to varying degrees, to the demand for a certain quality, the general quality of the crop, and the supply of each quality in the market channel.

A complex organization of private and public agencies provides price information, analysis, and management advice to farmers and to marketing firms. The USDA provides long-run price and production projections, as well as statistical information about U.S. and world markets. Local radio and television news reports provide short-term information, including daily reports of prices at local and central markets. Grain marketing firms also provide a continual flow of price information to producers and to other potential sellers and buyers of feed grains. Processors using contracts with producers often use prices on the CBOT as the base from which to set premiums, establishing prices even before the grain is planted.

**Table 5.6. Corn export sales by grade 1989–1990 (U.S. Department of Agriculture; 1990)**

| Grade | Moisture (%) | Test weight (lb/bu) | Total damaged kernels | BCFM[a] (%) | Volume (t) |
|---|---|---|---|---|---|
| 1 | 13.8 | 57.6 | 1.4 | 1.5 | 89,863 |
| 2 | 14.4 | 57.0 | 2.7 | 2.7 | 18,698,938 |
| 3 | 14.2 | 56.9 | 3.0 | 3.5 | 40,287,484 |
| 4 | 13.8 | 57.1 | 4.3 | 4.3 | 1,271 |
| 5 | — | — | — | — | — |
| Sample | 14.1 | 57.0 | 3.9 | 5.2 | 43,196 |
| Average shiplots | 14.1 | 57.0 | 2.9 | 3.2 | 59,120,752 |

[a]BCFM = broken corn and foreign material.

## Feed Manufacturing Industry

The feed manufacturing industry consists of a great number of feed processors, ranging in size from small portable mills on farms to country elevators with feed mixing operations, to large commercial elevators for which feed processing and branding are important activities, to multinational vertically integrated feed manufacturers.

According to the *Census of Manufacturers*, the 29 largest feed manufacturing firms accounted for 14% of all value added by manufacture in 1987. These 29 firms represent 2.7% of the total 1,738 firms in this industry classification. The largest 8.7% of all firms generated 34.3% of all value added by manufacturers (U.S. Department of Commerce, 1990).

Small firms obtain feed grain directly from farmers and add other feed ingredients purchased from large feed-manufacturers or from grain processors. The large integrated feed manufacturers process complete feeds, using feed grains and other ingredients selected on the bases of price and nutrient value. These firms also may manufacture protein supplements for sale to other feed millers and farmers. Some firms are integrated vertically from feed ingredients through livestock production and marketing, to retail distribution of meat products. Such vertical market control is most prevalent in the poultry industry and can reduce reliance on grades for determining value.

Large feed manufacturers select their sources for a balanced ration by using computers to identify the least costly combination. Risks of price fluctuations are reduced by using the futures markets to fix the prices of grains and of other ingredients. Grain sorghum and corn are the major feed grains used as a source of energy. Oats and barley, however, also are important ingredients in specialized rations. Feed manufacturers purchase grain from farmers or from country elevators, relying on experienced merchandisers, extensive information systems, and computerized programs to minimize the cost of feed ingredients needed to produce balanced rations. Quality is an important determinant of nutritional value, and information on chemical composition is needed to balance feed rations. Most firms, however, rely on U.S. grade factors as the only basis for price—other nutritional information seldom is obtained before the plant receives the grain.

## Wet-Milling Industry

The wet-milling industry is quite concentrated, with most of its capacity provided by multinational firms. The four largest firms (6.7% of the 60 wet corn-milling firms in the 1987 *Census of Manufacturers*) accounted for 17.7% of value added (U.S. Department of Commerce, 1990). These firms use a chemical steeping process to produce a variety of products, starting with starch as a basic output along with several by-products such as oil and feed. The starch may be converted into numerous other products including sweeteners and alcohol.

Although the wet-milling industry relies on corn as the primary source of starch, grain sorghum also is used. Sources of raw grain are determined by price and transportation costs, with least cost/unit of product a major determinant in the choice of grain and the origin of shipment. Quantity and quality of processed products depend on physical and chemical properties of each purchase. Most firms employ specialized merchandisers, whose assignment is to acquire an adequate supply of grain at a minimum cost. Forward pricing and the futures markets are used to minimize risk of price changes. Purchases are based primarily on numerical grade, although a few firms specify additional attributes or use detailed information about geographic differences in variety and quality of supplies. Quality in wet milling influences product yield but also becomes a health issue when final products enter the human food industries.

Although corn comprises most of the feedstock for wet milling and brewing, barley maltsters also are part of this industry. Malting barley has a separate set of grading standards, and stringent quality requirements often are included in contracts with producers. Blending and commingling are avoided by direct delivery from producers.

## Dry-Milling Industry

The 1987 *Census of Manufacturers* reported that 2,041 U.S. firms were engaged primarily in milling flour or meal from grain. This classification includes more than corn dry millers, with the majority of establishments also processing wheat or a combination of grains. Census data about concentration in the milling industry do not differentiate among grains, but it was assumed that the distribution of firms by size is similar for millers of feed grains and millers of food grains. The largest 40 firms (11.1% of all firms) accounted for 50% of the value added by manufacturing (U.S. Department of Commerce, 1990).

The corn dry-milling industry consists of a few large national and multinational firms, as well as a great number of small mills grinding corn for local consumption or producing specialty products. Corn is the basic ingredient for flaking grits, brewers' grits, and flour. The large dry mills use the same marketing channel and purchasing strategies as the wet-milling industry. But because the end products (grits, flour, meal, snack foods) of such mills are used primarily in the food industry, the dry mills give greater attention to quality control.

Dry mills use a variety of marketing strategies to obtain the quality of raw product required. Several contract directly with producers and specify cultivars to be grown, as well as managment, harvesting, and drying techniques. Other firms add special quality requirements, e.g., maximum allowable stress cracks, to their purchase requirements as a substitute for purchase contracts. Still others select the corn already in the market channel but merchandise any failing to meet the more restrictive quality needs. Even those firms using producer contracts rely on the futures markets for reducing risk in buying and selling and often base prices and premiums for producers' contracts on prices reported by the CBOT.

## Exporting Industry

Most firms engaged in exporting feed grains are operated by multinational companies, many of which have diversified into numerous agricultural activities. The industry is quite concentrated, with approximately 75% of the export volume moving through port elevators operated by five firms in 1989. The primary production regions are connected to the ports on the Gulf of Mexico by low-cost transportation—barge and rail offering competitive rates. Consequently, 80% of corn and 74.5% of grain sorghum exported in 1992 moved through the Gulf ports.

Most export firms also own river and inland subterminal elevators providing an integrated system of logistics. An increasing percentage of export volume is acquired through intracompany sales, whereby pricing and grading functions of a centralized market are nonessential. House grading by company employees is an acceptable substitute for the more costly official grading by licensed inspectors.

The ability to control and to determine quality accurately is extremely important to these firms because they are delivering grain into a sophisticated and discriminating export market. Grain quality must meet rigid standards, but company profits and survival depend on meeting the contract quality specifications at the lowest possible cost. Thus, accurate quality control and sophisticated cleaning and blending techniques are needed to deliver the minimum quality that will meet the contract. The objectivity and credibility of third-party inspection (such as that offered by federal employees) is important in retaining customers in foreign countries.

# Price-Quality Sophistication of Buyers

## Introduction

All the large firms processing feed grains employ sophisticated buyers with both extensive knowledge of price relations and ability to reduce costs through optimizing combinations of qualities and quantities, purchase times, and geographic locations. Many firms have quality-control departments with detailed information about the quality characteristics influencing value. When federal grades provide inadequate information, the processing sector substitutes the more costly alternative of producer contracts or firm-specific tests. To meet requirements of foreign buyers, firms in the export market channel rely on numerical grades and their own blending skills.

The discussion of quality issues related to feed grains will emphasize measurement and identification of quality characteristics required by the various users of major feed grains. Because value and quality of grains consumed on the farm where grown are entirely under the control of the grower-feeder, on-farm use usually will be excluded. Market information on quality is of minimal interest to farmers although some large farmer feeders formulating rations do obtain chemical analyses of their grains. This chapter therefore will be organized around the quality information system and the quality needs within the market channel. Quality concerns will encompass the market channel, from the producer controlling the quality at the farm gate to the final user of the raw product. Discussion of quality specifications for processed products, e.g., corn oil or corn gluten feed, will be omitted.

### Measurement of Quality in the Market Channel

#### Important Quality Attributes

The first step in establishing grades and standards with which to evaluate the quality of feed grains is to identify attributes important to buyers, processors, and users. Surveys as well as laboratory research and full-scale mill trials have provided the necessary information. Although the important attributes depend on the industry, a set of basic characteristics common to all feed grains exists. These characteristics include moisture content, *cleanliness* (or absence of foreign material or impurities) hardness, and damage. Within the market channel, any characteristic relevant to storage life is of importance to firms that may be storing the grain for either short or long periods. The time required for transport between farm and final destination (especially export destinations) will affect the extent of deterioration.

In addition to the characteristics of interest to most users, some properties are of special interest to only a few firms or to only one processing industry. In short, not all firms or industries seek the same qualities. Although chemical composition is important to several industries, significant differences exist among industries in terms of the best combination of chemical properties. For example, starch manufacturers are concerned primarily with starch content and with factors affecting recovery rate. Feed manufacturers are interested in nutritive value (energy, protein, vitamins, etc.). Wet and dry millers are interested in oil content; maltsters, in the malting quality of barley. Buyers in the export market are interested in the same set of factors that were identified in the domestic market; but breakage, molds, and storage life take on additional importance because of the extra handling and ocean transport time.

Density or hardness of corn kernels influences the yield of flaking grits in dry milling of corn but is of little importance in other processes. Method and severity of drying technology influence the yield of starch as well as the yield of products from dry milling in the corn industry. Each industry or processor often will identify a unique set of characteristics, which will be used to estimate quantity and quality of products derived from processing grain of a certain quality.

## Quality Control at Each Point in the Market Channel

A basic set of quality characteristics is measured at each point in the market channel. The number of tests and the degree of sophistication in equipment and procedures depend on the firm. Country elevators usually are the first receivers from farmers. Because elevators are not required to purchase by grade, the factors checked depend on elevator and crop year. Grade factors consistently found better than base limits may be ignored in subsequent deliveries. Extent and sophistication of quality measures increase as the grain moves through the market channel toward the final user. Most shippers clean or blend grain lots to minimize discounts and to produce uniform shipping lots.

In the case of exports, federal regulations require that all grain be inspected officially using USDA grades and standards for each grain. This regulation does not apply to purchases at other points in the market channel. Country elevators and other buyers may purchase on either official or private grades. Private inspectors, licensed by the USDA–FGIS, provide inspection services throughout the United States for commercial grain firms. But no buyer or seller is obligated to use licensed inspectors in the domestic market unless an official grade is required. House grades (inspection and grading done by buyer's or seller's unlicensed employees) are a common basis for transactions among firms with established reputations for integrity. Buyers and sellers, including farmers, have the right to request official grades from a licensed inspector. Grades given by a licensed inspector can be appealed to a regional office of the USDA–FGIS for an official grade that will supersede initial results. These alternatives provide safeguards for buyers and sellers, protecting them against errors and abuses in determining quality.

The availability of uniform grades throughout the market channel provides uniformity in the technology and the methodology used to determine quality. Although federal grades are not mandatory at the local level, their presence at each point in the market channel provides an economic enforcement that ultimately passes responsibility back to previous buyers and sellers. A buyer cannot pay full price for inferior quality without running the risk of selling the grain at less than the purchase price. Poor quality grain generally receives a discount at the first point in the market channel where the damage is detected.

## Grades and Standards

As indicated, quality is a much broader concept than either grades or standards. In the grain industry, great volumes must be traded on the basis of descriptive information, and thus uniform grades and standards are essential to efficient operation of the market. Current grades for corn (Table 5.1), grain sorghum (Table 5.2), barley (Table 5.3), and oats (Table 5.4) were established by the USDA and have been in operation for many years. All four grade tables have unique characteristics as well as several factors in common. All include a measure of damage and a measure of foreign material. Moisture is not a grade-determining factor but must be reported on the official certificate.

Grades for U.S. grains are based on what is known as the "lowest-factor approach," whereby the numerical grade assigned to a sample of grain is determined by the factor with the worst quality. For example, a sample of corn in which broken corn and foreign material (BCFM) exceeded 5% (See Table 5.1.) would be assigned a grade of No. 4 even if all other factors met the standards for No. 1. One characteristic of the lowest-factor approach is that it provides opportunities for blending and upgrading different lots of grain. For example, a sample of corn with 1% BCFM and 5% damage could be blended with an equal quantity of corn with 5% BCFM and 1% damage. The two lots separately would both grade No. 3; when blended, they would both grade No. 2.

Inspection and testing of scales and moisture meters used in grading grain generally are the responsibilities of state agencies, except when buyers and sellers use federal grades. Enforcement policy and calibration method differ among states. For example, calibration charts for the official USDA–FGIS moisture meter are created and enforced by the USDA–FGIS whenever the meter is used in an official grading activity. Other brands of meters, however, may be used in commercial trade and need not be approved by federal agencies. State departments of agriculture usually have the authority to inspect and to license moisture meters, but testing methods and calibration procedures differ from state to state. Equipment for grading and procedures for measuring quality other than moisture seldom are tested by government agencies.

The authority for grades for feed grains comes under the U.S. Grain Standards Act (GSA) of 1916 as amended. The USDA–FGIS was created in 1976 and given the authority for development, inspection, enforcement, and periodic review of U.S. grain grades and standards. Industry associations and producer organizations as well as processors and others participate in reviewing changes in regulations pertaining to grain grades, but the ultimate authority rests with the USDA–FGIS[12].

The U.S. GSA provides the regulatory authority for grades and standards for U.S. feed grains. The original legislation for this act was the culmination of nearly 50 yr of development and negotiation among private traders. Before the existence of organized markets, grain usually was sold after a personal inspection of the lot or a representative sample.

As the volume of trade—both domestic and foreign—has increased, the need for descriptive terminology to supplement or to replace physical inspection of every lot of grain sold also has increased. Industry groups first developed their own private grades and grading systems. These gradually were replaced with grades established by boards of trade, grain exchanges, and state governments, to limit inequity, inconsistency, and fraud in grading and pricing (Hill, 1990). Although these entities broadened geographic uniformity, their efforts still fell far short of meeting the need for national uniformity in grades and inspections.

In 1913, the powerful National Feed and Grain Association conceded that uniform grades on a national scale were unachievable without some type of federal legislation (Hill, 1990). After years of frustrated efforts to develop voluntary grades, the association shifted its support to legislation authorizing federal grades and standards and federal supervision of private inspection agencies. A compromise between federal inspection and federal supervision was included in the 1916 appropriations bill in a section entitled the U.S. GSA. This act has been modified several times since 1916; most significantly in the 1976 amendment creating the USDA–FGIS and the 1986 amendment introducing the concept of measuring end-use value into the purposes of grades.

In addition to the amendments, many regulatory changes have been made in the grades themselves. These have ranged from changes in the definition of terms to significant changes in the factor limits and the factors included. Standards for corn were created in 1916, standards for grain sorghum in 1924, standards for oats in 1919, and standards for barley in 1926.

The 1976 amendment to the GSA required that the USDA–FGIS review the standards for each grain every 5 yr. But pressure from producer groups, trade organizations, and foreign buyers often results in review of specific issues on a more frequent basis. The grain standardization division of the USDA–FGIS continually reviews and evaluates grades and standards for feed grains in an attempt to identify opportunities to improve operation of the grading system.

[12]In 1995, the FGIS and the Packers and Stockyards Administration were reorganized into the Grain Inspection and Packers and Stockyards Administration. FGIS has been used throughout this report for purposes of simplicity and consistency.

## Measurement Technology

Quality determinations require careful definition of each quality factor and technical specification of the equipment required to measure quality. Clearly, the more objective and quantitative these measures, the more uniform and consistent will be the quality determinations and the more valuable the information. Factors such as moisture, test weight, and BCFM have been mechanized and standardized for many years. They are quantitative and objective in nature and, for the most part, independent of inspector competence and experience. But for characteristics such as odor and damage, the procedure is far less objective and requires sound judgment on the part of the inspector.

Research and development continues to be directed toward improving objectivity and quantitative measures independent of the person performing inspection and analysis. The technology for measuring quality characteristics of economic interest is available commercially for many physical and chemical properties of grain. But the cost and time required for testing and the need to operate testing equipment under conditions found in most elevators and processing plants make many quality-determination technologies impractical.

For example, chemical composition and nutritional characteristics of feed grains can be determined accurately and easily by equipment available in most laboratories and in many feed processing firms. But these technologies have not been developed to the point at which they can be used accurately and inexpensively by elevator operators purchasing grain from farmers. On the other hand, new technologies have been developed that show promise for use in commercial channels, even at the country elevator level. Both improved technology for measuring moisture content of grain and NIR spectroscopy for measuring oil and protein content are being used by many processors and by some grain elevators and first-handlers.

## Price-Quality Relation

Each stage in the market channel for feed grains attaches price differentials to grain of different qualities and conditions. Certain factors such as moisture are measured and incorporated into price differentials each time that grain is bought and sold. Other characteristics such as damage or foreign material may be exempted from measurement, particularly at the country elevator, when experience indicates that most grain will meet the base grade limits for those factors. To avoid assessing discounts to a few farmers, some country elevator managers also average above- and below-average qualities among loads for the same farmer, and sometimes even among farmers. The manager can avoid discounts when selling poor quality grain if the commingled grain meets the minimum quality standard of the buyer.

But averaging among sellers eliminates incentives to improve quality. "Quality averaging" can be used as a competitive marketing strategy because it allows the buyer to offer all farmers full base price even though some grain is below base quality. Farmers delivering grain with quality better than the base level provide the buyer with the grain needed for blending with below-base quality grain. Although such blending allows the local elevator to pay average prices to all farmers, it treats farmers with different quality grains inequitably and weakens the incentive to improve quality.

Price-quality relations are established by the market and vary over time and among locations. For the most part, discounts in the final market (processing or export) get passed back through the market channel to river and inland terminals, country elevators, and farmers. Local conditions of above- or below-average quality provide incentives and opportunities for individual marketing firms to purchase grain at discounts greater than those elsewhere in the market channel.

For example, a country elevator manager receiving an unusually large quantity of dry grain might reduce drying charges and discounts for wet grain to attract a larger volume, knowing that blending can be used to meet minimum standards. High levels of foreign material in a certain area may result in the need for cleaning by owners of elevators in the region. The managers' response would be to increase discounts to cover costs of cleaning and to encourage delivery of clean grain. Grades and standards identify and describe characteristics evaluated in the market channel, but supply and demand of different qualities create the market forces determining price differentials.

## Issues and Problems Related to Quality

High quality is preferred to low, but depending on the price differential, high quality is not always the most economical choice. Thus, evaluation of alternative strategies for improving quality must take into account costs and benefits.

Grades and standards in official channels have been provided to generate information to assist buyers and sellers in determining value and setting price. Two longstanding questions are whether current grades identify the most important set of characteristics for describing value to each of the different users and whether definitions attached to grade factors in the official grades provide the necessary information for decision makers. As processing firms become more specialized and sophisticated, more information is needed than is offered in official grades. The cost of providing additional information throughout the entire industry, however, may exceed the benefit that would accrue to a small segment of the feed grain sector.

Uncertainty about the economic impact of altering quality has led to heated debates. The issue receiving the most publicity has been the effect of quality on U.S. market share for feed grains. As early as 1918, Congress was holding hearings on the damage that poor quality grain in the export market was doing to sales abroad (Hill, 1990). Although decreased export volume often has been evident, it is extremely difficult to quantify the relation between export quality and either the quantity purchased by various consuming nations or the U.S. market share.

Numerical grades do not provide all the important information desired by processors. Specification buying, through which buyers list in contracts those characteristics, definitions, and factor limits of concern to their firms, provides an alternative or a supplement to grades in domestic and export markets. Contract specifications of quality tie buyers to individual sellers and may nullify advantages of the large-volume, low-cost marketing channel that has developed in the United States. Specification buying in the export market may be more effective as a supplement to official grades than as a substitute, for the law requires official grades on grain exported from this country.

Specification buying also facilitates reliance on long-term bilateral agreements between firms and nations. Its effects on competition, market structure, and marketing efficiency must be evaluated in the context of the sometimes conflicting roles of governmental and private quality-specifications. Simple, uniform, universally accepted grades provide the greatest efficiency in terms of buying and selling large volumes of products and in terms of assembling large lots that can be sold and resold in the process of arbitrage over time, form, and space. On the other hand, private-brand specification relies on contractual arrangements, provides additional information, and gives buyers and sellers more accurate information for estimating value. Private brands or grades provide advantages to individual firms and enhance their bargaining positions, but the cost of this benefit is less efficient communication in the market.

Grades and standards theoretically are neutral in terms of economic impact. In practice, however, the structure of grades and standards and the characteristics included as factors create incentives and disincentives for practices that affect quality. The lowest-factor approach to grades generates a strong incentive for blending high-quality with low-quality grain. Wide spreads between factor limits from one grade to the next encourage sellers to blend grain to meet the lowest acceptable quality meeting grade limits. Grade factors that are universally recognized and assigned price-quality differentials create incentives for each seller at least to meet the grade limit that will avoid discounts. The absence of certain characteristics from grades creates an incentive to reduce the quality of that characteristic or at best to provide only average quality when characteristics are neither measured nor priced in the market channel.

The market seldom pays premiums for quality above the base standard in feed grains. Price bids sometimes are increased for individuals delivering exceptional quality or for geographic regions with above-average quality, but explicit premiums seldom are published in the commercial market. Exceptions to this rule occur, especially in the food grade markets or for other specialty uses.

Discounts, generally assessed only on factors included in grades, may range from zero to several ¢/bu, depending on the relative supplies of high quality and low quality grains. For example, in crop years during which the crop is unusually clean, first-handlers may ignore foreign material levels and assign no discounts or overlook an occasional low quality load. In years in which level of foreign material is unusually high, demand for clean grain for blending is great. In such years, discounts for foreign material may run \$.02 or \$.03/bu for each percentage point of foreign material above the base. A similar situation exists for damage. In years in which damage levels at harvest or when delivered out of farm storage are unusually high, the price differential between grains of low and of high damage levels is increased through greater discounts.

Proposals for changing the grades for feed grains have been focused on five basic questions differing in relative importance among the four grains.

1. **How many numerical grades are needed?** There are five grades for corn, feed barley, and wheat; four for grain sorghum and oats; three for

malting barley. There are separate sets of grades for feed barley, two-row barley, and six-row barley. No criteria have been established for determining the optimal number.

2. **Which factors should be used for determining grade?** Many attributes are associated with quality, and the relative importance of each attribute differs among grains and among uses. The 1986 Grain Quality Improvement Act (GQIA) emphasized the importance of identifying end-use value. New technology has expanded the range of quantifiable attributes that can be correlated with the yield of final products. Guidelines are needed to help select the set of grade-determining factors from the many potential attributes.
3. **What are the most useful and workable definitions of the attributes selected for official grades and standards?** Official definitions must describe the attribute and the measurement technology. For example, the definition of *BCFM* must include sieve size and mechanical separation techniques. The definition of *damage* must include the classification criterion used to determine whether a kernel is *sound* or *damaged.*
4. **For each factor, what are the appropriate limits that will differentiate among grades?** Factor limits for most grains have been changed several times. No rationale has been found for selecting any one set of limits or distance between grades.
5. **How can grades be used to generate economic incentives for improving quality?** Current grades are criticized for failing to provide incentives to produce maximum or even optimal quality. Some incentives encourage practices conflicting with good management strategies. For example, because 15% moisture is the basis for pricing corn, there is an economic incentive to store at 15% moisture despite the increased risk of mold growth. Grades and price differentials are combined in market transactions to generate economic reward or punishment. Managers respond by changing practices that influence quality.

### Information Dissemination

Price and quantity information relevant to the feed grain industry is distributed widely by means of public and private agencies. Historical data are readily available, as are projections and estimates from government, university, and private agencies. Organized futures markets such as the CBOT continually provide market information broadcast through the mass media to producers and to marketing firms. The feed grains market is influenced strongly by international economic conditions. Many information sources provide detailed reports on crop and market conditions throughout the world. Universities provide information through meetings, newsletters, and multimedia programs for use by farmers and by grain marketing firms making decisions about production and marketing.

Numerous trade organizations and farmer supported organizations also provide information and educational programs. Because feed grains tend to be generic products, seldom differentiated in the market channel, private brand promotion is difficult and rare. Generic promotion and market development, however, are important expenses in the budgets of both farm and trade organizations. For example, the U.S. Feed Grains Council, in conjunction with the USDA–Foreign Agricultural Service (FAS), invests heavily in market development programs throughout the world.

Information about grain quality is made available through several sources. Country elevators distribute discount schedules to customers and often post prices and discounts in their offices. During unusual growing seasons, quality concerns such as disease or aflatoxin are made known through government, public, and private news releases and reports. The USDA–FGIS also publishes export-grain and crop-quality reports based on information obtained from records of official inspections in the market channel. To provide information on the quality characteristics considered in official grades and standards, the USDA–FGIS also conducts surveys during the first weeks of harvest. Prices for feed grains in cash and futures markets generally are quoted on the base quality, e.g., No. 2 corn and grain sorghum, but no systematic method is in place for reporting discounts and price differentials for quality during the marketing season.

Additional quality information is distributed by several universities that conduct surveys to determine averages and ranges of quality discounts for the previous crop year (Bekric and Hill, 1991).

## Anticipated Industry Changes That Will Influence Quality

### Demand for Differentiated Characteristics

Only minor changes will be made in the quality requirements of feed grains to be processed into animal feed. Increasing the quantity of corn and sorghum used for food and industrial products, however, creates new demands for differentiated characteristics. The primary end-uses for feed grains will continue to be livestock, wet milling, and dry milling. But use of feed grains in the snack-food industry is increasing (albeit from a small base), and snack-food and specialty uses require ever more sophisticated specification of quality characteristics. Starch manufacturers are exploring genetic differences as an alternative to chemically altering starch molecules to meet specialty needs. To maintain control over quality, many dry millers include quality measures beyond current grade factors in contracts with producers. Exporters also are demanding higher quality, adding new nongrade factors to their contracts, and specifying lower limits on moisture and other defects.

## Changes in Production

Major changes in the quality of feed grains harvested from U.S. farms come slowly in terms of significant differences in the total crop. Genetic research to change the intrinsic properties of grains must be followed by commercialization that could require several years. Even with new commercial cultivars available, farmers will shift only slowly from current practices and cultivars. Changes come in small increments as new market opportunities and demands dictate. The number of cultivars with characteristics tailored to specific uses has increased recently, and it is anticipated that demands by processors and by consumers of feed grains likely will lead to proliferation of specialized cultivars. For example, the specialized quality needs of dry millers have induced several plant breeders to commercialize hard endosperm genotypes. Maintaining the identity of these unique characteristics in the commercial market channel will increase marketing costs.

## Changes in Marketing System and Industry Organization

The traditional market channel—from farm to country elevator, to subterminal, to processor—will continue to handle most feed grains. The importance of direct farm to processor contracts, however, will increase, creating a market channel that often will bypass the traditional country elevator as well as the grading system now used as the basis for pricing in the market channel.

Contract production is increasing in those markets requiring special characteristics that are not easily measured. Where vertical coordination and integration among producing, marketing, and processing firms have increased, reliance on official grades has decreased. Milling industries are expected to increase vertical ties. Vertical coordination also has increased in the export marketing channel as domestic, foreign, and multinational firms, in efforts to facilitate logistics and to ensure adequate supplies for delivery on time-specific contracts, purchase country and river elevators in production areas. Identity preserved (IP) shipments bypassing the traditional market channel provide full control of quality without relying on grades. In this manner, the volume requiring official inspection is reduced, which in turn increases inspection cost/bu for grain moving through the traditional channel.

Because of the economies of scale and the multinational nature of processing, firm size and industry concentration are increasing, and marketing and processing are being controlled by fewer and fewer firms. This trend likely will continue. The feed industry itself increasingly will be divided into two categories: (1) the many small firms that will remain small, providing services to farmers in grinding and mixing grains and (2) the large national and multinational feed firms that will provide feed for wholesale and retail distribution throughout the United States and the world. The latter firms will continue to gain market share, and industry concentration and vertical integration will increase.

Processing industries using feed grains for food and industrial products generally are large and multinational in scope. Nonetheless, certain new entrants in the snack-food industry and several old and new firms with specialized skills and market niches will continue to compete effectively in the world of the "giants." The total volume of feed grains used in food industries and the impact on quality from these new entrants will be minor and limited to small geographic regions or specialty markets.

The price discovery and dissemination system for feed grains in the United States is effective, well organized, and efficient. Major changes in the organizational structure of the industry providing information to farmers and marketing firms are unlikely. An increase in the number of professional advisory services to analyze this market information and to convert it into decision making advice for farmers and marketing firms may occur. The complexity of marketing and pricing may encourage specialization of firms devoted to understanding and interpreting the markets. Increased use of producer contracts by foreign processors has created a niche for a new group of entrepreneurs who supervise production and marketing of specialty grains and who, by supplying seed, testing chemical composition, and preserving identity throughout the market channel, ensure quality for foreign buyers.

## Characteristics of Product Demand

Traditional processing firms for feed and industrial products are becoming increasingly sophisticated in their demands for specialized characteristics. The starch industry, for example, continues to develop new cultivars of corn in which the chemical structure of the starch molecule closely fits the requirements of each of the many products in which starch is used. This fit makes conversion of starches from one molecular chain to another after extraction unnecessary.

Specialized demand for characteristics in the raw grains undoubtedly will increase in other industrial processes. The development of high-lysine corn, high-protein and high-oil corn, and low-tannin grain sorghum also will continue, requiring additional information on the chemical and physical properties of feed grains. Similar information will be required throughout the market channel, from the first-handler to the final processor or the consumer. An alternative scenario is an industry structured on contracts and vertical integration, with grain identity maintained from planting through final use.

The export market has the same characteristics as the domestic market in terms of the kind of processors and the sophistication of buyers. The domestic-export ratio will change from year to year as competition from other countries and price-quality relations change, but the export market will play a dominant role in setting price and quality. Exports will be essential to maintaining farm income, and competition with other exporting countries for market share will keep the congressional focus on quality.

## Quality Identification

The largest market for feed grains is the feed manufacturing industry, whose primary quality concern is nutritional value. Attributes readily measurable for corn, grain sorghum, barley, and oats include starch, protein, moisture content, and damage. Surveys, interviews, and research have demonstrated the importance of these measures of quality. Additional nutritional information often is desired, but under current technology, this information cannot be obtained economically in the commercial market channel.

Wet millers are interested in starch and oil yields, both of which are influenced by chemical composition, whole kernel percentage, and drying temperature. Dry millers' product yields can be estimated from kernel-hardness or -density measures, internal checks or stress cracks, and whole unbroken kernel percentages. The malting industry specifies protein, germination, and acceptable malting cultivars in many of its producer contracts.

The measures of quality considered important to processors and to end users must be converted into economic signals in the marketplace. This requires rapid, accurate, and repeatable measures that can be implemented in purchases from farmers. Descriptive information obtained at the processor's plant may be useful to the plant manager but will not influence delivered quality unless information and appropriate price signals are conveyed to producers.

National grades and standards will continue to be the primary basis on which price and quality differentials are established. An increasing number of processors, however, will demand supplemental information on attributes not provided in grades. The responses may be to incorporate additional characteristics into grades and to develop more private agencies offering specialized testing services. Increasingly detailed specifications in export contracts and increased use of contracts with producers will supplement information provided by grades.

Measurement technology must progress simultaneously with demand for new information. A quality characteristic cannot be incorporated into the pricing structure unless measurement technology is available to allow identification of quality differences at the point in the market channel where control can be exerted. Preferences for genetic quality differences must be reflected back to the producer and the plant breeder before change will occur.

As measurement technology and industry sophistication develop, demand will increase for information about quality characteristics not cited in grades. In response, the market will begin to reflect value differences in price-quality relations. These changes will occur slowly if research and introduction are left entirely to the market. Competition limits the ability of an individual firm to institute a different system of premiums or discounts. Grades and standards are beneficial in the aggregate to an efficient marketing system; they are much less so to an individual firm taking independent action. Therefore, changes in grades must be coordinated across the industry to introduce new grading factors or new quality-price relations for all firms simultaneously.

# Quality-Related Needs and Opportunities

## Impediments

Although *maximum quality* is an elusive concept seldom consistent with economic principles, *improved quality* is not. But the cost associated with improving quality must be balanced against economic and aesthetic benefits. Moreover, cost is only one of several impediments to improving the quality of feed grains.

Practices and techniques for certain types of quality improvement are well known. Implementation of these practices, however, is limited by absence of economic incentives. Firms have established cultivars, production and harvesting techniques, and handling, drying and storing practices in response to environmental and economic conditions. Thus, even if no additional costs were involved, without incentives, producing and marketing firms would resist change.

Grades and quality standards, together with price differentials, provide many of the incentives or disincentives for quality improvement. For example, a base grade limit of 3% BCFM for discounts on corn has resulted in a disincentive for producers to deliver corn with less than 3% BCFM even though the technology to deliver clean corn is available. In a recent survey in Illinois, Iowa, and Indiana, 10% of farmers admitted that they adjusted harvesting and cleaning practices to deliver the greatest amount of BCFM possible without receiving discounts. Marketing firms also use cleaning and blending strategies to bring shipments to the lowest quality still meeting contractual requirements. Grades, in combination with market price differentials, send a clear economic signal. Farmers and marketing firms respond to such a signal, and quality is determined by the aggregate effect of individual actions.

Quality characteristics included in uniform grades are incorporated easily into price negotiations. Quality factors not in grades but of interest to individual buyers and sellers can be incorporated contractually, but only at a significant increase in transaction cost. Locating supplies of feed grains exhibiting unique qualities can be prohibitively expensive when the information about quality in each region is unavailable and must be created by the firm desiring the specialized qualities.

Communication about value is facilitated by uniform grades and standards. But supplemental or alternative channels of communication have been developed. Identity preserved transactions control feed grain quality, from selection of the cultivar through the entire market channel. The identity preservation strategy includes containerization at the farm or at the first-handler, where the identity still is known. The cost of such IP shipments includes that of contractual arrangements, special storage and handling, and sacrificing potential benefits associated with alternative sources of supply. Price risk is increased in that contract prices generally do not move in concert with market prices. Nevertheless, IP contracts are accounting for an increasing volume of feed grains when the increased value of special processing characteristics justifies the cost.

The 1986 GQIA and Title XX of the 1990 farm bill clearly require the USDA–FGIS to address the issues of incentive, cost and benefit of quality change, and incorporation of characteristics reflecting value in processing or consuming feed grains. The effectiveness of this legislation will depend on the response of farm and industry and on the degree to which the value of the information generated exceeds the cost of obtaining it.

## Alternative Solutions

In some instances, quality of feed grains can be improved with no increase in cost. For example, some genetic changes in quality could be made without sacrificing yield but would be lost by blending. Many changes generally associated with increased quality, however, can be achieved only by increasing costs of production and marketing. Incentives therefore are essential to stimulate change influencing quality.

Incentives may be regulatory or economic. The former include prohibitions such as those against reintroduction of foreign material in grain under the 1986 GQIA. Grade changes frequently have been introduced as a regulatory effort to improve quality. The lowering of limits on BKFM in grain sorghum is an example. But grade changes generally influence quality indirectly through actions by the market. Only if grades are associated with price differentials do they influence actions by producers or by marketing firms. The most notable exception to this statement is found in the export market, where use of official grades is mandatory.

Economic incentives are developed most effectively by a competitive market seeking profit opportunities. But competitive markets still operate under rules and regulations established by society and government. Although grain buyers are not forced to use federal grades or grading factors, in the domestic market the presence of these rules encourages the use of uniform grades in the application of discounts. Imposition of user charges discourages the use of official grades and federal inspection personnel. The convenience and the efficiency of a single uniform standard take precedence over private benefits of product differentiation based on customer preferences. Policies and standards established by the government are not neutral descriptors of quality and value—they become the normal basis for trade, and significant distortion of market forces is required before the uniformity of federal grades will be abandoned or overridden by private firms' own quality measures.

# Glossary

**Cleanliness.** Absence of foreign material or impurities.

**Feed grains.** Corn, grain sorghum, barley, oats, etc., used in the diets of livestock. Wheat also is used, depending on relative prices.

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# 6 Wheat

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## Introduction

The term *quality* has a unique meaning for each segment involved in the production, processing, and use of wheat. To the producer, *quality* signifies high yield, tolerance to a broad range of agronomic conditions, and resistance to disease and insects; to the grain trader, it means cleanliness and conformance to grades and standards. The miller views *quality* in much the same way as the grain trader does, but also considers *millability*, or the ability to be processed efficiently from grain into flour by existing equipment. The end user views *quality* as the functional performance of wheat that has been milled into flour or other products: soft wheat quality is judged on the basis of flour performance in cakes, cookies, and crackers; hard wheat quality, on that of breadmaking.

Wheat has a wide variety of uses in addition to flour, e.g., animal feed, industrial products such as alcohol, and exports such as grain or further-processed products. By-products from flour milling also are used in feed and food products.

Wheat quality is influenced by a number of factors, including varietal genetic background, soil, growing climate, drying, storing, and handling. Quality therefore differs from lot to lot and from season to season, even for a given cultivar.

## Major Uses of Wheat

Almost all wheat is milled into food. Some wheat, of course, is produced for seed, and relatively small quantities are used for animal feed. Nonfood industrial applications of wheat include wallpaper paste and wheat starch fermented for ethanol.

### Milling

Wheat generally is milled into either whole wheat flour or white flour. The entire wheat kernel, including bran coat, germ, and endosperm, is included in the former. Although the modern mill separates these fractions during milling, sifting, and remilling, all fractions (or "streams" in the mill) are recombined to yield a flour with all components of the kernel present in the same proportion as in the grain. White flour is produced by separating endosperm fractions from bran and germ during milling and sifting. As much as 72 to 80% of the wheat kernel can be separated into white flour. Levels above 80% generally contain some bran fractions, which discolor the flour with their brown or red specks. People in some parts of the world desire this bran-containing flour and deliberately mill to a level of 85 to 90% of the kernel.

The mill streams containing bran and germ often are sold as animal feed. More and more bran, however, is being sold for food use because consumers are increasingly interested in the added fiber that bran-fortified baked products and breakfast cereals contribute to the diet.

Some wheat milled into particles larger than those found in flour is marketed as "cracked" or "crushed." Some wheat is milled into a coarse granulation and sold as "farina" for hot breakfast cereals or as semolina for pasta. These products generally are white flour products.

Health concerns and eating habits of consumers boosted per capita consumption of flour from 110 lb in the early 1970s to 135 lb in 1990. Milled wheat products are used in a wide variety of processed foods, including breads, rolls, buns, cookies, cakes, crackers, doughnuts, pretzels, pastries, bagels, tortillas, pastas, and soups. These food uses of wheat account for greater than two-thirds of domestic disappearance and amount to more than half a billion bu (13.7 Mt [million metric tons]) of wheat.

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### Feed

Wheat used for animal feed has ranged from less than 3% to more than 18% of domestic disappearance but has averaged approximately 10%. The amount of wheat moving into the feed market depends in large part on the wheat-corn price ratio. As this diminishes, wheat becomes price competitive with other feed grains, and additional wheat finds its way into animal rations. A more certain amount of wheat is fed to animals each year, but this amount often is a result of local supply and demand conditions.

### Carryover Stocks

Carryover in the United States was approximately 225% of domestic requirements in 1960. This caused low prices and led to strengthened price support and export programs. In the early 1950s and the mid-1970s, carryover decreased precipitously to only about half of domestic requirement. Carryover stocks and government programs have been responsible for some of the quality problems to be discussed.

### Exports

The export market is essential to utilization of the increasing amounts of wheat harvested each year. The percentage of total crop exported has averaged from 60 to 65 but changes substantially from year to year. Approximately 90% of wheat exported is whole grain; the remainder is flour.

## Production Characteristics

The United States, producing about 13% of the world's wheat, harvests about 60 Mt annually. The six major classes of wheat produced in the United States are grown in distinct geographic regions. Hard red winter wheat accounts for about half of U.S. production and is grown primarily in the Central Plains states of Kansas, Nebraska, Oklahoma, and Texas. Hard spring wheats (hard red spring and durum) account for about 23% of production (18 and 5%, respectively) and are grown in the North Central Plains states of Minnesota, Montana, North Dakota, and South Dakota. Soft white wheat (12% of production) is grown in the Pacific Northwest states of Washington, Oregon, and Idaho; and soft red wheat (16%) is grown primarily in Illinois, Indiana, Ohio, and Missouri. The new class of hard white winter wheat is being grown on limited acreage, primarily in Kansas. In recent years, California and the southeastern United States have emerged as new wheat-producing regions, producing both hard and soft cultivars. Kansas is the leading wheat-producing state, as can be seen in the listing of percentages of U.S. production by state (Table 6.1).

Increased mechanization made possible, if not necessitated, the move to fewer but larger farming operations. The number of farms in Kansas, for example, decreased from about 135,000 in 1950 to about 70,000 in 1985. Fewer than 50,000 are projected for the year 2000. The average size of Kansas wheat farms increased by more than 10% in just 5 yr (1980 to 1985). There is, however, considerable variation in farm size from one region of the country to another. The average farm in Minnesota, for example, is 317 a.; in Montana, it is more than 2,500.

## Marketing System Organization

### Overview of the Market Channel

The private sector of the grain trade plays the major role in directing the movement of wheat through marketing channels. But the federal government is involved in grain storage through the Commodity Credit Corporation (CCC) and in export marketing through a variety of programs and activities.

#### Country Elevators

Approximately 82% of wheat harvested by farmers moves directly from farm to country elevators. Inland states such as Montana and the Dakotas move most of their wheat through country elevators because there are no terminal collection points for transfer to export markets or for sales to large domestic users. In states in which terminal elevators are available, less grain goes first to country elevators than directly to terminals.

Approximately 10,000 country elevators exist in

**Table 6.1. Leading U.S. wheat producing states**

| Rank | State | Percentage U.S. production |
|---|---|---|
| 1 | Kansas | 19.2 |
| 2 | North Dakota | 11.8 |
| 3 | Oklahoma | 10.1 |
| 4 | Washington | 6.4 |
| 5 | Texas | 5.5 |
| 6 | Montana | 5.4 |
| 7 | Minnesota | 4.2 |
| 8 | Nebraska | 4.0 |

the United States. The number of privately owned country elevators has decreased, and the number owned by cooperatives or large grain-firms has increased. Thus, cooperatives and large grain-traders have been put in the position of owning wheat from the time it leaves the farm until it is sold to domestic processors or is loaded onto a ship for export.

#### Subterminals

Subterminals represent a fairly new development in grain handling. Subterminals replacing old or obsolete country elevators offer high-speed loading and at times ancillary services such as origin weights, origin samples, and cleaning facilities to meet grain grade specifications.

Subterminals usually are located along rail lines so as to take advantage of multiple- or unit-car rates. Usually owned by multinational U.S. grain companies, U.S. cooperatives, or foreign investors, subterminals are larger than country elevators and can load 50- to 100-car unit trains at a rate of 20,000 to 30,000 bu/hour (hr).

#### Terminals or Grain Centers

Fifteen prominent U.S. grain centers handle about 33% of off-farm sales through terminals operated on their premises. Much wheat destined for export bypasses these terminals and moves directly from country elevators or subterminals to port facilities.

Grain merchandisers and brokers are headquartered in terminal markets and facilitate assembly and flow of wheat. Merchandisers take title to grain; brokers do not. The roles of grain merchandisers and brokers in the marketing of wheat have diminished in recent years because of the vertical integration of grain companies and the expanded regional marketing activities of cooperatives.

#### Processors (Millers)

Two decades ago, a reversal in the downward trend in per capita flour consumption in the United States revitalized the U.S. wheat milling industry. The number of flour mills in the nation continues to decrease although industry milling capacity increases. The firms involved in flour milling have become larger through both acquisition of existing plants and growth of new entrants. In 1991, the largest three flour millers in the United States accounted for approximately 60% of flour milling capacity. Many of the principle flour millers have been or still are involved actively in wheat origination. Additionally, flour-milling operations are locating ever closer to the nation's population centers.

#### Export Elevators

Six large companies handle most U.S. wheat exports. Nearly all firms are multinational; are integrated vertically; and have inland terminals, subterminals, and country elevators. These companies thus control wheat exports from farm to final use.

#### Wheat Transportation

A comprehensive survey of wheat shipments in the United States indicated a sharp increase from 1977 to 1985 in the demand for transportation services for wheat (Reed and Hill, 1990). This increase was attributed to increasing inland-wheat production and to rail industry deregulation. Inland states require additional transportation services to move production to market. But because deregulation lowered rail rates, it became profitable to ship more wheat farther.

The survey indicated that about 52% of intrastate wheat shipments were made by truck and about 46% by rail. For interstate shipments of wheat to destinations other than ports, about 61% were by rail, 31% by truck, and 8% by barge. For shipments to ports, about 63% were by rail, 9% by truck, and 28% by barge.

## Pricing Practices and Strategies

#### Price Discovery

Price discovery for wheat occurs in the United States through the interaction of cash and futures markets. Information on current and anticipated world supplies and weather conditions, along with that on current and anticipated world demands, is available widely through public and private sources. Traders use this information to arrive at prices for wheat currently in the cash or the futures markets. Large profit (or *arbitrage*) opportunities, developing as cash prices change relative to futures prices, quickly are bid away as traders respond. The same is true as cash prices in one region change relative to those in another.

The price discovery process for wheat is influenced heavily by government programs. Using loan rates and storage or buffer stock programs for wheat, the government sets price floors in the market. Such programs support price by subsidizing wheat storage when cash market prices are below a certain threshold. Farm programs also set target prices to support farm prices without changing market prices for wheat directly. If market wheat price falls below target price, eligible producers receive a check for the product of price difference and wheat for sale.

Government programs also include provisions for reducing wheat acreage by making eligible for benefits producers taking a certain percentage of wheat acreage out of production. But controlling wheat acreage is a rather ineffective means of controlling production inasmuch as producers find it profitable under acreage controls to apply additional fertilizer and to adopt high-yielding wheat cultivars, thus increasing yield/a.

#### Producer Prices and Price-Quality Differentials

Wheat price is affected directly and indirectly by the government's Export Enhancement Program, which subsidizes wheat or wheat flour exports to target countries. Increasing demands for wheat and flour translate into potentially higher wheat prices.

The wheat price that farmers receive at country or terminal elevators usually is stated as a base price plus premiums less discounts. Base price changes as prices in cash and futures markets change. Discounts typically are applied to easily measurable characteristics such as test weight and moisture content. With improvements in technology, many elevators are measuring protein content and, given market demand, are paying premiums for high-protein wheat. Certain premiums and discounts change over the year; others remain relatively stable. Country elevator managers may base premium and discount schedules on those of terminal elevators where they likely will sell their grain. For a variety of reasons, some country elevator managers pay no premiums or discounts but instead use station average pricing. This method, which involves estimating the average wheat quality in the firm's trade area and paying each farmer approximately the same price for wheat, tends to dampen price signals for quality.

Wheat is segregated according to class at the country elevator. This procedure is essential to the orderly marketing of wheat because different end-users require different wheat classes. Thus, some wheat is segregated according to protein level. Segregation according to cultivar is rare although interest in the potential advantages of IP wheat marketing continues.

On occasion, milling companies have contracted with producers for selected cultivars to use primarily as blending wheats. Blending of cultivars can minimize fluctuations in quality from year to year. And in the spring of 1991, a major milling company announced that it was paying a slight premium to producers for a specified cultivar of wheat desired by a large, national wholesale baking company. The new hard white winter wheat is being marketed by identity preservation through an association controlled by producers.

#### Price-Quality Adjustments in the Export Market

Price and quality adjustments for export wheat depend on the country. Some countries have state buying-agencies that purchase wheat for their milling industries. Such agencies have limited foreign exchange with which to purchase the wheat needed for a great variety of end uses. Thus, the agencies tend to be quite price sensitive and to use U.S. grades when purchasing U.S. wheat. More recently, buying agencies have specified limits on wheat characteristics in addition to those provided by the official grades. In other countries, the role of the state buying-agency has diminished, and processors themselves now specify requisite wheat characteristics. Other wheat exporting and importing countries have relied more on written contracts specifying limits on wheat characteristics than on official grading.

Recently, at least one wheat importing country added a penalty for exceeding dockage limits in the contract. In such a case, the exporting company must, in essence, pay the transportation cost for dockage when levels exceed contract limits.

#### Information Dissemination

The USDA, land-grant universities, and other public and private sources extensively disseminate information about wheat price, supply, and demand. Information about protein premiums, at least during years in which they are paid, also is widely available for farmers, wheat traders, and processors. Other premium and discount information on milling and baking qualities is less accessible. Processors making open offers to purchase wheat by specification or cultivar usually announce a premium above the going market price. But often contracts among processors, farmers, and elevators are private, and thus dissemination of premium information is unlikely.

### The Milling Industry

The milling industry has undergone significant changes over the past few decades. Changes in consumption patterns have provided an opportunity for growth in flour milling. Various economic pressures have affected location, size, and concentration of the flour milling industry.

Changes such as the increased sale of buns through fast-food establishments and the increased attention to healthful food products have provided an opportunity for growth of value-added products and of specialty flour-milling products. Whole wheat and specialty flours have become increasingly important for millers as changes occur in consumer tastes and in baker demands for flours performing well in automated baking processes.

Moreover, both transportation cost differentials between shipping flour and wheat and shifting population centers have caused the location of U.S. milling to shift. Between 1979 and 1989, for example, the flour market shares of Texas, Oregon, Washington, and Michigan increased, while those of Kansas, Minnesota, Missouri, and New York decreased.

Previously, the largest flour milling firms had been originators or primary processors of commodities before entering flour milling. But potential for value-added processing, regional shifts in milling, and excess capacity in commodity origination attracted new entrants. Today, the three largest U.S. flour millers account for nearly 60% of the nation's flour milling capacity. Many of the largest flour millers have extensive operations in the processing of food and other commodities. Moreover, the largest three millers also are the largest three multiple-facility grain companies in the United States.

Total number of U.S. flour mills decreased from 1,243 in 1947 to 361 in 1982, according to census data. And mill numbers continue to drop as average mill capacity increases. The average daily capacity/mill for the largest three firms is about 9,500 cwts/d; the average capacity of the remaining mills, only 3,900 cwts/d.

Large firms reduce costs through economies of scale in production and marketing. Firm size also is associated with economies of information gathering. Firms integrated vertically from wheat origination through flour milling or baking can access more information than can other firms. Vertical integration thus can be a source of competitive advantage for a flour mill inasmuch as millers typically buy wheat according to milling and baking characteristics and not official numerical grade. Identifying a better source of milled wheat can mean producing better flour products or producing them at lower cost.

# Measurement of Quality in the Market Channel

## Important Quality Attributes

The quality characteristics of wheat are of three general types:

1. Physical properties
   a. Test weights
   b. Broken kernels
   c. Foreign material
   d. Damaged kernels
2. Sanitary properties
   a. Infestation
   b. Pesticide residue
3. Intrinsic properties
   a. End-use performance
   b. Protein content

Wheat quality characteristics include attributes common to all grain users and attributes specific to an industry. All users rely on the following classification system to identify different types of wheat, which differ markedly in genetic characteristics:

1. hard red winter
2. hard red spring
3. soft white
4. soft red
5. durum
6. hard white

*Red* and *white* refer to the color of the grain. *Winter* wheats are planted in the fall and harvested the next summer. *Spring* wheats are planted in the spring and harvested in the summer. *Hardness* (or *softness*) refers to the texture of the kernel and indicates other inherent characteristics of the wheat and the flours milled from it. For example, hard wheats generally have higher protein levels than soft wheats do, and the chemical nature of the protein in the former is more suitable for bread making. Hard white wheat is a relatively new development, and standards have been established for this class just recently. Although produced in limited quantities, it seems to have the potential for a substantially larger market.

Pasta is made with durum—and occasionally hard—wheat. Breads are made with flours milled from hard wheats. Cakes, cookies, crackers, and canned specialties are made with flours from soft wheats. The flour used in frozen specialties depends on the type of product being produced and frozen and can be milled from hard, soft, or drum wheats.

There are more than 200 cultivars of the 6 official classes of wheat grown in the United States. This cultivar has a major effect on the range of quality characteristics of wheat and its products.

## Quality: Producers and Processors

Obviously, different segments of the industry have different quality priorities. This situation probably will continue. Unless rewarded financially for sacrificing yield, farmers will not plant lower-yielding cultivars just because an end user prefers their functional performance characteristics. There is considerable talk about paying "protein premiums" to encourage production of wheat with desired end-use, e.g., bread making, performance characteristics. In reality, the system works ineffectively because the premiums paid rarely find their way to the producer or, if they do, fail to compensate for a potentially lower-yielding crop.

Following is a list of the quality factors that different segments of the wheat production, marketing, and utilization systems consider important.

1. **Producer**: yield, disease/insect resistance, and tolerance to varying agronomic conditions.
2. **Grain storage operator**: conformance to standards for class and grade, especially to standards regarding moisture, foreign material, and insect infestation.
3. **Miller**: conformance to standards for class and grade, unmillable material, millability, and potential end-use performance characteristics.
4. **End user**: consistency of end-use performance characteristics.
5. **Grain trader/exporter/importer**: conformance to standards for class and grade, cleanliness, protein content (an increasing interest), and potential end-use performance characteristics (also an increasing interest among some buyers).

## Quality Control at Each Point in the Market Channel

Quality determination in the early stages of marketing wheat is based on standards for classes, subclasses, and grades, as established by the USDA–FGIS. Inspection and grading services are provided by either USDA–FGIS personnel or state inspectors approved and monitored by USDA–FGIS staff.

### First-Handler

Minimal testing usually takes place at the country elevator although the operator attempts to evaluate a farmer's grain based on federal standards and may even send a sample to a private testing laboratory. The development of NIR instruments to measure wheat protein content quickly, accurately, and easily has enabled operators of country elevators to perform this test before or during unloading. Some elevators also determine test weight and moisture content, other simple quality characteristics that affect prices.

As the wheat moves through the marketing channel, it is subject to additional testing. Most wheat destined for domestic millers is graded U.S. No. 1; most intended for export is graded U.S. No. 2, a grade generally adequate for the needs of most importing countries and priced somewhat lower.

### Quality Concerns Among Plant Breeders

Concern grows about the quality of wheat in all segments of development, production, and utilization. Thus, abilities to identify and measure quality factors and to buy and sell become increasingly sophisticated. Wheat breeders attempt to meet the needs of producers by developing cultivars that increase yield and resistance to diseases, insects, and adverse agronomic conditions. Breeders also are sensitive to the needs of processors, i.e., millers, who seek improved millability in new cultivars.

Simultaneously, end users pressure breeders to develop and to release new cultivars with improved end-use properties. Bread bakers, for example, complain that flour from most currently available wheats is insufficiently tolerant of variations in mixing time and produces the wrong type of crumb grain.

The job of breeders is quite difficult. But their improved communication with producers, processors, and end users is a positive development. New tools designed for germplasm availability determination, genetic engineering, and testing and evaluation promise to help breeders meet the needs of a diverse clientele.

### Quality Measurement Technology

Processors and end users continue to improve techniques for measuring the quality characteristics of wheat and its products. These techniques are being used by buyers and sellers, as well as by breeders. The move toward use of highly mechanized high-speed operations to convert wheat into flour and flour into product has created a demand for products of uniform high quality. But with the move toward just-in-time deliveries of raw materials, neither the miller nor the baker has time to run numerous quality tests on shipments, and certainly neither has the luxury of rejecting shipments and waiting for replacements.

Because of the speed at which modern mills and bakeries operate, poorly performing materials can lead to substantial and unacceptable levels of scrap or reject product in a brief period. Thus, uniformity generally is as important as quality. Although adjustments in formula and processing can compensate for a degree of quality variation, once these adjustments are made, they should not be changed from shipment to shipment.

The need for quality consistency has created the demand for analytical tools rapidly measuring the performance properties of wheat and flour. Such tools must be inexpensive to purchase and to operate and must provide rapid, reliable data. Although advances are being made, much work remains to be done.

Foreign buyers of U.S. wheat are becoming increasingly sophisticated. Although most exported wheat is sold on a class and a grade basis, e.g., *U.S. No. 2 Grade hard red winter wheat*, foreign buyers are beginning to include additional requirements in purchase contracts. These requirements generally refer to end-use performance characteristics. Moisture content, protein content, and dockage are the most common quality factors specified in addition to class and grade.

Millers generally purchase wheat both on a protein-specification basis and on a class and grade basis. To meet customer needs, most mills segregate wheat in storage, according to protein content or other end-use performance characteristics, and blend two or more wheats before milling. Millers also may send representatives into the field at harvest to collect samples for analysis and use this information in purchasing decisions.

### Export Quality

Wheat to be exported from the United States must be graded officially. Measurements of grade-determining factors must be provided for both buyer and seller, but measurements of informational factors are optional. Foreign buyers can request additional information about wheat quality and can specify wheat-quality limits impossible to guarantee by means of official grades alone.

Standards for export wheat affect not only the average levels of the grade-determining factors but also the variability of each factor. To ensure that factor level does not vary too widely from start to finish when a shipment is loaded for export, the *cu-sum* method is used. This method involves continual sampling of wheat that enters the ship and summing of deviations from a factor limit.

### Diminishing Use of Official Grades

Increasingly, both domestic and foreign buyers of U.S. wheat are bypassing official U.S. grades when purchasing wheat. Domestic buyers have for some time used factors other than grade when purchasing milling wheat, and several foreign customers now are specifying in the purchase contract the official U.S. grade as only one of many factors. As buyers become increasingly sophisticated in specification of their wheat-quality needs, the importance of official U.S. grades will diminish.

### History, Including Federal Legislation and Agencies

In the mid-1800s, merchants at the CBOT devised a systematic grading terminology for grain. This effort was followed quickly by application of standards and inspection by other commercial enterprises. The proliferation of local and regional grading terms and standards came to an end in 1916, when the GSA, which authorized the secretary of agriculture to establish and to promulgate national grain standards, was passed.

Relatively small changes were made in grading until the 1976 GSA, which in large part was enacted in response to widespread violations of law. The act authorized the USDA–FGIS, which was to oversee grain grading throughout the country.

Between 1977 and 1986, a series of small changes was made in the USDA–FGIS. But a set of four objectives for U.S. grade standards was developed and passed as the 1986 GSA. In 1990, two objectives were added to the list, with the passage of the Food, Agriculture, Conservation, and Trade Act (FACT 1990). Two objectives added in 1990 emphasized measurement of the grain characteristics determining end-use value. The objectives of U.S. grade standards were then as follows:

1. To define uniform and acceptable descriptive terms to facilitate trade.
2. To provide information to aid in determining grain storability.
3. To offer end users the best possible information from which to determine end-product yield and quality.
4. To create a tool with which the market can establish quality improvement incentives.
5. To reflect economic value-based characteristics in the end uses of grain.
6. To accommodate scientific advances in testing and new knowledge of factors related to, or highly correlated with, end-use performance of grain.

### Current Grades

When changes are considered for wheat grade standards, farmers, merchants, processors, and exporters have an opportunity to comment. On reviewing their comments, the administrator of the USDA–FGIS decides whether their modifications should be adopted.

The wheat grading process currently consists of grade-determining and informational factors. Grade determining factors are used to calculate official numerical grades from 1 through 5, as well as the category Sample Grade. Informational factors are measurements provided to buyer and seller but not used to calculate official grade. Additionally, there are eight distinct classes of wheat, each with a unique end-use.

Grade-determining factors include test weight, damage, foreign material, shrinkage and breakage, and defect. *Test weight* is a measure of density and is considered an indicator of flour yield of wheat. *Damaged kernels* result from weather, heat, disease, infestation, mold, sprouting, or handling. *Foreign material* typically is weed seeds and seeds from other grains. *Defects* are the sum of damaged kernels, foreign materials, and shrunken and broken kernels.

The amount of wheat of other classes also is used to calculate official grade. There is a limit to the percentage of wheat of other classes and the percentage of wheat of contrasting classes that a load can contain after which its grade is lowered. Because the classes of wheat have different characteristics and end uses, mixing wheat of different classes reduces value in the marketing channel. Careful blending of wheats by flour millers, however, is done to meet contract specifications for finished flour.

Various informational factors such as hardness, protein, color, moisture, and dockage are measured but not used to calculate official grade. Wheat kernel hardness is important in predicting milling characteristics. Typically, hard wheats have high protein levels and are used for leavened breads. Soft wheats generally have low protein levels, and their starch qualities differ from those of hard wheats. Color of seed coats or of bran can affect color and taste of end-use products. Red seed coats tend to have high levels of tannin, which can impart a bitter flavor to bran and flour. Until recently, hard wheats grown in the United States have had red seed coats. Now, however, hard white wheats are available in some parts of the country.

Moisture content and dockage affect storability and appearance. High-moisture wheat typically is dried before storage to prevent infestation and mold. *Dockage* is nonwheat material separable by specific processes.

Regulation of live-insect tolerance was tightened in May 1988. Wheat can be labeled *infested* if containing two or more live insects injurious to stored grain. Infested wheat is designated *Sample Grade.*

### Measurement Technology

Measures of wheat cleanliness, e.g., dockage, foreign material, and insect and heat damage, are taken either by visual inspection or by use of a small, simple cleaning device. These measures are made routinely at elevators and elsewhere in the marketing system.

Measurement technology has improved, and test costs have decreased. Measuring protein content once was time consuming and expensive, but tests using NIR technology now are conducted routinely in many country elevators. Kernel hardness, which indicates millability, heretofore has been measured primarily by visual inspection, but current research is seeking an objective measure.

Notwithstanding, the measurement of many milling and baking characteristics remains difficult and time consuming. Additionally, measurements can differ from one machine to another such that test results are useful only when compared with samples of wheat tested on the same machine.

## Issues and Problems Related to Quality

### Price-Quality and Price-Quantity Relations

Like price-quantity relations, price-quality relations for wheat are dynamic. For a variety of reasons, however, the latter have been much more evident at the production level than have the former. Government supports of wheat prices and farm incomes are based on quantity of production, not on quality. And when country elevators use station-average pricing, the market's price signals to producers tend to be masked. The economic incentive for producers thus has been to adopt high-yielding cultivars of wheat and to use production and handling practices consistent with large volumes.

Over time, quantity and quality of wheat around the world depend on weather, production practice, infestation, and disease. For example, in dry years, test weights and wheat yields often will be low and protein contents high. And although wheat prices will be high, protein premiums will be quite low. Consequently, a producer who sacrifices yield for improved protein may find protein premiums insufficient to offset reduced income from low yield. Producers generally have found it less risky to produce for quantity than for quality.

## Optimum and Maximum Quality

Although wheat quality is important to end users, there is a difference between optimum and maximum quality. The latter indicates that wheat is in the best possible physical condition; the former, that the ability to improve wheat quality and the cost of doing so are balanced with the willingness of end users to pay for such improvement. Policies designed to improve wheat quality must consider the willingness of domestic and foreign millers, bakers, and consumers to pay for improved quality.

## Characteristics to Include

Recently, a wheat cultivar that had received quality awards at fairs was refused by a flour miller, who cited its poor milling and baking characteristics. Clearly, objective measures of wheat and flour quality are needed. But achieving industry consensus regarding which wheat characteristics to identify and to measure is complicated by technological limits and by myriad domestic and foreign end-use products.

Many tests conducted in the marketing channel are proxies for true measures of interest. Test weight, for example, is a proxy for flour extraction, and protein content a proxy for protein quantity and quality. Even tests conducted at flour mills fail at times to measure relevant characteristics. For example, some millers measure flour ash content to help judge quality whereas others claim that there is little or no relation between the two.

The time required, the ease of measurement, and the reproducibility of results must be considered in determination of which wheat characteristics to measure. With improvements in technology, for example, have come convenient and timely measuring devices to estimate protein content of wheat. Although the old test took days, the new one can be done in minutes.

## Loss of Export Markets

A major issue in discussions of U.S. wheat quality is the loss of export markets. In the mid-1980s, concern became evident that poor quality U.S. wheat was responsible partly for reduced exports. The quality concern usually is one of cleanliness although milling and baking characteristics also have been issues. Wheat cleanliness is dictated by, among other things, dockage, foreign material, and infestation. The Canadian wheat marketing system, in which wheat is cleaned routinely in the marketing channel and in the port, often is cited as a model that the United States should adopt.

Studies conducted in the mid-1980s identified a number of factors contributing to the decrease in U.S. wheat exports, including price, exchange rate, and world production. But the jump in the number of foreign complaints about U.S. wheat quality in the mid 1980s focused attention on the need for changing policies. As world competition in the wheat export business continues to intensify, calls for additional regulation and for routine cleaning of U.S. wheat likely will intensify. Estimating the costs as well as the benefits of cleaning wheat destined for export is the focus of much current research.

## Contract Specifications and Economic Incentives

Studies have indicated that the wheat market generates price signals only for wheat characteristics measured as part of the grading process. Thus, milling and baking characteristics for wheat that are inaccurately reflected in grades have generated no consistent price signals to which farmers can respond. To acquire wheat with special characteristics, millers and bakers have in some instances resorted to the more costly alternatives of production contracts or purchase agreements.

Production contracts specify quantity and quality of wheat as well as either a specified price or a price premium. Millers also have offered to purchase wheat meeting certain specifications, typically at a stated premium. Such specifications often include acceptable wheat cultivars and management practices. One midwestern flour mill set up production contracts with producers to raise a cultivar of wheat that it owned and whose release it controlled. The strategy was abandoned when farmers began saving the seed and selling it to other farmers. The difficulty experienced by this company in maintaining control of the release of a special cultivar has stymied other attempts.

Offers to buy wheat of a specific cultivar or wheat with specific characteristics have been more common than production contracts. Recently, a leading flour mill and a bakery offered a premium for delivery of a specific cultivar. Another flour mill has begun specifying in its purchase contracts that it will reject a certain cultivar because of its poor milling and baking characteristics.

Wheat moving through the marketing system, especially that destined for export, usually is bought and sold on the basis of official U.S. grade. Domestic millers, on the other hand, purchase wheat almost entirely on the basis of specifications.

With increasingly automated flour mills and bakeries, demand for consistent milling and baking characteristics has increased. Flour millers and bakers are developing average wheat specifications while requiring that the range of characteristic values be relatively narrow.

### New Cultivars Invalidating Old Classifications: Cultivar Control

The current marketing system is organized to move a great deal of wheat at very low cost, but the introduction of new wheat cultivars has caused problems. Arkan wheat, for example, was often graded as soft wheat when in fact it was hard. Thus, because soft and hard wheats have quite different end-use characteristics, industry leaders were concerned that buyers would be doubtful of receiving the wheat that they required.

The introduction of hard white winter wheat also gave cause for concern. Domestically, there had been no hard wheat with a white seed coat. Again, industry leaders were concerned that this wheat would be mixed with either hard red wheats and receive substantial price discounts or with soft white wheats and dramatically change their milling and baking properties. After considerable debate within the industry, a new class of wheat was established. The hard white winter wheat, however, was to be kept separate, or IP, from either the hard red or the soft white cultivar.

Each state uses its own criteria to decide whether or not to release new cultivars. A basic criterion is that they must be an improvement in terms of at least one characteristic and not worse in terms of any other characteristic, compared with currently released cultivars. In the United States, universities and crop improvement associations are not the only groups able to release new cultivars. Private companies and farmers also can cultivate and sell them. In contrast, other countries, e.g., France, have quite strict cultivar-release programs requiring official approval before a new cultivar can be sold to producers.

Crop improvement associations attempt to maintain the integrity of cultivars by designating foundation registered or certified classes of seed. The latter may include a limited amount of weed seed but is genetically pure. But farmers often save some harvested wheat for use as seed for the next year. The extent to which farmers practice seed saving depends on the region, but this practice can affect quality and consistency of wheat entering the marketing system.

### Relating End Use to Physical Properties

Concern is growing that U.S. standards for class and grade of wheat disclose insufficient information about end-use performance characteristics. Although class of wheat is related in general terms to end use (durum for pasta; hard wheat for bread; soft wheat for cakes, cookies, and crackers, etc.), some domestic and foreign buyers recommend that class and grade standards include relatively specific end-use characteristics. Others recommend that end-use performance information be included in specifications between buyer and seller of processed wheat products such as flour.

Because of the broad uses of flour from each class of wheat (with the possible exception of durum), it is unlikely that a realistic and workable system can be developed to include end-use specifications in standards for class and grade.

### Dockage and Foreign Material in Grades

The value of changing the status of dockage in wheat from that of an informational to a grade-determining factor has been debated throughout the industry. The controversy has stemmed from complaints about the quality of U.S. wheat shipped overseas. Currently, to calculate the weight for which they will pay, buyers simply subtract dockage. The controversy over cleaning dockage from wheat is that such a procedure also tends to remove material that otherwise would have been sold at wheat price. Some believe that cleaning U.S. wheat before export would help the United States maintain and possibly increase its world market share. Others argue that foreign buyers simply can specify in the contract an upper limit on dockage, and few have indicated a willingness to pay premiums for cleaner wheat.

## Information Dissemination

### Price, Quantity, and Quality Information

In the wheat marketing system, most information concerns prices and quantities of wheat. Prices for Grade Nos. 1 and 2 are quoted from many points around the United States. Many major grain handling firms provide discount and premium schedules for foreign material, infestation, moisture content, and test weight. Throughout the year, a great deal of information about anticipated crop size, actual crop size, stock of wheat owned by the government and private companies, and world export projection is made available to the market.

Quality information on wheat crops is provided by the National Agricultural Statistics Service (NASS) of the USDA and by industry groups. Wheat-quality surveys are conducted and summarized. Additionally, universities and industry groups conduct milling and baking tests for new wheat cultivars and compare results with those for proven wheat cultivars. This information is made available to universities, seed companies, millers, and farmers making decisions about releasing, milling, and planting.

## Coordinating, Promoting, and Advertising

A number of organizations are involved in a broad range of activities to promote consumption of wheat based foods. But there is no central coordinating organization in either the public or the private sector.

Three private organizations are concerned about the quality of wheat: the Wheat Quality Council (WQC), the Spring WQC, and the Soft WQC. These organizations receive no federal monies but are supported by contributions from the agribusiness community with an interest in wheat production and use. For example, flour millers are a major source of financial support.

The primary goal of these councils is to improve the quality (as defined broadly by all firms from producer through end user) of wheat and thereby to increase the value of the crop and the U.S. market share of world trade. These councils play a vital role in communicating quality requirements among breeders, producers, millers, and end users.

### Foreign Agriculture Service

The USDA–FAS is essential to the collecting and disseminating of information about wheat export market requirements. The FAS stations, in many U.S. embassies, agricultural attachés who collect information about wheat production, import needs, quality requirements, etc. After being forwarded to the FAS in Washington, D.C., this information often is compiled into reports by government policymakers and by private companies involved in the international grain trade. Agricultural attachés also serve as focal points in the dissemination of U.S. crop information to key people in the country served.

The FAS financially supports programs of cooperator groups, e.g., the U.S. Wheat Associates (USWA), that also are involved in disseminating information and providing technical assistance, often through technical consultants, universities, and other training organizations.

### Commodity Groups

Numerous wheat-producing states have commissions appointed by a state agency or authority and financed by a check-off paid by producers. These commissions support programs designed to increase wheat sales and wheat-based product use.

Most state wheat commissions have banded together to finance a new Wheat Foods Council, which aggressively promotes use of wheat based products and consumption of wheat based foods. The state wheat commissions also contribute a significant portion of their budgets to support the USWA, a Washington D.C.-based cooperator group involved in export market development activities. This group received financial support for its international activities from the FAS.

The USWA has 13 international offices in locations in which the potential market for American wheat is significant. In addition to its own foreign based technical staff, and in an indirect effort to increase demand for wheat, the company uses consultants from numerous universities and other organizations to provide technical assistance to buyers and users of wheat and wheat flour.

The USWA also finances training for foreign buyers, decision makers, and staff in mills and end-use product manufacturing plants and communicates critical information to foreign buyers from appropriate federal agencies, domestic producers, handlers, and traders. Grain and end-use parameters are important issues to be communicated between the United States and the importers of its wheat.

# Anticipated Industry Changes Influencing Quality

## Use

Changes in wheat use are likely in the form of new products and new processes for both domestic and export markets. New products are expected in food, feed, and industrial uses. Changes in consumer tastes and advances in food processing technologies will place increasing demands on food-quality wheat. As new processing technology evolves and as mills and bakeries become increasingly automated, demands on wheat quality will intensify. Foreign purchasing agencies and other foreign buyers are becoming increasingly sophisticated and concerned with wheat quality, as evidenced by their use of numerous quality specifications in addition to official grades.

### Production

Geographically, there is likely to be little shift in the production of the various classes of wheat within the United States. Improvements in genetic potential, however, will continue. With effective economic incentives for wheat quality in the marketing system, wheat breeders will be able to respond with new cultivars meeting various end-use demands. These new cultivars will be a challenge to the current classification and grading system.

### Market Structure

Current trends in the wheat marketing system likely will continue. The flour milling industry will become ever more concentrated and integrated with food processing. The extent of this concentration, however, will depend on economies of scale in flour milling and on federal enforcement of antitrust laws.

Some domestic processors are responding to wheat-quality concerns by contracting directly with producers for the wheat cultivars preferred in milling and baking. As mills seek to satisfy at least part of their daily grind with specific cultivars, it is likely that wheat increasingly will bypass traditional marketing channels in favor of contracts.

As flour millers turn to contracting, price incentives passed to producers for wheat quality will become more evident than those passed to producers in traditional marketing. Although the traditional marketing channels will continue to move large quantities of wheat to various domestic and export markets, firms and cooperatives increasingly are interested in originating U.S. wheat meeting the specifications of large foreign buyers. Purchase contracts specifying cultivar and origin have the potential to provide farmers with unambiguous price incentives.

### Quality Measurement

Improving techniques to measure quality and to identify cultivar is critical to the strengthening of economic incentives throughout the marketing system. But to achieve widespread use, these techniques must be rapid and simple. Additionally, buyers and sellers must have confidence in their results.

Currently available techniques can provide a "fingerprint" of a wheat cultivar. Because wheat of a given cultivar is relatively homogenous, techniques accurately identifying it can provide a basis for price incentives. Although some techniques are too expensive or time consuming to be applied effectively to an entire wheat crop, they still can form the basis of transactions demanding strict adherence to wheat quality guidelines. The use of such techniques may increase as technology improves.

It will be difficult to include many new measurements in the official grades as grade-determining factors or even as informational factors. Thus, it is believed widely that official U.S. grades and standards will continue to wane in importance. Domestic flour mills already do not rely on numerical grades when purchasing wheat. And, increasingly, foreign buyers are using numerical grades as only one of many specifications. As techniques to measure wheat quality improve, there will be less reason for domestic and foreign buyers to rely solely on U.S. numerical grades as the basis for purchase, especially if grades are not revised to meet the requirements of end users.

## Quality-Related Needs and Opportunities

### Economic Incentives

The current marketing system for wheat is based on moving large volumes at low cost to major domestic and export markets. To keep handling and transportation costs manageable, wheat of differing qualities is commingled (blended), for the most part according to numerical grade, test weight, and/or protein content. Economic incentives present in the system therefore are based largely on grades and not necessarily on milling or baking quality. This situation, together with the widespread practices of station average pricing and government price supports, dampens price incentives for milling and baking characteristics. But through miller-farmer contracts, some economic incentives are being passed from millers and bakers back to producers.

For contractual or other market mechanisms to provide effective price incentives for wheat quality, the market system must identity-preserve an increasing number of wheat categories. There are costs of measuring wheat qualities on a large scale, as well as of handling, storing, and shipping smaller lots. The increased costs of identity preserving ever more categories of wheat must be balanced against the values that millers, bakers, and consumers place on learning about milling and baking performance.

### Grades and Standards

The purpose of grades and standards is to indicate the quality of wheat so that the buyer need not inspect each lot personally. Because desired qualities can differ greatly depending on end use, a great number of characteristics would need to be included to satisfy all purchasers. Yet a small set of characteristics currently is used to calculate the official numerical grade of wheat, and only a few informational factors are provided.

It is accepted widely that numerical wheat grades bear little relation to the end-use value of wheat in flour milling. Wheat millers must resort to buying by specification or must use other informational sources to identify wheat meeting their end-use needs. Often, experience gained in buying wheat within a locale for years is used to determine the source of future supply. Firms also specialize in tracking wheat quality over large geographic areas and selling the results of wheat-quality tests to interested parties.

In the export market, the importance of official U.S. grade standards in their current form is diminishing. Increasingly, major importing countries are specifying wheat characteristic limits. Official U.S. grade may be only one of several contract specifications.

### Communication

Effective communication is critical to a healthy market. And in the U.S. marketing system, communication takes place largely through price, which influences decisions ranging from which wheat cultivars should be planted to how wheat should be handled in the marketing channel. This information is augmented by that from various industry associations. At least one mission of farmer, handler, miller, and baker associations is to communicate membership concerns to buyers and sellers throughout the market stages. Communication of wheat-quality concerns in the industry is formalized through associations such as the WQC. Effective communication regarding wheat quality will become essential as global competitive pressures intensify.

### Other Topics—1986 Grain Quality Improvement Act

The 1986 GQIA marked a change in the emphasis of grade legislation. This act moved beyond a focus on grades and standards as means of facilitating handling and shipping of grains to one on end-use quality. The 1990 Grain Quality Incentives Act moved even farther in this direction. The USDA–FGIS now has the authority to consider both the economic value of characteristics to end users and the measurement of characteristics highly correlated with end-use values.

## Alternative Solutions

A variety of solutions to continuing and persistent wheat- and wheat-product quality problems have been proposed. Some proposals suggest legislative or regulatory control over quality requirements. Legislative action certainly may be appropriate in some instances. For example, changes in the parameters of grain standards may improve communication between foreign buyer and domestic seller and result in greater buyer satisfaction with quality.

But in other areas, government "interference" is opposed. The suggestion that the USDA–ARS use selected quality characteristics as criteria on which to approve the release of new wheat cultivars is opposed by many.

Organizations—primarily the wheat councils discussed previously—are in place to enhance quality of the U.S. wheat supply by facilitating communication among breeders, producers, and end users. Strengthening the effectiveness of these councils may be the most promising method of improving the quality of wheat for producers and its supply for both domestic and international users. Changes in grades, incentives to growers and plant breeders, and coordinated efforts by the many organizations interested in wheat all can contribute to solving the problem of improving wheat quality.

## Glossary

**Arbitrage.** A process of buying a commodity in one market and selling it in another because the prices in the two markets differ by more than the costs incurred in transferring that commodity from one market to the other.

**Cu-sum.** A set of rules established by the FGIS, which must be followed when loading grain on ocean vessels for export. The rules control variability among sublets blended to meeting contract grade limits.

**Damage.** Deterioration resulting from weather, heat, disease, infestation, mold, sprouting, or handling.

**Defects.** Sum of damaged kernels, foreign material, and shrunken and broken kernels.

**Dockage.** Nonwheat material separable by specific processes.

**Foreign material.** All matter other than wheat that remains in the sample after the removal of dockage and shrunken and broken kernels.

**Hardness/softness.** The amount of hard vitreous endosperm in the kernel. Kernel hardness is related to variety and protein content, and to other morphological characteristics.

**Infested.** Wheat label if two or more live insects injurious to stored grain occur in a sample.

**Spring wheat.** Wheat planted in the spring and harvested in the summer.

**Test weight.** Measure of density considered an indicator of flour yield of wheat.

**Winter wheat.** Wheat planted in the fall and harvested the next summer.

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# 7 Rice

Eric J. Wailes[14]

## Introduction

Rice was first used for food approximately 5,000 yr ago in India and China. Today, this food grain constitutes the primary staple for more than half the world's population.

Most production and consumption of rice occurs in Asia, where average annual per capita consumption exceeds 220 lb, compared with a world average of 141 lb. The relative importance of rice in the diets of the rest of the world is evident when one considers that U.S. annual consumption averages only 21 lb per capita (Childs, 1991).

Acreage devoted to rice production in the United states averages less than 1% of total cropland harvested. Not surprisingly, total value of rice output is small compared with that of other grain crops, and rice usually ranks sixth in farm crop cash receipts, behind corn, wheat, soybean, sorghum, and barley.

Yet the United States is the world's second largest rice exporter after Thailand. The competitive position of the United States in world rice markets has depended on its supply of high-quality rice. A comparatively efficient rice production and marketing sector has been augmented by government programs to stabilize producer incomes and to promote exports.

Because such a great percentage of rice is consumed in its country of origin, only about 4% of total world rice-production enters into international trade. Thus, the world market in rice is characterized as quite thin. World rice-markets are segmented distinctly according to quality. Important characteristics include kernel size and shape, stickiness when cooked, milling level, percentage broken grains, and fragrance.

Efferson (1985) identified six basic types of rice traded in world markets: (1) Indica, high-quality, long grain, raw milled rice; (2) Indica, medium quality, long grain, raw milled rice; (3) Japonica, short or medium grain, raw milled rice; (4) parboiled rice with any length grain, and two specialty rice types; (5) aromatic (fragrant); and (6) glutinous (waxy).

The last 50 yr have seen world rice-consumption increase by more than 225%, the result of an almost doubled population, combined with a 70% increase in per capita consumption. Because of genetically improved rice yields and the increased productivity of resources used in production, less than 64 million additional hectares of land has been required to support that increased consumption.

Current productive capability greatly exceeds what reasonably might be projected as rice demand during the next 25 yr. Productive capability, however, refers to what can be done, whereas whether something will be done depends on economic criteria. Land can be expected to shift to rice production only if net returns from rice exceed those from other crops.

## Rice Market

Domestic and export markets have been important outlets for U.S. rice production, and historically the latter has been somewhat more important. In 1984, however, the domestic market began growing steadily; it has surpassed the export market since 1989. The domestic market includes rice consumed immediately after milling, as well as rice that is processed further. The brewing industry is the largest domestic user of milled rice for further processing. Figure 7.1 depicts the distribution flow of the U.S. rice market for the 1988–1989 market year (August–July).

### Domestic Use

Rice distributed domestically from mills and repackagers enters three principal outlets: direct food use, processed food use, and brewery use. *Direct food use* refers to the consumption of rice that has been milled but not processed further; *processed food use*, to the consumption after other ingredients have been added or changes made in kernel composition for fermenting. Although rice use in the beer industry is a form of processing, most data sources separate rice for brewing alcohol from that for processing food

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(Childs, 1991).

Total domestic use of rice increased 152% from 1970 to 1990. Per capita consumption increased from 10 lb in 1970 to 21 lb in 1990. In market year 1988–1989, direct food use share of total domestic use was 60%. From 1970 to 1990, direct food use share decreased as processed useincreased. Market share of domestic rice in processed food grew from 12% in 1974–1975 to 19% in 1988–1989. The proportion of domestic rice used by brewers has remained stable, averaging approximately 21% of total use.

## Direct Food Use

The rice market distributes rice for direct food use through three principal outlets: retail, wholesale, and institutional (primarily restaurant) trade. In 1955, total direct consumption of rice for food in the United States was 8.1 million cwt; in the 1988–1989 marketing year, the total was 31.6 million. That increase, which has been steady, was the result of both increased per capita consumption and population growth of approximately 82 million.

Direct food use includes, in addition to rice that is milled, rice that is processed at the mill to acquire specialty characteristics. Parboiled, precooked, brown, and aromatic rice types are termed *specialty rice*. Because they often are aromatic, imports, e.g., jasmine rice from Thailand and Basmati rice from India and Pakistan, also can be included in this category.

Domestic parboiled rice historically has accounted for the greatest percentage of specialty rice. In 1988–1989, domestically produced parboiled rice accounted for 52% of all specialty rice whereas precooked and brown rice each accounted for only 8%.

Aromatic rice, distinctive for its aroma, especially after cooking, has become more popular with U.S. consumers since the early 1980s. The amount of domestically supplied aromatic rice remains quite small, however, although imports increased from only 7,000 t in 1980 to 153,000 t in 1990 (Wailes and Livesey, 1991). In 1988, imported aromatic rice accounted for 32% of the specialty market in rice.

## Processed Food

Processed food use of rice occurs in both food processing and beer industries. Use of rice as a food ingredient was stimulated by the marketing loan provision of the Food Security Act (FSA) of 1985, which decoupled rice consumption from farm price-supports. Moreover, marketing loan provisions for rice allowed consumer rice prices, previously constrained by the loan-rate pricefloor, to become relatively competitive.

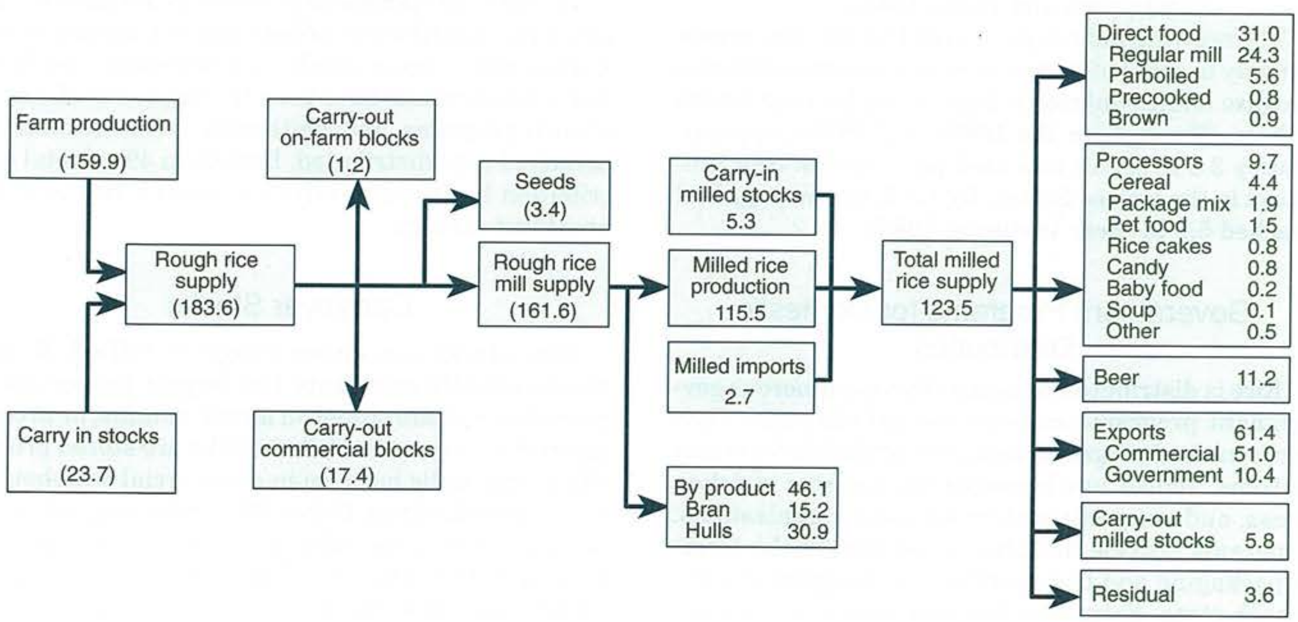


**Figure 7.1. Market channels for U.S. rice with estimated flows for 1988–1989 (Year beginning August 1. All quantities in millions cwt. Figures in parentheses are rough basis; others except by-products are milled basis.) (U.S. Department of Agriculture, 1991b.).**

Markets for rice in food processing are becoming increasingly numerous and include breakfast cereals, package mixes, pet foods, rice cakes, candies, baby foods, soups, and frozen dinners (Childs, 1991). Figure 7.1 identifies the distribution of total rice production to the various types of processors in the 1988–1989 marketing year.

Cereal processors are the main channel for processed food distribution. Notwithstanding, cereal use of rice has declined recently, partly because of both the price competitiveness of other grain ingredients and the substitution of ingredients, e.g., bran, with greater fiber contents. Pet foods and rice cakes, both rather new markets, are the fastest growing uses of processed rice.

## Brewer's Use

Use in beer production is the single largest processed market for rice. Brewer use has grown slowly but steadily during the past two decades. In 1988–1989, 11.2 million cwt, or 21% of total domestic rice produced, was used by brewers. Broken rice kernels, typically referred to as *brewers' rice* or as *second heads*—kernels measuring less than three-fourths of Whole Kernel length—are used as a fermentable carbohydrate adjunct by several major U.S. breweries. After yeast is added, the carbohydrates in rice convert to alcohol. Some brewers prefer rice to corn grits because rice has lower protein and lipid contents (Yoshizawa and Kishi, 1985).

The brewing industry's demand for rice has grown not only because of increased beer production but also because additional rice is being used for each barrel of beer. Throughout the 1960s and 1970s, approximately 3.5 lb of rice was used per barrel of beer produced in the United States. By 1985, the average had reached 5.0 lb (Beer Institute, 1986).

## Government Programs for Domestic Distribution

Rice is distributed domestically via numerous government programs and commercial channels. Government food programs make rice available for senior citizens, school lunch programs, disaster stricken areas, and nonprofit institutions and organizations. Programs provide financial assistance in the forms of packaging and transporting to a designated point ineach state. From that location, rice is distributed through state agencies to eligible local recipients.

Two alternative methods of commodity distribution for rice are (1) entitlement and (2) bonus commodity distribution. Entitlement commodities are goods purchased by the government and sold at a discount to participants. An example is the school lunch program, through which schools are charged a set rate/meal and receive commodities in exchange.

Bonus commodity distribution occurs when large surpluses are held by the CCC and stock reduction becomes desirable. Beginning in fiscal year 1983, regular milled white rice was placed in this category. In 1984, brown rice was added. While in the bonus category, rice can be obtained without charge by schools, institutions, and eligible persons within the bonus program's purview. Not all participants in government commodity distribution programs may take advantage of bonus commodities. Eligibility is determined by the controlling agency—the USDA-Food Nutrition Service (1991a).

Because the various supply-control and market oriented programs have been effective, U.S. government rice stocks have shrunk since the 1987 market year. As a consequence, regular milled white rice was removed from the bonus commodity list as of 1989 and now is available only as an entitlement commodity.

All U.S. rice mills can process rice for government programs. Food program recipients place orders through their respective state agencies for the commodities needed. Subsequently, the government seeks bids from rice processors wishing to supply the allotment. Costs of processing, packaging, and transporting from mills are paid by the government.

Government programs in recent years have resulted in the distribution of between 0.4 million and 2 million cwt of rice annually. Child-feeding and family-feeding projects have been the major beneficiaries of such programs, and white milled rice has been the principal type distributed. Less than 4% of total distribution has been brown or processed rice used for breakfast cereals.

## Carryover Stocks

Rice stocks are either rough or milled. Rough stocks usually constitute the largest proportion of carryover and are stored on farms, at mills, or in commercial warehouses. Milled stocks are stored primarily at rice mills but also in commercial warehouses and transit facilities. Before 1986, price supports were maintained by accumulations of excess production in CCC inventory. The FSA of 1985 essentially eliminated government's role in carryover stocks by means of the marketing loan provision. Since 1986, carryover stocks have been reduced substantially and have stabilized at approximately 26 million cwt. The stock-to-use ratio has ranged from 16.5 to 20%, the range specified in the 1990 Farm Bill (Lynch, 1991).

### Rice Exports

During the last 5 yr, the United States has produced only slightly greater than 1% of the world's annual rice crop. In the 1980s, five Asian nations (the People's Republic of China, India, Indonesia, Bangladesh, and Thailand) produced almost 75% of the world's annual rice output, averaging greater than 360 Mt annually for the years 1986 to 1990 (U.S. Department of Agriculture, 1991b). United States production, at approximately 7 Mt/yr, is quite small compared with the output of certain other countries that depend heavily on rice to meet food requirements.

Rice exports, however, are a different story. Though only fifth in terms of total production, Thailand is the world's leading exporter. On average, 36% of world exports originated from that nation from 1987 to 1991. Export shipments account for one-third of Thailand's annual output. The United States, ranking tenth in terms of rice output, is the world's second leading exporter, providing approximately one-fifth of total world exports. The next four leading exporters (Pakistan, the EC, the People's Republic of China, and Vietnam) have a combined share of 26% of total world exports. Since 1991, Vietnam has increased its rice exports to a level only slightly below that of the United States. The six leading exporters have supplied more than 80% of world export rice during the past 5 yr.

Through the 1970s, the United States' share of world exports ranged from 16.5 to more than 28%. The 1980s saw a steady decline in this figure, through 1985, when the share reached 16.7%, the smallest since 1970. From 1985 to 1990, however, U.S. share reached an estimated 20.1%.

### Government Export Programs

United States rice is exported by means of two primary transactional methods: commercial cash exports and government assisted export programs. Throughout the 1960s and until 1972, government exports accounted for more than half of total U.S. exports. They constituted only 29% of the total in the 1970s, and 37% in the 1980s. The government's growing role in rice exports during the 1980s reflects changes in the program, specifically an increasing emphasis on commercial export credit programs relative to concessional sales.

### Summary

In the 1988–1989 market year, distribution of milled rice from mills to domestic and international markets amounted to 52.5 million and 61.4 million cwt, respectively. The major domestic market for milled rice is direct food consumption, whereas processed food uses (including brewing) account for approximately 40% of total domestic use. Both direct consumption and processed uses by U.S. consumers have increased relative to exports during the past 20 yr. United States consumption of milled rice more than doubled from 10 lb per capita in 1970 to 21 lb per capita in 1990.

Half of processed food consumption of rice is as breakfast cereal. Package mixes are the second most important processed food use. Two relatively new and significant uses are rice cakes and pet foods. The brewing industry is the largest user of rice for processing purposes. Distribution also occurs through a number of government programs designed to supply food to school children, the elderly, and the needy. Since 1981, more than 8 million cwt has been distributed by means of such programs.

Although the United States produces only a small amount of rice compared with other rice producing countries, it is the world's second largest exporter of the grain and has a market share of approximately 20%. Government policies designed to reduce the price of U.S. rice to world price levels have reduced U.S. carryover stocks significantly and have stimulated the export market. Various government export programs have been used to stimulate exports, including both concessional and credit guarantee programs.

## Rice Production

Rice producing areas in the United States—with the exception of California—have been planted since the late 1800s (Figure 7.2). Farmers in the Sacramento Valley have become the latest addition to the list of major rice producers.

Six states produce almost the entire U.S. rice crop. Production is concentrated in these areas: the Arkansas Grand Prairie, Northeastern Arkansas and the Boot Heel of Missouri, the Mississippi River Delta (in Arkansas, Mississippi, and northeastern Louisiana), southwestern Louisiana, the Coast Prairie of Texas, and the Sacramento Valley in California.

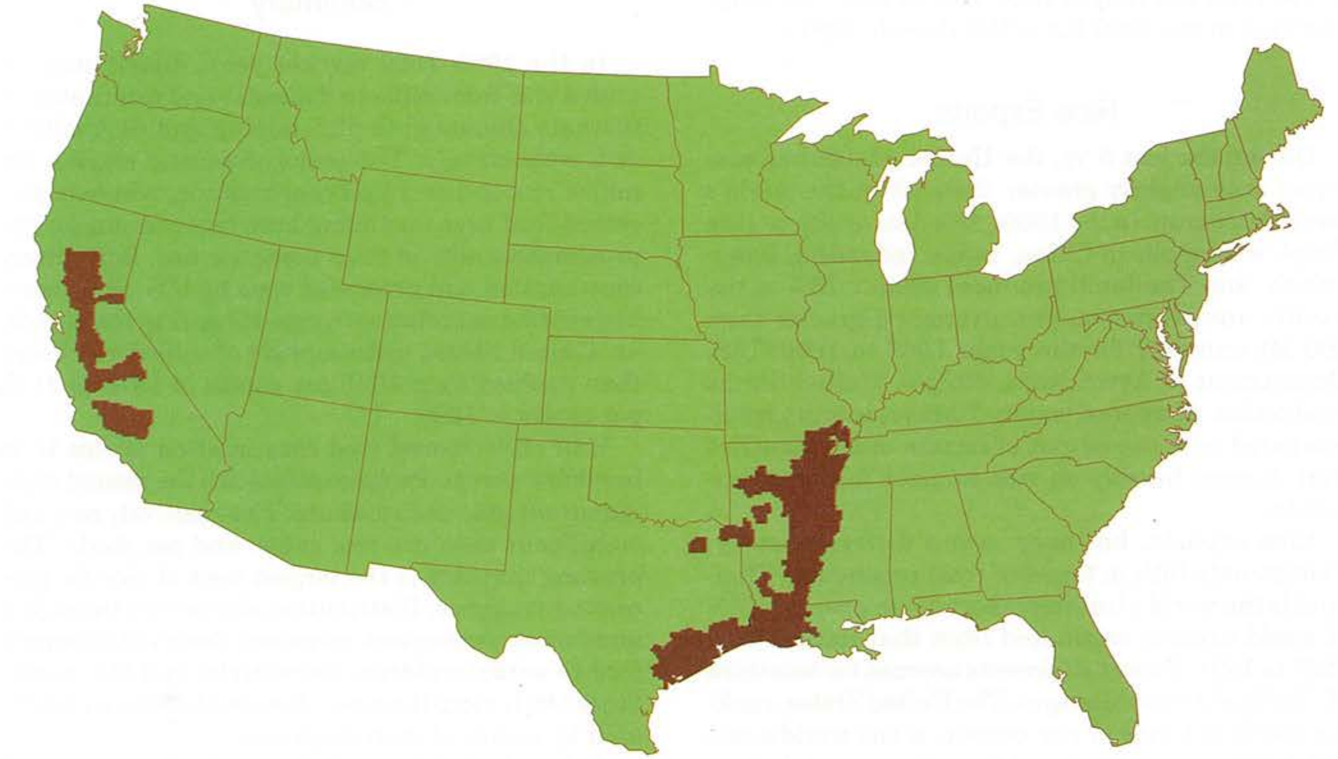

Figure 7.2. United States rice producing counties, 1989 (Smith et al., 1990).

## Production Trends

United States rice plantings have ranged from 1.6 million a. in 1960 to 3.8 million in 1981. Although planted acres during the last 20 yr have averaged approximately 2.7 million, great changes have occurred. The most significant have been (1) the planting of 632,000 a. in 1978, an increase of more than 13% over the 1977 acreage planted, and (2) the decline in acreage planted in 1984, when 1.1 million fewer acres were planted than in 1983, or a 33.5% decline.

Annual fluctuations in terms of harvested acreage, yield/a., and total output of rice since 1970 appear in Figure 7.3. Total output has increased by a simple average of 3.3%/yr for the period graphed. Because total output is determined from both rice acreage and yield, production can be more erratic over time than can either acreage or yield, as the production index demonstrates. The widest swings in output have occurred when both acreage and yield have changed in the same direction, thereby accentuating individual influences on production.

Such simultaneous changes have occurred 11 times in the 18 yr preceding 1991, with both acreage and yield increasing in 7 yr and decreasing in 4. The output index has ranged from a low of 90% of base in 1970 to a peak of nearly 197% in 1981, the latter being a year in which both acreage and yield indicated sizable increases.

Relative production levels for the three classes of rice (long, medium, and short grain) have changed considerably since 1960. Long grain rice, constituting less than half the nation's rice output in 1960, increased its proportion of the total even while the

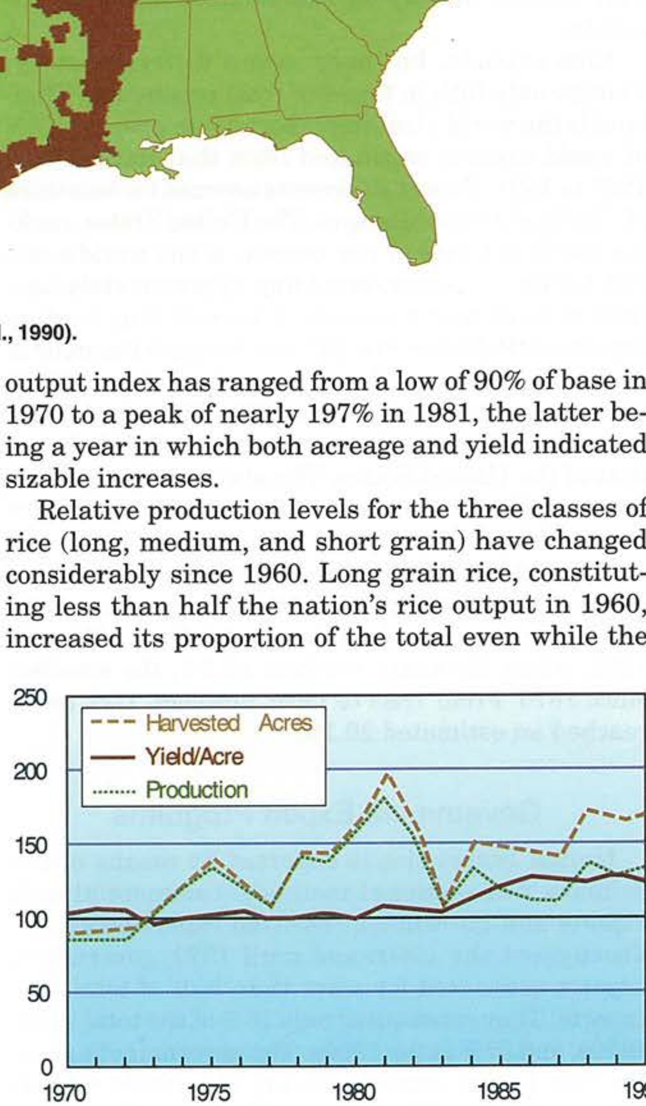


Figure 7.3. Indexes of U.S. rice, 1970–1990 (average 1968–1970 = 100) (Smith et al., 1990; U. S. Department of Agriculture, 1991b).

national output nearly tripled, and approached 75% of the total by 1988. Accomplishing this proportionate gain required more than a fourfold increase in long grain production—from 26.3 million cwt in 1960 to 115 million in 1988.

Arkansas led all states in the increased output of long grain rice, providing close to one-half the 89 million cwt gain in long grain rice output. From just a 54% long grain share in 1960, Arkansas expanded this share to 89% in 1988.

Other southern rice producers made similar adjustments in rice types produced. Both Mississippi and Texas now are at or near 100% long grain rice production. Louisiana producers increased their proportion of long grain rice from approximately half in 1960 to 73% in 1988. Since 1988, however, both Louisiana and Arkansas have increased their shares of medium grain rice production in response to reduced production in drought stricken California.

California has made great changes in the production mix of medium and short grain rice. short-grain rice, constituting more than two-thirds of the state's production in 1960, had fallen to nearly one-tenth by 1988. During the same period, California producers increased their share of medium grain rice from less than one-third to more than three-fourths of the total. California recently has begun to produce long grain cultivars as well.

Such changes occur not simply as a result of chance but from carefully considered decisions by producers responding to changing physical and economic conditions. Varietal developments improving long relative to medium grain productivities, as well as market developments, have encouraged producer emphasis on long grain rice. Compared with medium grain cultivars, most long grain cultivars are less cold tolerant, an important quality at the seeding stage in California. That state is developing long grain cultivars with greater cold tolerance, and more long grain rice likely will be produced.

As relative prices change to reflect consumer preference, a strong signal for producers to adjust operations is provided by the price system. Since 1980, the price of long grain rough rice has exceeded that of medium grain by an average of 21%. This difference has more than compensated for the lower yield of long grain rice.

For the two leading production states, Arkansas and California, long grain rough rice yields have averaged 91 and 94% of medium grain yields, respectively. The rough rice yield differential suggests, for example, that California, with only 10% of production in long grain, could benefit from additional substitution for medium. But in California the milling yield differential between long and medium (20% less head rice for long grain than for medium grain rice) keeps medium grain rice relatively profitable.

## Rice-Producing Farms

Since 1969, the number of rice farms has increased even though the total U.S. farm number has continued to decline. By 1987, the number of rice farms was 12,013, greater than the previous peak in 1956. The 1987 distribution of rice farms by state is as follows: Arkansas, 46%; Louisiana, 19%; California, 14%; Texas, 10%; Mississippi, 7%; and Missouri, 4%.

The increase in rice farm numbers since their low in 1969 reflects producer reaction to both market conditions and policy changes that have improved the profitability of rice relative to that of substitute crops and have created an incentive to reconstitute farms to benefit from policies such as payment limits. The greater returns above cash costs for rice than for wheat, corn, sorghum, soybean, and cotton help explain the great increase in harvested rice acreage from 1977 through 1982.

In 1987, average acreage of rice/farm in the United States was 202, down from 283 in 1982. With the exception of Mississippi, all states demonstrated an increase in average rice acreage/farm between 1974 and 1982. Most states showed a major increase over the 1974 to 1978 period, partly because acreage allotments were lifted in 1974 and eliminated in 1981. The dramatic decline in acreage harvested per farm in 1987 reflects changes in rice policy. First, payment limits induced reconstitution or splitting of farms, as mentioned. Second, and even more important, excellent compliance (95%) with voluntary acreage-reduction programs (ARPs) reduced acreage by 35% (Smith et al., 1990).

In 1987—the most recent Census of Agriculture year—U.S. rice farms were operated predominantly by tenants or by part owners, with a trend toward tenant farming. More than 88% of rice farmers were full-time farmers (Setia, 1991).

## Supply and Disappearance

An overview of U.S.-produced rice disposition appears in Figure 7.4 and compares 1990 rough rice production, domestic use, export, and ending stocks with average levels for the 1960s, 1970s, and 1980s (U.S. Department of Agriculture, 1991b).

Over the years, the government's rice policy often has encouraged greater increases in production than

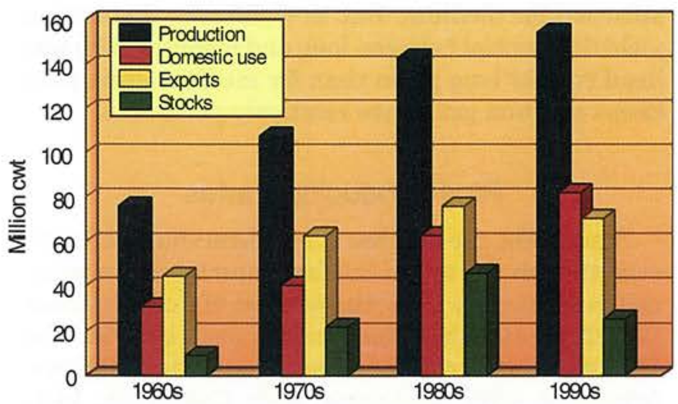


**Figure 7.4. United States rice crop disposition (U.S. Department of Agriculture, 1991b).**

domestic and foreign markets could absorb, in spite of large increases in both markets. Year-end stocks peaked at 77.3 million cwt of rice in 1985–1986. From that peak, 1990 ending stocks were only about half the average level of the 1980s even though 1990 exceeded 1980 production by more than 8%. The figure also demonstrates persistent growth in domestic use and relative decline in the importance of exports.

## Production Costs

Relative to substitute crops such as soybeans, rice has a high production cost/a. The costs of producing rice include chemicals (fertilizers and pesticides), machinery and equipment, power and energy, irrigation water, and other major and minor inputs. Extensive preparation before planting alleviates many problems that might affect yields. Such preparation costs as leveling, terracing, and flooding are substantially higher than those incurred for other crops. Total production costs increased steadily through the late 1970s and the early 1980s but have declined since their high in 1981. Total production costs are lowest in the Delta area (Arkansas, Mississippi, and Louisiana), where farmland is well suited to rice production, and irrigation water is abundant.

## Government Rice Programs

Federal legislation affecting rice producers has been in effect since the early 1930s. Much of the legislation adopted since has involved programs affecting acreage and thus rice supply. Legislation passed in 1938 (Public Law 430, 75th Congress) enacted a policy toward conservation and supply controls through acreage adjustment, marketing quotas, and storage under loans of excess supplies. Nonrecourse loans were offered in 1941 to producers harvesting rice within the government's acreage allotment provisions.

Because producer income also was a concern during the early rice-legislation years, producers received payments according to the *parity price*, defined as the price giving a unit of product the same purchasing power that it had had from 1910 to 1914. *Parity income* was defined as the gross income maintaining income parity for producers relative to other actively employed individuals elsewhere in the U.S. economy (Holder and Grant, 1979).

By 1954, rice production had increased much more rapidly than had domestic and foreign consumption, and the CCC held its first significant share of production in stocks. By passing the Agricultural Adjustment Act (AAA) of 1954 (Public Law 690), the 83rd Congress set out to reduce stocks by setting support prices between 75 and 90% of parity. Promotional efforts encouraging consumption of U.S. rice in foreign countries were included in the Agricultural Trade Development and Assistance Act of 1954 (PL–480), whose purpose was to reduce rice stocks and to improve trade relations with other countries. From 1955 to 1973, acreage allotments and marketing quotas were used to reduce CCC stocks and to stabilize their growth (Holder and Grant, 1979).

In the 1970s, Congress shifted attention from acreage allotments and market quotas to market oriented programs. A target price was established, and direct payments were made to producers holding rice acreage allotments. Payments were based on the difference between the target price and either the August–December farm price or the loan rate, whichever was higher. Acreage planted above allotments received no loans or direct payments. A cap of $55,000 was placed on the total amount that could be paid any one producer. 1978 legislation provided for set-aside and diversion provisions when supply became excessive.

Rice legislation in the 1980s eliminated the rice-acreage allotment system. Planting patterns and government payment eligibility of producers no longer were restricted by allotment holdings, and payments became based on actual production. At the discretion of the secretary of agriculture, target prices were to be set and loan rates adjusted by the same percentage. An ARP also was introduced to divert land into approved conservation uses. Other measures, e.g., paid land diversion and a Payment-In-Kind program, were used simultaneously with ARP in 1984 to reduce acreage and large government surplus rice stocks.

The FSA of 1985 set farm policy for the 5-yr period ending on September 30, 1990. This legislation attempted to reduce rice stocks by encouraging aggressive competition in the world market. The U.S. farm price for rice was allowed to move to the calculated world level by means of a marketing loan program. Price and income support payments were continued, but target prices for each succeeding year were lowered.

Government support payments, as designed by the legislation, have been an important source of income stability and of a substantial proportion of rice producers' income, especially early in the marketing loan program period (Cramer et al., 1990). Subsequently, government payments have declined as burdensome stocks have been liquidated and market prices have increased. Every year since 1975, producers have received payments of various amounts from the government. Before 1975, direct payments had not been made to rice farmers since 1957, under the acreage and conservation reserve programs established by the AAA of 1956.

Income for rice producers has been especially dependent on government payments since the 1983 crop year, when payments under the various programs amounted to 41.4% of their total rice income. For the 1980s, government payments averaged 30% of annual producer income, peaking at 64% of total income and at 178% of the value of the rice crop itself. Payments declined in the late 1980s; for example, in the 1988–1989 crop year, higher crop values and lower government payments resulted in a government payment share of total income below 40%.

### Rice Research and Promotion

Rice producers in the United States actively have supported rice research and promotion funding. Funding for rice research and promotion is quite similar in most of the rice producing states. A legislative check-off system is used to secure the funds needed for related activities. This program consists of a mandatory tax/bu or tax/cwt, which is collected from the producer at the first point of delivery. Most states, however, have a refund clause allowing farmers to request a refund of tax contributions.

Money for national promotion goes to the Rice Council for Market Development (RCMD) (a board composed of elected members from each state Rice Council). Each state has a prescribed number of board members on the RCMD, the number being determined according to funds allocated by both domestic and foreign promotion of U.S. rice. Foreign promotion funds are supplemented by the USDA–FAS.

From 1986–1989, $18.6 million was expended by the RCMD under the Foreign Market Development Program and the Targeted Export Assistance (TEA) program. Producer sources for funding grew when California joined the RCMD in 1987.

Two other boards are active in research and promotional efforts. The National Rice Research Board (NRRB) is an organization of representatives from the five southern states that coordinates ongoing research developments. The main objective of another group, the Rice Foundation, composed of members of the NRRB and the RCMD, is securing industry funding for rice promotional and research efforts.

## Organization of the Marketing System

### Overview

The rice industry is the total of all value-adding operations performed during production and marketing stages. Within each sector of the industry, decisions are made regarding input supply, production, transportation, processing, and marketing.

An agricultural commodity marketing system such as that for U.S. rice entails not only producers of the commodity but also a network of processing and marketing channels facilitating movement of the desired product to consumers. Figure 7.1 illustrates the nation's rice marketing system, from farm production to final consumption.

Rough rice is produced on farms using seed and other productive inputs such as land, machinery and equipment, labor, fertilizer, chemicals, and irrigation water. When harvested, rice typically contains 15 to 22% moisture. To prevent spoilage during storage, the grain must be dried to a moisture content from 12 to 13%. Drying and storing are the first postharvest stages in the market channel and are carried out in either on-farm or commercial facilities.

Rice must be milled before it can be consumed. Before milling, the essential characteristic of rice is kernel size. Processing of rough rice is completed in mills designed to clean, hull, and sort kernels. Milling facilities further process rice into forms for either direct consumption or further-processed food use. Rice can be processed as regular milled, parboiled, precooked, or brown.

Once milling is complete, milled rice and by-products enter domestic and export segments. Traditionally, by-products of the milling stage (bran or mill-feed) have been used primarily for livestock feed. Because of the potential cholesterol reducing effects of bran, however, these by-products are beginning to be used in processed foods. Additionally, hulls are used for chicken litter, industrial products, and—increasingly—fuel fodder in industrial burners.

United States food processors purchase rice in milled form for further processing and use the grain in specific product lines. Further processing at this stage may involve the addition of other ingredients for packaged mixes or the use of rice in alcohol production.

Once harvesting is complete, rice flows into two major channels: (1) on-farm drying and storing and (2) commercial drying and storing. The former channel is self-descriptive; the latter is composed of both independent and cooperative facilities.

When marketing their rice, producers have a number of alternative pricing methods, such as pooling, bidding, direct contracting, and hedging. Each producer chooses the pricing method best fitting his or her risk behavior and desired payment timing. With alternatives in prices, there also are alternative marketing methods.

Producers not delivering their rice to a cooperative usually sell to a proprietary milling facility and pay for drying and short-term storage before the rice is sold. Thus, the rice often remains in on-farm storage or commercial facilities until relocated to a storage facility at a milling site.

## Drying and Storing

Commercial warehouse and on-farm drying and storing are integral parts of the marketing channel. Farmers without their own storage facilities must have access to others. Because rice is harvested over a short period, large surpluses can occur throughout harvest. But milled rice is demanded for consumption on a daily basis. The resulting imbalance of supply and demand creates the necessity of a postharvest, premilling stage at which rice is stored until processing.

In addition to supplying storage space before milling, these facilities also provide drying services to maintain quality during extended storage. Rice is different from other cash grain crops, e.g., soybeans and wheat, the consumption of which usually occurs in crushed or flour states. Because rice is consumed in kernel form, the number of broken kernels must be minimized throughout all premilling stages.

Exposure to rapid moistening or drying before milling can cause cracks or fissures in the rice kernel (Kunze and Calderwood, 1980). Unsatisfactory drying also can have a dramatic effect on grain milling quality. Cracks caused by poor harvesting or drying methods can cause broken kernels during milling and thus lower prices and lower profits for farmers, drying facilities, and mills.

## On-Farm Drying and Storing

Investment in on-farm storing and drying facilities allows rice producers to integrate operations further. By utilizing on-farm drying and storing facilities and by performing related functions themselves, producers may be able to improve returns. Improved returns on such an investment may result because costs of drying and storing are lower than commercial rates or because greater care in handling rice leads to higher quality and price.

One study indicated that producers willing to accept the increased risk of price uncertainty can increase the price of their rice by providing their own drying and storing facilities (Elam and Holder, 1985). Specifically, producers could realize a gain of as much as $0.16/cwt. But the risks associated with storage also led to a variation of $0.22/cwt in the net price received.

Although on-farm storing and drying facilities are located in every major rice producing state, no data are available on the number of farms with facilities or the total capacity of existing on-farm facilities. Since 1982, farm stored quantities have declined in each state because of decreased production levels. The percentage of on-farm stocks peaked at 37% in 1982, fell to as low as 25% in 1986, but recently has increased to 34%.

## Commercial Drying and Storing

Commercial drying and storing facilities are alternatives to on-farm facilities and include both independent and cooperative facilities. Commercial plants are important to the industry's market channel. December 1 of each year is used to indicate the largest supply period of the year. Warehouse dryers typically have held more than 60% of U.S. rice stocks in recent years. California warehouses stored the greatest percentage of its stocks in commercial facilities. Louisiana and Mississippi held the smallest percentage of rice stocks in commercial facilities because of abundant on-farm storage space.

The number of commercial warehouses has been increasing since the mid-1960s (Smith et al., 1990). Fluctuations have occurred in the number of facilities, and certain capacity ranges have declined. Commercial storage facilities with capacities of less than 400,000 bu have demonstrated the only recent decrease in numbers. This decrease could have resulted from expansion of existing facilities as well as from forced exit due to noncompetitiveness.

The combined five-state data indicate that the total number of commercial warehouse facilities has been increasing since 1965, with the most significant increase occurring in the greater-than-1,200,000-bu capacity category. The greatest number of facilities occurs in Arkansas, where the number of commercial rice dryers has increased by 44% since 1965 to 1986 with a 10% increase between 1982 and 1986. By 1986, Arkansas had 35% of all dryers in the five states and 38% of facilities with capacities exceeding 400,000 bu. The greatest decrease in warehouse capacity occurred in Texas, where increased production costs for rice shifted planting patterns to other crops.

Drying facilities are affected by government policy changes. For example, the 1981 farm bill raised the producer loan rate above world rice price levels. As a result, production levels for 1981 were the highest ever, reaching 183 million cwt and causing storage shortages.

Local dryer cooperatives unaffiliated with marketing cooperatives also are available as a marketing alternative. These facilities may either market rice to a mill for the producer or act only as a drying and storing facility. In Texas, most nonaffiliated-cooperatives' marketing decisions are made by individual producers.

Since the early 1970s, the number of cooperative facilities has increased only 29% whileindependents have gained 56%; both types of facility have more than doubled capacity. Thus, capacity increase most likely has been due to the expansion of existing facilities operated by cooperatives, whereas independent growth most likely has been due to the increased number of new facilities (Smith et al., 1990).

## Rice Milling

The milling sector of the U.S. rice industry receives, stores, processes, packages, and distributes rice. Compared with the number of storing and drying facilities, the number of rice mills is small. The size of individual mills and the extent of their vertical integration also has increased, creating a more concentrated sector with a smaller number of firms possessing a larger share of national milling capacity.

During the milling stage, rough rice is received from storing facilities in the surrounding production area, milled, and shipped. Mills must have available storage space for their rough rice. This is working storage to hold rice destined for processing within a short period; some mills also have attached drying facilities. The major function of local rice drying and storing facilities is to provide long-term storage until the mill itself has working storage available for rough rice. Rice mills also must have clean-rice storage to facilitate orderly marketing arrangements.

Direct processing in mills involves cleaning, shelling, and sorting of rough rice. Sorting of rough, brown, or white rice is done according to size, grade, and color, with several types of rice being processed for direct food use. Regular milled white rice has the hull and bran layers removed by friction or abrasion; brown rice is processed similarly, but the bran layer is retained on the kernel.

Mills are of two basic types—regular and parboil—and nearly all are capable of producing both white and brown rice. Because of the need for uniformity in milling, due to screening and calibrations on hullers and bran removal equipment, mills typically process in lots containing like cultivars. Parboil mills prefer cultivars that tend to be uniform throughout the parboiling process.

Understandably, as one moves from the producing to the processing sector in most agricultural industries, the number of active firms decreases sharply. This situation occurs in therice market system as well; in fact, the milling sector has the smallest number of firms in the industry. In 1985, there were approximately 12,000 rice farms, 300 rice dryers, and 66 rice mills in the United States. Numerous studies have addressed such structural characteristics of the milling industry as the number of mills, their locations, and their sizes (Godwin and Jones, 1970; Holder and Grant, 1979; Wailes and Holder, 1987).

Before 1978, rice mill numbers had decreased to as few as 40. Milling technology had increased at such a fast pace that a great number of mills were forced out of business by newly remodeled, more efficient factories. By 1985, however, 66 mills were operating, a consequence of the greatly expanded rice output generated by farm policy changes in 1978 and 1981. Whereas the number of U.S. mills increased by half between 1978 and 1985, the number of active mills in Arkansas increased by more than 160%.

As scale economies in rice milling contribute to the growth of large firms, this sector becomes more concentrated, with fewer firms handling the bulk of product passing through the system. Thus, the degree of concentration, or *concentration ratio*, i.e., the proportion of total output handled by a few of the largest firms in the industry, can indicate the degree of potential competition in the industry.

In the U.S. rice industry, the concentration ratio for the eight largest milling firms has increased from 66% in 1963 to 75% in 1982, meaning that in 1982 the eight largest firms milled 75% of U.S. rice while the other 58 mills processed the remaining 25% (U.S. Department of Commerce, 1963, 1982).

Competition for the procurement of rice in different regions sometimes is unfeasible. Mills in California and the southern rice regions, for example, are unable to compete with one another because of the great distances involved. But competition does exist among mills in the South. Texas mills obtain some of their rice in Louisiana, and much of Missouri rice is purchased by Arkansas mills.

Although the number of mills in the United States in 1989 was quite similar to the number in the early 1960s, there had been considerable structural change within this sector. A number of mergers and acquisitions have resulted in concentration. Individually owned, single-facility rice mills have been replaced by larger facilities. Yet data indicate that the number of very small mills is increasing, possibly because the markets for specialty products and the demand for rice among ethnic populations are expanding (Wailes and Holder, 1987).

### Transport Mode

Nearly all rough rice is shipped by truck from farm and commercial storage to mills. A survey of rough rice flows for 1982–1983 indicated that 96% moved by truck and 4% by rail (Wailes and Holder, 1985).

## Pricing Practices and Strategies

### Marketing Methods

Rice producers actively seek the highest return through the use of alternative marketing methods. Within the rice industry, organized pricing methods as well as direct sales agreements between producers and mills have developed. The ways in which rice is marketed will differ among individuals and production areas. For instance, producers in both Arkansas and California market primarily through marketing cooperatives located in their respective states. But producers in Louisiana and Mississippi rely primarily on direct sales or bidding.

Marketing agencies acting only as selling agencies operate in all the southern rice-producing states. Such agencies can be either independent firms or cooperative marketing associations. Independent selling agencies handle no commodity physically. Instead, samples of the rough rice are delivered from either the producer or the commercial storing facility, shelled and milled by a small huller and miller, and graded by the agency. Interested buyers representing mills arrive on sale days and inspect the samples. A sealed bid method is used to sell each lot.

After receiving a bid, producers usually are given 24 hr to respond. On acceptance, ownership is transferred by the selling agency, with the buyer paying the transportation costs arising from movement of the rice from storage.

The Louisiana Farm Bureau Marketing Association has a rice sales desk for marketing members' rice. An estimated 20% of the state's rice marketings for the 1987 crop year was sold by the Bureau. Arkansas has three independent rice marketing companies, which marketed an estimated 6% of production in the 1987 crop year. Between 40 and 50% of Mississippi rice production was marketed by the bid and acceptance method. Texas, with 17 sales desks, had the greatest number of agencies marketing rice by the bid and acceptance method. Such marketings are estimated to constitute more than one-third of Texas' total rice output. California was the only state not using marketing associations as a method of marketing rice, primarily because marketing cooperatives predominate there.

Most rice marketing agencies charge a flat-rate fee/unit (bu or cwt) for sales made, and some agencies offer to producers services beyond marketing rice. For instance, some agencies make payments to creditors owed by the producer from gross rice sales. These creditors may be commercial drying and storing companies, land owners, water districts, or others. Such payments, once made, are subtracted from marketing earnings, the balance of which producers receive.

Rice marketing agencies perform an important price-discovery function in the marketing of rough rice. Before futures markets were established for rice, no other price discovery mechanism had existed on which farmers could depend to determine the value of their crop.

### Cooperative Pooling

Rice marketing cooperatives in California and Arkansas use a seasonal pool for grain storing and marketing. Seventy percent of the rice production of these two states is marketed in this manner. Rice delivered to cooperative dryers is sampled, graded, and commingled with other producers' rice of like quality. A partial payment is made to producers at the time of delivery, with additional payments made later in the year. Costs associated with drying and storing also are pooled. Producer members pay a base rate/unit of rice, with discounts and premiums given for quality and moisture-content differences.

Cooperatives are an important element in the structural makeup of the rice industry. The Rice Millers' Association (RMA) indicates that cooperatives processed half the 1987 U.S. rice crop. Cooperatives within the rice industry usually are more vertically integrated than most other farmer cooperatives are. This integration extends from provision of seed rice, machinery, fertilizer, and credit to produce the crop to drying and storing, milling and transporting into distribution channels.

The major cooperative strength within the industry is concentrated in four marketing cooperatives, two in Arkansas and two in California. These allow producers to be integrated vertically from the production stage through the marketing of milled rice to consumers. Profits realized from drying and storing, milling, and marketing are returned to producers. Producer members of the marketing cooperatives usually are also members of locally affiliated dryer cooperatives. This system of membership is identical to that in a centralized cooperative, through which producers are members of the larger marketing cooperatives.

Cooperatives contract for the delivery of rice from their members by the end of June. The type of rice and the number of acres planted are specified. Contract terms differ in that some cooperatives penalize undelivered grain. Membership contracts specify that the cooperative will determine grade, weight, milling yield, class, and quality of all delivered rice, which may be pooled before or after milling with rice of like grade, class, and quality.

## Private Contracting

Rice also can be sold green, such that ownership is transferred directly after harvest, either through a private contract between the producer and the mill or at a public sale. Twenty-five percent of the rice marketed in 1984 was estimated to have been sold in this manner (Dismukes, 1988), which is favored by producers in Texas, Mississippi, and Louisiana.

## Government Marketing

The CCC is another market channel used by producers. Since the 1985 FSA, whose primary purpose was to reduce rice stocks, very little rice has been accumulated by the CCC, which acquires rice by offering producers nonrecourse loans. If the price to be received by producers is lower than the loan rate set each year by the secretary of agriculture, the producer may choose to forfeit the rice, and the CCC must take delivery in full payment of the outstanding loan. With the addition of the marketing loan mechanism, the producer could sell the rice even if the price was below the loan rate by as much as 50% in 1986–1987, 60% in 1988, and 70% since 1989. The difference is retained by the farmer and is called the *loan deficiency payment.*

## Futures Market

Another pricing mechanism that may be used as a marketing alternative is the futures market. Rice futures (No. 2 long grain) are traded on the Mid-America Commodity Exchange. Futures markets allow hedging opportunities for producers and handlers of rough rice, with speculators thus sharing in the risk of price fluctuations.

The rice futures market is quite thin. For example, rice open interest futures contracts amounted to only 13 million bu on February 16, 1988, whereas soybean open interest futures contracts amounted to 622 million bu. These quantities comprised 6.7 and 32.7% of the rice and soybean crops, respectively. The thinness of the rice futures market can lead to great price fluctuations on days of heavy trading. The major benefit of the active rice futures market is that of providing a price discovery system similar to that for other grains (Chicago Rice and Cotton Exchange, 1988).

Rice futures contracts not offset by an opposite futures transaction before the last day of trading for that contract month must be delivered. Delivery of rice on a futures contract must be an alternative to permit the futures and cash price to converge as the contract month approaches. Once the short (sell) and long (buy) contracts are matched by the Board of Trade Clearing Corporation, each person is notified.

Delivery points for short-contract holders (sellers of contracts) are in 12 designated counties in Arkansas. Price is determined according to the settlement price on the last day of trade for that contract. Storage charges for the rice must be paid by the seller through the delivery day. Price is adjusted by discounts and premiums over the par milling yield of the contract, which is 55/70 (55 representing the percentage of whole kernels; 70, the percentage of total milling yield). Premiums and discounts are 1.75% for each percentage point difference in whole kernels, and 0.5% for each percentage point above or below 15% brokens (Mid-America Commodities Exchange, 1992).

### Producer Prices and Rice Quality

Producer prices typically are based on milling yields and reflect discounts and premiums for various quality characteristics, including BCFM. Because only a few cultivars are grown each year and all have unique processing quality-characteristics, prices depend on both cultivar and specific quality characteristics reflected in grades and standards.

### Quality Adjustments in the Market Channel

Because of vertical integration in the market channel, a situation due largely to the prevalence of producer cooperatives, observations on price adjustments for quality are made with difficulty. Export prices are adjusted according to percentage brokens, and grade classification is based on criteria differing among export countries (The Rice Council for Market Development, 1987).

### Price Dissemination

Milled rice prices, free-on-board (FOB) mill, and cost and freight at Rotterdam and German Ports (composite of ports near Rotterdam), by quality, are reported weekly by the USDA–AMS, in the *Rice Market News* (U.S. Department of Agriculture, various years). Information about rough rice prices is more difficult to obtain.

The USDA's monthly rice prices are estimated for all rice only, without separate estimates by rice type or grade. Moreover, monthly price estimates are based on a composite of rough rice prices and quantities reported by independent buyers and mills and rough-equivalent milled rice prices and quantities reported by rice cooperatives. Use of these two different price concepts in addition to aggregation over quality differences raises concerns about representativeness and quality signals in the reported price series. One additional useful source of price information is Louisiana market prices by grade, cultivar, and milling yield, which occasionally are reported in the *Rice Market News*.

### Summary of Price-Quality Sophistication

The level of sophistication characterizing price and quality relations within the U.S. rice industry is high. Notwithstanding, knowledge of the relative value of quality differences could be more inaccessible to farmers when the lack of published price data by the USDA and the relatively small number of rough rice buyers are considered. Premiums and discounts for quality characteristics are used widely.

Emphasis on quality in varietal selection influences choices available to producers and mills. Considerable communication among mills, producers, and breeders transpires to maintain the level of production necessary to meet the quality requirements of mills. Because quality is influenced and controlled from production to final processing, all sectors in the market channel can be analyzed in terms of related quality issues.

## Quality Measurement in the Market Channel

### Important Quality Attributes

Because rice can be used in a great variety of ways both domestically and abroad, milling, processing, cooking, and nutritional characteristics are quite relevant to quality determination and measurement. Even for the same use, very different tastes and preferences exist, with distinctions based on cultural and ethnic preferences, especially in terms of grain size, stickiness, and flavor.

Quality determination reflects objective as well as subjective criteria, with the relative importance of each criterion depending on end use. Because rice, unlike other cereals, usually is consumed as a whole grain, the physical characteristics of the whole grain, e.g., shape, size, uniformity, color, and general appearance, are its most important quality attributes (Webb, 1985).

Rice quality is influenced by genetics and by environment. In the United States, cultivars are selected in a collaborative state-federal breeding program at the experiment stations of Arkansas, California, Louisiana, Mississippi, and Texas. Private rice breeding and seed companies have a very minor share of breeding and seed markets, unlike such companies in some other grain and cereal markets.

This situation probably is due in part to the relatively small scale of the rice seed market (approximately 3 million a.), the high cost—in terms of labor—

of developing hybridized rice seed, and the efficiency of the current system, whereby state-federal breeding programs in collaboration with state seed foundation programs work closely with the industry to produce cultivars with desirable end-use qualities. This system is enhanced by the USDA National Rice Quality Laboratory at Beaumont, Texas, which assesses cooking and processing qualities of developmental cultivars.

Environmental factors include influences such as weather and cultural practices during field growth, timing, duration, harvest purity, and postharvest operations such as drying and storing, handling and transporting, milling and packaging. A number of books and handbooks contain extensive reviews of rice-quality testing procedures (c.f., Houston, 1972; International Rice Research Institute, 1979; Juliano, 1985; Luh, 1980; U.S. Department of Agriculture, 1975; Wolff, 1982).

## Quality Characteristics Common to All Users

The most important quality characteristics common to all users include (1) milling qualities—milling yield, kernel size, shape, weight, uniformity, and general appearance (translucence and color) and (2) cooking and processing qualities—percentage of amylose and alkali spread (Webb, 1985). Milling qualities include physical descriptions. The most important descriptor in this country is length of grain.

Webb (1985) summarizes characteristics and provides average values and ranges for physical properties by class of rice. Milling yield is of obvious importance, for it is a measure of head (full grain) and of total (full plus broken) yield. Because most rice is consumed as whole grain, a premium is attached to rice yielding a great whole grain percentage. Milling yields are influenced by many factors, including heritability.

Physical abnormalities such as chalk, *peck* (insect damage), and heat damage typically lower milling yield and grade. End uses for which a high milling yield is a meaningful quality characteristic include brewery and flour uses. In fact, high milling yield generally increases the cost of brewer's rice and flour because of the resulting relative shortage of brokens.

Important cooking and processing qualities for users include texture and stickiness. Distinct preferences for dry, fluffy, separate grained rice compared with moist, clingy, sticky rice are found in the United States as well as in other countries. The two most important quality indicators for these characteristics are *percentage amylose*—a predictor of stickiness, and *alkali-spreading value*—a means of classifying rice in terms of gelatinization temperature.

These chemical characteristics tend to differ by rice type in the United States. Specifically, long grain types tend to have relatively great amylose and relatively small alkali-spreading values, which result in relatively dry, fluffy, and nonsticky rice. On the other hand, medium and short grain cultivars have been selected for relatively low amylose and high alkali-spreading values, which result in relatively moist, sticky rice.

## Quality Characteristics of Concern to Specific Users

Numerous other quality characteristics are important to only one or more end-users. Hull color, for instance, is important in the parboiled rice industry because a dark golden color will impart a dark stain on the endosperm during parboiling. Because markets generally prefer a light stain, a light hull color is desirable.

Bran color has a similar staining effect but also is an important quality characteristic for regular milled rice. Removal of dark brans generally requires great milling pressure, which tends to result in lowered milling yield due to breakage.

Translucence is an important quality characteristic for all types of rice except glutinous cultivars, which are opaque. Glutinous cultivars have extremely low amylose and very high amylopectin contents and thus commonly are used in dessert rice in the United States.

Test weight is an important predictor of total milled rice yield and is a useful quality characteristic to consider during determination of weight and volume relations during drying and storing. The U.S. standard is 45 lb/bu; the average for long grain, however, ranges from 42 to 45 lb, and that for medium and for Short Grains ranges from 44 to 48 lb (Webb, 1985).

Selective cooking and processing qualities are important in a few industries. The use of milled rice as an adjunct in beer production is enhanced by the grain's low lipid content; because most oils are in the bran layer, brewer's rice must be well milled. High levels of either lipid or oil in the rice adjunct can lend an off-flavor, reduce fermentation efficiency, and limit foam formation and retention (Yoshizawa and Kishi, 1985).

The brewery typically sets a permissible range of particle sizes for broken rice. High gel temperature and viscosity (characteristics typical among long grain cultivars) reduce brewing efficiency. On the other hand, these long grain characteristics, as well as high levels of amylose, are desired for grains used in canned, precooked, and parboiled rice.

A relatively new quality characteristic demanded in U.S. rice consumption is aroma. Traditional and well-established Asian cultivars such as Basmati (Pakistan and India) and jasmine (Thailand) are popular aromatic cultivars throughout the world. Several aromatic cultivars have been available in the United States for a number of years, and growth in demand for this type of rice has been relatively rapid.

# Quality Control in the Market Channel

## First-Handler: Voluntary, Private

Quality control in rice is initiated when producers select cultivars to plant. Cultural practices such as insect and weed control prevent harvest contamination with pecky rice, red rice, and numerous other quality degrading factors. By rewetting field-dried rice, adjusting cylinder speed of the combine, and limiting foreign material transferred into the grain bin, producers can influence quality in terms of grain-moisture content at harvest.

The percentage of moisture in the grain at harvest has a nonlinear relation with milling yield, with low yields resulting from grain harvested at moisture levels above 25% or below 16%. Needless to say, this relation depends to some extent on cultivar. Harvest at too high a moisture level can result in chalky rice, as can numerous other factors (Webb, 1985). Harvest when grain is field dried below 16% moisture increases the potential for stress cracking, mechanical injury, and rewetting. In general, the slower the cylinder speed of the combine, the greater the milling yield. This relation is even more important for grain harvested at low moisture levels (Dilday, 1989).

A primary concern among millers is that grain be dried to a standard moisture level of 13%. Although many factors during the drying and storing stage contribute to quality changes, most important is the rate at which rice is dried. Drying too rapidly at too high a temperature generally will lead to low milling yield due to stress cracking (Kunze and Calderwood, 1980). Cleanliness, insect control, and adequate aeration are important quality control activities during storage.

## Interfirm Transfers

More than half the U.S. rice crop moves from farms to producer cooperatives with well-integrated drying and milling operations. Quality control at the first-handler stage in U.S. rice therefore tends to be relatively comprehensive. Deliveries typically are sampled for moisture and grouped by grade and cultivar to be cleaned, dried, and stored. A dried sample will be sent to the quality control lab of the mill where the milling grade is evaluated.

As the commingled sample moves to the mill, the lot shipment is resampled to form uniform quality groups for milling. Transfers from private elevators or rice auctions to private mills are accomplished in a similar manner, with dried samples being made available for inspection to rough rice buyers.

## Exports

Export shipments are graded by the USDA–FGIS or, if the importer agrees to the procedure, by an independent grading firm. Industry sources have indicated that approximately half of U.S. rice is graded by the USDA–FGIS. Official grades are used essentially as minimum standards in the nation's rice trade. Because rice processors have many different requirements, rice mills typically will have more specific quality requirements. For example, criteria regarding peck and heat damaged kernels for parboiled rice generally are relatively rigid, with allowances for chalk and head yield.

# Grades and Standards

## Inspection and Grades

Long, medium, and short grain rice types are graded as U.S. No. 1 through U.S. No. 6. If the grain fails to meet the requirements for any of the six grades, it is labeled U.S. Sample Grade. The USDA–FGIS will inspect samples sent to one of their offices. But grade placed on the submitted sample is for the rice contained in the sample only. An official lot inspection certificate can be obtained if an employee or inspector of the USDA–FGIS takes the sample from a lot of rice and inspects and grades that sample.

Federal inspection is voluntary. An inspection certificate issued after a federal lot inspection clearly is, however, a safeguard for both buyer and seller. Although federal inspection is used primarily for export rice, the service is used to some extent in all transactions, from farm to final distributor.

### General Description

Grades and grade requirements for classes of rough rice, brown rice, and milled rice are provided in Tables 7.1–7.3, as published in the *United States Standards for Rice* (U.S. Department of Agriculture, 1983) and in the *Rice Inspection Handbook* (U.S. Department of Agriculture, 1982).

### Sources of Authority: Legislative, State, and Federal

The statutory authority for rice standards is found in the Agricultural Marketing Act (AMA), part 68. State inspectors in California and Missouri currently have federal authority, but inspection in all other states including Arkansas, Louisiana, Mississippi, and Texas is conducted by federal personnel. Because federal inspection is mandatory only for government assisted exports, federal inspection has become increasingly limited to this movement. Increases in user fees, in addition to the vertical integration common throughout the industry, have led to primary reliance on either internal quality control or independent grading firms.

Although the USDA–FGIS is responsible for setting grades, a committee of the RMA meets regularly to evaluate and to revise grade standards.

### History of Grades and Changes

Although grade standards have not changed significantly since their introduction, adjustments have focused on inspection procedures. Some standards, of course, have been changed; for example, seed limits in brown rice have been tightened in response to industry needs.

With the growing importance of specialty rice, new standards have been introduced such as those for *waxy*, or glutinous, rice, whose opaque white appearance can be labeled only Sample Grade under the Milled Rice Standard. This problem occurs because waxy rice is difficult to distinguish in appearance from chalky rice.

Another recent issue has been the grading of aromatic rice. In appearance it grades similarly to most long grain cultivars currently grown in the United States. Mills, however, wish to prevent aromatic currently from being mixed into milling lots because the aroma can contaminate both equipment and non-aromatic currently. Current grading procedure requires the designation *aromatic*, along with the regular milled rice grade requirements. If rice is inspected without being declared *aromatic* and a natural aroma is detected, it is considered Sample Grade.

## Rice-Quality Measurement Technology

Measurement technology for various quality factors in rice has not changed substantially over recent years. Comprehensive reviews of measurement technology and methods are found in Kunze and Wratten (1985), Webb (1985), Juliano (1985), and the USDA (1982, 1983). Because appearance is so important, many factors tend to entail a great degree of subjectivity. Rice inspectors, both federal and independent, attempt to control for this source of error by submitting graded samples to an additional inspection office for review.

Various attempts to make grading procedures more objective are being attempted. Japanese manufacturers, for example, are introducing equipment able to measure simultaneously a wide set of quality factors. Other research in the United States is attempting to develop measures of grain fissure before drying. Such measures would enhance the ability early in the market channel to sort and to store rough rice by potential milling yield.

## Quality Related Issues and Problems

### Price-Quality Relations

Limited research has investigated price and quality relations in rice. Hedonic price models have been studied by Grant et al. (1986), Brorsen et al. (1984, 1988), Fryar et al. (1986), and Denison et al. (1988). The models regress rough rice price as a function of mill price and a set of quality factors. The studies use different methods to the extent that they use different rough rice prices. Some use the bid price, which reflects demand for quality characteristics; others use the settlement price so as to examine the equilibrium supply and demand of quality factors.

Quality factors typically included in these studies are head yield, broken kernel, seed, peck, red rice, smut, chalk, green rice, heat damage (*stack*), and test weight. Study data indicate that the most important

**Table 7.1.** **§ 68.210 Grades and grade requirements for the classes of rough rice (U.S. Department of Agriculture, 1983)**

| | Maximum limits of | | | | | | |
|---|---|---|---|---|---|---|---|
| | Seeds and heat damage | | | Chalky kernels[a] | | | |
| Grade | Total (singly or combined) (kernels in 500 g) | Heat damaged (singly or combined) (kernels in 500 g) | Red rice and damaged (singly or combined, %) | In long grain rice (%) | In medium or short grain rice (%) | Other types[b] (%) | Color requirements[a] |
| U.S. No. 1 | 4 | 3 | 0.5 | 1.0 | 2.0 | 1.0 | Shall be white or creamy |
| U.S. No. 2 | 7 | 5 | 1.5 | 2.0 | 4.0 | 2.0 | May be slightly gray |
| U.S. No. 3 | 10 | 8 | 2.5 | 4.0 | 6.0 | 3.0 | May be light gray |
| U.S. No. 4 | 27 | 22 | 4.0 | 6.0 | 8.0 | 5.0 | May be gray or slightly rosy |
| U.S. No. 5 | 37 | 32 | 6.0 | 10.0 | 10.0 | 10.0 | May be dark gray or rosy |
| U.S. No. 6 | 75 | 75 | 15.0[c] | 15.0 | 15.0 | 10.0 | May be dark gray or rosy |
| U.S. Sample | Shall be rough rice that (a) does not meet the requirements for any of the grades from U.S. No. 1 to U.S.No. 6, inclusive; (b) contains more than 14.0% of moisture; (c) is musty, sour, or heating; (d) has any commercially objectionable foreign odor; or (e) is otherwise of distinctly low quality. | | | | | | |

[a] For the special grade parboiled rough rice see § 68.212(a).

[b] These limits do not apply to the class mixed rough rice.

[c] Rice in grade U.S. No. 6 shall contain not more than 6.0% of damaged kernels.

**Table 7.2.** **§ 68.261 Grade and grade requirements for the classes of brown rice for processing (maximum limits) (U.S. Department of Agriculture, 1983)**

| | Paddy kernels | | Seeds and heat damaged kernels | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Grade | (%) | (No. in 500 g) | Total (singly or combined) (No. in 500 g) | Heat damaged kernels (No. in 500 g) | Objectionable seeds (No. in 500 g) | Red rice and damaged kernals (singly or combined, %) | Chalky kernels[a] (%) | Broken kernels removed by a 6 plate or a 6 1/2 sieve[b] (%) | Other types[c] (%) | Well milled kernels (%) |
| U.S. No. 1 | — | 20 | 10 | 1 | 2 | 1.0 | 2.0 | 1.0 | 1.0 | 1.0 |
| U.S. No. 2 | 2.0 | — | 40 | 2 | 10 | 2.0 | 4.0 | 2.0 | 2.0 | 3.0 |
| U.S. No. 3 | 2.0 | — | 70 | 4 | 20 | 4.0 | 6.0 | 3.0 | 5.0 | 10.0 |
| U.S. No. 4 | 2.0 | — | 100 | 8 | 35 | 8.0 | 8.0 | 4.0 | 10.0 | 10.0 |
| U.S. No. 5 | 2.0 | — | 150 | 15 | 50 | 15.0 | 15.0 | 6.0 | 10.0 | 10.0 |
| U.S. Sample | Brown rice for processing that (a) does not meet the requirements for any of the grades from U.S. No. 1 to U.S. No. 5, inclusive; (b) contains more than 14.5% of moisture; (c) is musty, sour, or heating; (d) has any commercially objectionable foreign odor; (e) contains more than 0.2% of related material or more than 0.1% of unrelated material; (f) contains live weevils or other live insects; or (g) is otherwise of distinctly low quality. | | | | | | | | | |

[a] For the special grade parboiled brown rice for processing see § 68.263(a).

[b] Plates should be used for southern production rice and sieves should be used for western production rice, but any device or method that gives equivalent results may be used.

[c] These limits do not apply to the class mixed brown rice for processing.

Table 7.3. § 68.310 grades and grade requirements for the classes long-grain milled rice, medium-grain milled rice, short-grain milled rice, and mixed milled rice (U.S. Department of Agriculture, 1983)

| Grade | Maximum limits of: Seeds, heat damaged, paddy kernels (singly or combined) (per 500 g) | | Red rice and damaged kernel (singly or combined) (%) | Chalky[a] | | Broken kernels | | | | Other types | | Color requirements[a] | Milling requirements[d] (minimum) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Heat damaged and obj. seed | | In long grain rice (%) | In medium or short grain rice (%) | Total (%) | Removed by a 5 plate[b] (%) | Removed by a 6 plate[b] (%) | Through a 6 sieve[b] (%) | Whole kernels (%) | Whole and broken kernels (%) | | |
| U.S. No. 1 | 2 | 1 | 0.5 | 1.0 | 2.0 | 4.0 | 0.04 | 0.1 | 0.1 | — | 1.0 | White or creamy | Well milled |
| U.S. No. 2 | 4 | 2 | 1.5 | 2.0 | 4.0 | 7.0 | 0.06 | 0.2 | 0.2 | — | 2.0 | May be slightly gray | Well milled |
| U.S. No. 3 | 7 | 5 | 2.5 | 4.0 | 6.0 | 15.0 | 0.1 | 0.8 | 0.5 | — | 3.0 | May be light gray | Reasonably well milled |
| U.S. No. 4 | 20 | 15 | 4.0 | 6.0 | 8.0 | 25.0 | 0.4 | 2.0 | 1.0 | — | 5.0 | May be gray or slightly rosy | Reasonably well milled |
| U.S. No. 5 | 30 | 25 | 6.0[d] | 10.0 | 10.0 | 35.0 | 0.7 | 3.0 | 1.0 | 10.0 | — | May be dark gray/rosy | Lightly milled |
| U.S. No. 6 | 75 | 75 | 15.0[e] | 15.0 | 15.0 | 50.0 | 1.0 | 4.0 | 2.0 | 10.0 | — | May be dark gray/rosy | Lightly milled |
| U.S. Sample | Shall be milled rice of any of these classes that (a) does not meet the requirements for any of the grades from U.S. No. 1 to U.S. No. 6, inclusive; (b) contains more than 15.0% of moisture; (c) is musty, sour, or heating; (d) has any commercially objectionable foreign odor; (e) contains more than 0.1% of foreign material; (f) contains live or dead weevils or other insects, insect webbing, or insect refuse; or (g) is otherwise of distinctly low quality. | | | | | | | | | | | | |

[a]For the special grade parboiled milled rice, see § 68.315(c).

[b]Plates should be used for southern production rice and sieves should be used for western production rice; but any device or method that gives equivalent results may be used.

[c]These limits do not apply to the class mixed milled rice.

[d]For the special grade undermilled milled rice, see § 68.315(d).

[e]Grade U.S. No. 6 shall contain not more than 6.0% of damaged kernels.

quality characteristic is the percentage head yield, which is reflected in price premiums. Important discount factors consistent with grade standards are seed, peck, and red rice.

Brorsen et al. (1984) compared price models as a function of rough rice grade alone with models both of specific quality factors and of grade and quality factors. These researchers argued that rough rice grades inadequately represent the value of rough rice. The study demonstrates that, in addition to rough rice grade, variables such as head yield, mill yield, and test weight independently help explain rough rice price. Thus, a U.S. No. 1 rough rice lot might mill out with high brokens and result in a milled rice grade below U.S. No. 1. Rice mills, however, are oriented to make a low rough rice grade result in a high milled-rice grade by means of cleaning, sorting, and mixing.

## Price-Quantity Relations

The price-quantity relation has been examined little. Brorsen et al. (1984) have reported that size of lot shipment influences acceptance price behavior by producers. Specifically, the larger the lot size, the less likely a given bid price will be accepted. Producers with small lot sizes are more likely to accept a given bid price than to hold out for a higher bid. Cooperatives traditionally have avoided discriminating in this manner.

## Optimum Versus Maximum Quality

In that quality control is implemented throughout the market channel, beginning with the producer, hedonic price models for rough- and milled-rice prices can provide a framework in which to identify the benefits derived from improving a given measured quality factor. But the information in hedonic price models tends to indicate that economic returns due to quality control vary from year to year as a function of supply and demand (Brorsen et al., 1988).

Optimal costs of controlling red rice, peck damage, breakage, and other factors, although reported in these studies, generally are poorly understood from year to year and location to location. Red rice, one of the most persistent problems in U.S. rice production, has been subject to industrywide quality-control campaigns.

## Characteristics To Be Included

Because humans usually consume rice as a whole grain, most economically important characteristics are included in the grade and quality information used in rice transactions. Changes in the comparatively undifferentiated U.S. rice market, however, are likely to challenge the grading and quality evaluation system as increasingly diverse imported rice types continue to be demanded by the U.S. consumer (Wailes and Livezey, 1991). Factors such as aroma, color, appearance, and cooking properties will influence future rice quality issues.

## Quality and Market Competitiveness

The U.S. rice industry has an international reputation for offering the world's highest quality rice. This reputation has resulted from careful breeding programs, improved cultural practices, and modern and sophisticated rice drying and storing, and milling sectors. The United States has had a dominant market share in high-quality rice import markets such as Europe and the Middle East.

Two factors related to quality have, however, led to a shrinking U.S. market share. The first is that Thailand, an export competitor, has over the past 20 yr made substantial improvements in the quality of its rice exports. The export price premium commanded by U.S. long grain No. 2, 4% broken, relative to a comparable Thailand grade, has fallen markedly over time. Investment in handling and milling facilities in Thailand has done much to improve its rice export quality.

The second factor contributing to shrinking U.S. market share has been slow growth of the high-quality import market compared with rapid growth of the low-quality market. This difference is due to both demographic and income relations with consumption. The low-quality market tends to be much more competitive from an export supply position, in large part because infrastructure and costs can be lower and also because government-to-government sales of low-quality rice are taking place. For U.S. producers to compete in the low-quality market, they must rely on government export-programs. In short, the cost of a system necessary to deliver high-quality rice has to some extent priced the United States out of low-quality world rice markets.

Other issues related to rice quality include whether economic incentives adequately reflect qualities demanded for end use. A major problem in the rice industry is relating cooking properties to physical characteristics of uncooked rice. Using only a few cultivars with known cooking characteristics is a primary means by which the industry addresses this issue. The relation between cultivar and quality is discussed by Webb (1985).

## Information Dissemination

### Price, Quantity, and Quality Information

Information about rice prices, quantity, and quality is available for only a small proportion of the quantity marketed because producer cooperatives—where pricing and quality is an intrafirm activity—dominate the industry. Rice auctions in Texas, Louisiana, and Arkansas provide information about bids and acceptance prices, but it is not published widely. The *Rice Market News* (U.S. Department of Agriculture, various issues) typically reports representative Louisiana Rough rice sales reporting lot size, grade, cultivar, head, and total milling yield and price. Milled rice price data usually are reported by grade and by percentage broken kernel. The *News* also typically reports the offering prices of the United States, Thailand, Argentina, Uruguay, Surinam, Guyana, Italy, Brazil, and Australia.

### Promotion and Advertising: Government

The U.S. government provides for foreign market development through the FAS, which is responsible for a wide array of U.S.-produced farm products. Rice is promoted especially in traditional importing countries but also in countries with significant trade barriers. Because rice is a staple crop in most Asian countries, it is sensitive to political pressure. Consequently, trade protection and substantial import restrictions are common.

### Commodity Group Promotion

The RCMD, located in Houston, Texas, has the primary responsibility for promotion and market development of domestic and export markets. Because no international rice grading system exists, the RCMD initiated a study to evaluate world rice cultivars and types. Rice samples used in their studies are collected by the USDA and by international Council representatives. These samples are graded by the USDA–FGIS, according to the U.S. Standards for Rice. The Rice Council has received TEA funds to promote U.S. rice in export markets and cooperates with the FAS in developing foreign markets.

## Anticipated Industry Changes Influencing Quality

### Changes in Use

Growth in the domestic consumption of rice both directly and in processed foods has the potential to challenge quality requirements for the industry. Relatively new and growing uses include rice flour in instances when quality control of microbial activity is important. Growing demand for ready-to-eat and easy-to-cook rice may require new cultivars for which current standards are inadequate.

With the potential for liberalized trade in rice, the United States may have the opportunity toexport rice to countries, for example Japan and South Korea, with rigid quality requirements. Similarly, specialty rice imports into the United States have increased twentyfold during the 1980s (Wailes and Livezey, 1991). The growth of market niches may give rise to domestically produced substitutes for these imports. As discussed, aromatic cultivars, as they increase in popularity, may require their own standards.

### Production Changes

Production changes affecting quality are most influenced by cultivar, location, and cultural requirements. Development and maintenance of a national germplasm collection at Arkansas and at other state experiment stations can provide an important resource with which to continue to improve quality characteristics. The current geographic specialization of Indica-type Long and medium grain in the southern states and Japonica-types in California is unlikely to change rapidly; as world and domestic markets shift to create opportunities for different rice types and cultivars, however, adjustments in quality characteristics by location and cultivar will challenge breeders, producers, and processors to adjust and to develop rice of a quality satisfying end-use demand.

### Marketing Structure Changes

The market structure of rice in the United States experienced rapid growth in the 1970s, contraction in the early 1980s, and stabilized production in the late 1980s. As a result of contraction, rice firms and cooperatives were forced to compete aggressively for limited production. Restructuring has left firms and cooperatives evidently capable of providing a diverse rice product, both for domestic markets in direct and processed uses and for volatile export markets. With larger and more vertically integrated firms, the tendency will be to internalize price-quality relations, making such information more difficult to obtain.

Thus the ability of the market channel to provide adequate signals back to producers and breeders may be compromised. Despite sophistication in pricing and quality in the rice industry generally, most rice producers have limited information about how to achieve optimal quality and associated production practices and costs needed to improve net income.

### Quality Measurement

Continuing research on quality measurement and on quality characteristics' economic value is needed. Growth in specialty rice markets will require new techniques and tests for texture, taste, and flavor. New technology presents the opportunity for improved grading early in the market channel so that the efficiency of pricing and technical aspects of processing can be improved.

## Glossary

**Alkali-Spreading value.** Means of classifying rice in terms of gelatinization temperature.

**Brewers' rice.** Broken rice kernels measuring less than three-fourths of Whole Kernel length; used as a fermentable carbohydrate adjunct by several major U.S. breweries.

**Concentration ratio.** Proportion of total output handled by a few of the largest firms in the industry.

**Direct food use.** Consumption that has been milled but not processed further.

**Loan deficiency payment.** The difference, which producers retain, between price received for rice and loan rate.

**Parity income.** Gross income maintaining income parity for producers relative to other actively employed individuals elsewhere in the U.S. economy.

**Parity price.** Price giving a unit of product the same purchasing power that it had from 1910 to 1914.

**Peck.** Insect damage.

**Percentage amylose.** Predictor of stickiness of rice; measure of one type of rice starch.

**Processed food use.** Consumption of rice after other ingredients have been added or changes made in kernel composition for fermenting.

**Second heads.** See brewer's rice.

**Specialty rice.** Parboiled, precooked, brown, and aromatic types.

**Stack.** Heat damage.

**Waxy.** Glutinous, short-grain, low-gelatinizing types with nearly 100% amylose starch.

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# 8 Oilseeds

Thomas H. Applewhite[15]

## Introduction

Most oilseeds are produced primarily for the oils and the oil related products that can be derived through processing. But oilseeds also produce an important by-product—high-protein meal—that may be as important as the oil itself.

Seven major oilseeds were grown in the United States in the 1993–1994 crop year. Soybeans accounted for 84% of total tonnage, cottonseed for 11%, and peanuts for 3% (Table 8.1). Although sunflowerseed ranked fourth in production in the U.S. oilseed complex, it represented only 2% of total U.S. production of 58.729 Mt of all oilseeds. Canola, flax, and safflower, each with a highly specialized use and market, accounted for less than 1% of total production.

## Major Uses

All seven major oilseeds are processed into oil and meal, each with unique characteristics and end uses. All oils are used in industrial products, and high-protein meals are used as feed for livestock in domestic and export markets. A small quantity of soybean meal is used in the production of textured vegetable proteins, which are converted into food products such as meat substitutes and bacon flavored topping. Although growing, this market requires only a small proportion of the total crop. Soybeans and sunflowers also are used as food in various forms.

A great amount of the crude and degummed edible oil produced by crushers is sold to refiners, who refine, bleach, and deodorize it to produce salad oils. Some bleached oil is partly hydrogenated to improve stability and functionality and deodorized to provide base stocks for shortenings, margarines, frying fats, and other specialty fats.

Because each oilseed has unique characteristics and production and marketing practices, quality related issues for each will be discussed separately. Peanuts will be discussed in Chapter 9. As in the discussion of such problems for other commodities, the discussion of quality related problems for oilseeds will be limited to the raw product and will terminate when the commodity is converted to intermediate or to final product, primarily meal and oil. Quality measurements for oil and meal rely almost entirely on industry or trade association grades rather than on governmentally established grades and thus will be relegated to Appendix A except when direct relations with oilseed quality exist. Use of each oilseed will be discussed.

**Table 8.1. U.S. production of major oilseeds, 1993–1994 crop year (U.S. Department of Agriculture, 1994)**

| | Production | |
|---|---|---|
| | 1,000 t | Percent of U.S. |
| Soybeans | 49,220 | 83.81 |
| Cottonseed | 6,347 | 10.81 |
| Peanuts | 1,539 | 2.62 |
| Sunflower | 1,178 | 2.00 |
| Flax | 88 | 0.15 |
| Canola | 114 | 0.19 |
| Safflower | 243 | 0.41 |
| Total production | 58,729 | 100.00 |

### Soybeans[16]

More than half the U.S. soybean crop is used by the domestic crushing industry to produce meal and oil. Preliminary data for 1993 show an estimated crush of 34.3 Mt of soybeans out of a total production of 49.2 Mt, exports of 15.8 Mt, and seed and feed use of 2.6 Mt (Table 8.2).

In the United States, the ratio of export to domestic use is relatively constant. Over the last 7 yr, exports have ranged from 28 to 34% of total supply, but in four of these years, the percentage varied only 1%

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[16]cf. Schaub et al. (1988).

**Table 8.2. Supply and disappearance for U.S. soybeans (1,000 t) (converted from United States Department of Agriculture, 1994)**

| Year beginning September | Supply | | | Disappearance | | | | |
|---|---|---|---|---|---|---|---|---|
| | Beginning stocks | Production | Total | Crush | Exports | Seed and feed | Total | Ending stocks |
| 1988 | 8,232 | 42,153 | 50,385 | 28,794 | 14,350 | 2,379 | 45,529 | 4,954 |
| 1989 | 4,954 | 52,354 | 57,308 | 31,162 | 16,952 | 2,757 | 50,871 | 6,505 |
| 1990 | 6,505 | 52,416 | 58,921 | 32,305 | 15,159 | 2,584 | 50,048 | 8,955 |
| 1991 | 8,955 | 54,065 | 63,020 | 34,128 | 18,615 | 2,781 | 55,524 | 7,578 |
| 1992 | 7,578 | 59,545 | 67,123 | 34,809 | 20,943 | 3,467 | 59,219 | 7,953 |
| 1993[a] | 7,953 | 49,220 | 57,173 | 34,292 | 15,785 | 2,600 | 52,677 | 4,632 |

[a]1993 data are preliminary.

from average (U.S. Department of Agriculture, 1990a). Thus, a rule of thumb is that about one-third of the soybean crop is exported.

The 1993 crush produced 6.02 Mt of soybean oil; 0.54 Mt were exported, and 5.7 Mt were used domestically. Domestic use overshadows export of soybean oil. According to USDA data, for the last 6 yr, the export level has ranged from 8.6 to 12.6% of total U.S. supply, and in this period some soybean oil (30 million to 200 million lb) was imported. Soybean cake and meal also are important export commodities. Of the 27.16 Mt produced in 1990, 4.46 Mt (16%) were exported (Table 8.3).

Over the last 6 yr, between 18 and 26% of total U.S. meal has been exported. When domestic prices are high, meal may be imported into the United States.

Soybean meal provides more than 60% of the value of processed products from soybeans. Although classified as an oilseed, soybeans are primarily a protein crop. The bean's oil content is only 18 to 20%, and protein content ranges from 33 to 38%. The protein content of the meal usually is adjusted to 44 or 48% although 50% is preferred by some poultry producers.

Processors often use meals and other by-products as components in animal feeds. Meal also is shipped in bulk to animal feed manufacturers or to other users. Soybean meal in the United States is used largely in swine or poultry rations. There also is a market in pet foods, and some meal finds its way into specialty products for human consumption.

Because corn provides a relatively inexpensive source of carbohydrates and because soybeans require heating to deactivate the trypsin inhibitors (antigrowth factors), few soybeans are used directly as animal feed. Extrusion of whole soybeans produces a full-fat soybean meal. This product is not used in significant quantities except in markets such as the EC, where the price of corn nearly is equal that of soybeans. Some soybeans are held by farmers for planting the next season, and some are carried over in storage, in anticipation of higher prices.

In the United States, only 3 to 5% of the crop is used for food. This proportion is much larger in other countries, especially those in the Orient, where soybeans are a staple of human diets. The importance of food use in the Orient is illustrated by the estimated import of more than 1 Mt of food-grade soybeans into Japan in 1990 (0.893 Mt from the United States) (Griffis and Wiedermann, 1990) and 600,000 t into Korea (American Soybean Association, 1993).

Soybean oil is produced by crushers of soybeans, who have several marketing options. They can sell crude oil or degummed oil. If they have a refinery, they can process this oil into food or industrial products (Erickson et al., 1980; Schaub et al., 1988). Soybean oil is used by a variety of industries including food processors and industrial concerns, by food-service organizations, and by consumers. Food processors use fats in a multitude of products in which the fats provide functionality, flavor, texture, and mouth feel, all characteristics that consumers expect in quality foodstuffs. Industrial concerns use fats in preparing baked goods and a myriad of other products for the retail trade. Food-service organizations are the fastest growing segment of the fat-consuming industry; they use soy oil mainly in cooking but also in salad dressing, margarine, solid or liquid shortening, and mayonnaise. Fats are a high-energy part of the diet in the United States, providing calories, essential fatty acids, fat-soluble vitamins, and satiation. The many industrial uses of fats include soap, ink, and pesticide carriers.

**Table 8.3. U.S. production and exports of oilseeds and products (1,000 t) (U.S. Department of Agriculture, 1994)**

| | 1993 | |
|---|---|---|
| | Production (1,000 t) | Exports (1,000 t) |
| Oilseeds | | |
| Soybeans | 49,220 | 15,785 |
| Cottonseed | 6,347 | 150 |
| Flaxseed | 88 | 5 |
| Peanuts | 1,539 | 249 |
| Safflower seed | 243 | ? |
| Sunflower seed | 1,178 | 109 |
| Total | 58,615 | |
| Meal | | |
| Soybeans | 27,160 | 4,460 |
| Cottonseed | 1,411 | 100 |
| Linseed | 149 | 41 |
| Peanuts | 132 | 19 |
| Sunflowerseed | 340 | 32 |
| Total | 29,192 | 4,652 |
| Vegetable oils | | |
| Soybeans | 6,200 | 540 |
| Cottonseed | 510 | 91 |
| Linseed | 81 | 3 |
| Peanut | 98 | 23 |
| Sunflowerseed | 274 | 210 |
| Total | 7,163 | 867 |

## Cottonseed[17]

Crushing of cottonseed after removal from cotton fibers yields oil, meal or cake, hulls, and linters. The oil has the greatest value (about 40% of total) and is used almost entirely for edible purposes. Meal and hulls are used in feed for ruminants. Cotton linters are part of many manufacturing operations that use short fibers. A use for cottonseed that is new and quite price-competitive with crushing is as a feed for dairy cattle. Dairymen value the seed for its high energy, protein, and roughage contents and feed it to superior dairy cows.

Cottonseed oil was the first edible vegetable oil used in significant volume in the United States. Consumers consider it a high-quality, flavorful ingredient for frying, baking, and food preparation. Currently, because it is valued for its flavor and stability, one of cottonseed oil's major uses is in the preparation of snack foods. Because it has desirable functional properties, it also is used in margarines, shortenings, and specialty fats.

Cottonseed oil refiners buy crude oils and refine, bleach, and deodorize them to salad oils. Salad oils form a cloud of solids, called *stearine*, at refrigerator temperatures. In the past, this happened naturally in the winter; hence, the clear oil taken from the tops of the tanks was called *winter* or *winterized* oil. Refiners now winterize oils in specially designed cooling vessels. The solids formed are filtered off and sold as stearine to be used in compound shortenings and margarine stocks. Winterized salad oil is used in preparing salad dressings and other products requiring clear oil at low temperatures. Some bleached oil may be partly hydrogenated for use in shortenings, cooking fats, and margarine stocks. Some refiners use the bland, nearly colorless oils captively in frying fats for snacks, in salad dressings, or in other food preparation systems. Other refiners sell the edible grades of cottonseed oil products to other food manufacturers, to food-service traders, or to brokers.

After oil, meal is the principal by-product of the cottonseed and accounts for about one-third of its value. Cottonseed meal is the proteinaceous residue remaining after removal of the oil by means of direct solvent extraction or prepress-solvent extraction. Hulls are a roughage product and are removed. The meal is sold primarily as a feed for livestock, and the producer sometimes markets it as an 80:20 hulls:meal mixture for winter feeding. Hulls also are sold separately as a roughage product for ruminants.

Feed mills are the primary users of cottonseed cakes, meals (usually sold at 41% protein), and hulls, which are used as components of feeds requiring high-protein, inexpensive roughage. End users are dairy farmers and other livestock producers. Some cottonseed meal also is used in the formulation of swine and poultry rations. Small amounts of cottonseed meal are used as fertilizer. Although hulls are used mainly as roughage feeds, several industrial uses have been developed. Hulls have been used as an additive to certain plastics and oil well-drilling muds and in the production of *furfural*, a chemical solvent.

Cottonseed is stored or transported with difficulty because it is bulky and quite moist. Thus, the United States exports only a small quantity. In the period 1984–1990, exports of cottonseed have ranged from 9,000 to 50,000 t, out of a total production of 4 Mt to 6 Mt (U.S. Department of Agriculture, 1990a; U.S. Department of Agriculture, 1990c). This product may well have been low-grade seed destined for

[17]cf. Anonymous (1990a) and Jones and King (1990).

direct animal feeding.

Exports of cottonseed oil were 160,000 t in 1989–1990, but over these 6 yr the export:domestic ratio of cottonseed oil decreased. From a high of 38% in 1985, exports have fallen to only 25% of total supply in 1990 (U.S. Department of Agriculture, 1990a). Exports of cottonseed meal and cake were only 29,000 t in 1990 (Table 8.3). The domestic use:export ratio has been relatively large for the 1984–1990 period. In fact, in 1989–1990 the United States imported more meal than it exported. Exports have ranged from 5,000 to 45,000 tons in that timeframe, but even the largest export volume represented only 2.7% of total domestic disappearance (Anonymous, 1990b; U.S. Department of Agriculture, 1990a).

## Sunflowerseed[18]

Sunflower production is divided between confection use and oil use, with different genotypes and industry organizations. The confection industry is quite export oriented. In 1990–1991, 36% of available confection seed was exported. In contrast, only 4% of production of the oil type was exported as seed, and more than 75% was crushed for oil. Nearly two-thirds of the remainder was used for bird feed and for planting seed. Most oil produced was exported (62%); 34% was used domestically, and the remainder was carryover.

Sunflower oil, valued by consumers for its quality, usually trades at a slight premium over soybean oil throughout the world. It has a bland flavor, a light color, and a high smoke point. Thus, it is used as both a cooking and a salad oil. It is an excellent source of linoleic acid but contains very little linolenic acid, which causes off-flavors, and is relatively low in saturates. Thus, it is viewed by many consumers as a "healthful" oil.

The meal, at 28 to 38% protein, competes with other feedstuffs and is used primarily by local livestock feeders. Only 1 to 2% enters the export market.

## Safflowerseed[19]

Safflowerseed is either crushed or exported, depending on relative prices and profitability. The oil is a premium edible oil promoted widely for its high level of polyunsaturates. Unlike other polyunsaturated oils, safflower oil contains no linolenic acid and thus neither yellows nor oxidizes as rapidly as certain other edible oils do. The oil is used primarily for salads. Less than 5% is used for industrial purposes such as paints.

Unless carefully processed, the meal tends to be high in fiber and low in protein (25%). For these reasons, most processors either dehull the seed before processing or dehull by screening the meal after oil extraction. Safflowerseed meal is used most frequently in a blend with other meals, primarily for cattle rations. Oil is sold to food manufacturers or directly to bottlers, who package it for the retail trade.

Exports of safflowerseed in 1990, at 78,000 t, exceeded exports of cottonseed and flaxseed. Thus, safflowerseed ranked fourth in terms of export importance among all oilseeds. Since 1986, exports of safflowerseed have ranged from 18 to 35% of the total crop, with a slight trend toward the export market. Japan has been the major importer of U.S. safflowerseed. About half the oil is exported, primarily to Europe, where it is valued for its high polyunsaturate content. Export volumes of meal are insignificant (Table 8.3).

## Flaxseed[20]

Historically, flax was grown in the United States for oilseed. Before the advent of petrochemicals and the rise of soybean oil production, linseed oil (flaxseed oil) was one of the world's primary industrial oils. Paints, caulks, plastic goods, and coatings were manufactured with linseed oil as a principal ingredient. Now, however, only two plants process flaxseed in the United States. One plant is in North Dakota, the other in Minnesota. Because consumption exceeds production, the United States imports as much as 65% of total supply, primarily from Canada (U.S. Department of Agriculture, 1988a updated by Carter, 1991).

There is a small but growing market for edible oils high in omega-3 acids, and linseed oil, with 26 to 58% alpha-linolenic acid (cis-9, cis-12, cis-15-octadecatrienoic acid), is currently the best source of this type of oil. Processing plants in Washington state and in British Columbia refine linseed into edible oil.

The industrial uses of linseed oil are in concrete treatments (1%), hardboards (10%), stains (13%), printing inks (15%), core oils (3%), paints and varnishes (33%), alkyd resins (10%), brake linings (3%), fatty acids (3%), epoxy compounds (5%), packaged oils

[18]See Anonymous (1991b).

[19]See Smith (1991) and Gyulai (1992).

[20]See Carter (1991).

(paint use) (3%), and other (2%) (Reutz, 1988).

Linseed meal is used primarily in rations for cattle. The 1990 production of 146,965 t was allocated between the export market (37,195 t) and the domestic feed market (109,770 t) (U.S. Department of Agriculture, 1992b).

### Canola (Rapeseed)[21]

*Canola*, the name coined in Canada for the low-erucic acid, low-glucosinolate cultivars of rapeseed, is experiencing a growing popularity in the United States because the oil has a very high oleic acid level and a low saturated fatty acid level. Use increased 223% between 1987 and 1992, from 263 million to 849 million lb. Currently, most U.S. canola oil requirements are met by imports from Canada and the European Economic Community (EEC).

Between 1985–1986 and 1990–1991, imports of canola oil from Canada rose from 32,000 to 171,000 t and accounted for nearly 60% of all edible canola oil consumed in the United States. During this same period, the tariff on Canadian oil imports fell from 7% (ad valorem) in 1985 to 6% in 1987, and finally to 3.5% in 1990. In January 1992, as part of the United States-Canada Free Trade Agreement, the tariff on canola oil was eliminated, an action increasing the competitiveness of Canadian oil in the U.S. domestic market. Approximately 91,000 a. were harvested in the United States in 1991, but oil demand has been estimated to require as many as 2.5 million a. planted to canola by the year 2000.

Canola oil is used almost entirely as an edible product in baking, frying, and making salad dressings. Meal is used in both cattle and hog rations.

## Oilseed Production

### Soybeans[22]

Soybeans are one of the most important cash crops in the United States. In 1990, the USDA reported that 56.5 million a. were planted to soybeans and were producing 52.4 Mt (U.S. Department of Agriculture, 1990b). Soybean production is concentrated in the midwestern and the southeastern United States, but production and acreage for 29 states are reported in the USDA–NASS (U.S. Department of Agriculture, 1991). Four states (Illinois, Indiana, Iowa, and Minnesota) accounted for 62% of total production in 1990. In these states, average acreage of soybeans/farm growing soybeans in 1987 was 123 (Table 8.4).

### Cottonseed[23]

Cottonseed production is reported for only 17 states; however, three states—California, Mississippi, and Texas—account for more than 63% of total production. In 1987, the average number of acres planted to cotton per farm for these three states was 271.

The crop has moved steadily westward, and more than 80% is grown west of the Mississippi, with 50% grown in Texas and California (Table 8.4).

### Sunflowerseed

Total U.S. production of both confection and oilseed sunflowers amounted to 1.2 Mt in 1992–1993 (Table 8.3). Of this, confection seed accounted for 0.314 Mt and oilseed for 0.783 Mt. The crop is grown mainly in the upper Midwest, with North and South Dakota accounting for 86% of production. Minnesota, Kansas, and Texas accounted for most of the remainder, with some additional acreage in western Nebraska and eastern Colorado. Average numbers of acres planted to sunflower/farm for North Dakota and South Dakota were 200 and 158, respectively, in 1987 (Table 8.4).

### Safflowerseed[24]

In terms of acreage and volume, safflower is a minor U.S. oilseed crop. Peak number of acres planted to this crop just exceeded 500,000 in 1962 and had declined to 325,000 in 1986 and to 235,000 in 1990. Most acreage is in California, Arizona, Montana, and the Northern Plains, a fact dictated in part by the location of processors in California and in Montana. Top seed production in 1986–1990 was 167,400 t in the peak year of 1989. California accounted for 80% of total U.S. production in 1992. Crush has ranged from 108,216 to 142,136 t.

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[21]See Dotson (1991).

[22]See Schaub et al. (1988).

[23]See Anonymous (1990a) and Jones and King (1990).

[24]See Smith (1991) and Gyulai (1992).

**Table 8.4. Production and number of farms growing oilseeds, 1992**

| Grain | | Production[a] | | Acreage[b] | No. of farms[b] | Average acreage/farm |
|---|---|---|---|---|---|---|
| Soybeans | Rank/state | 1,000 t | Cumulative percent | | | |
| | 1 Illinois | 11,048 | 18 | 8,768,833 | 61,547 | 142 |
| | 2 Iowa | 9,915 | 35 | 7,903,395 | 68,278 | 116 |
| | 3 Indiana | 5,296 | 44 | 4,397,253 | 40,068 | 110 |
| | 4 Minnesota | 4,708 | 52 | 4,384,981 | 36,348 | 121 |
| | United States | 59,850 | 100 | 46,937,261 | 329,997 | 142 |
| Cotton[c] | | 1,000 bales | | | | |
| | 1 Texas | 5,095 | 32 | 4,349,755 | 16,557 | 263 |
| | 2 California | 2,918 | 51 | 1,083,811 | 3,037 | 357 |
| | 3 Mississippi | 1,550 | 61 | 1,028,249 | 4,225 | 243 |
| | United States | 15,764 | 100 | 8,667,048 | 37,359 | 232 |
| Sunflower seed | | 1,000 lb | | | | |
| | 1 North Dakota | 1,162,800 | 51 | 1,407,115 | 7,043 | 200 |
| | 2 South Dakota | 516,800 | 74 | 262,847 | 1,659 | 158 |
| | 3 Minnesota | 247,500 | 85 | 82,278 | 683 | 120 |
| | United States | 2,289,820 | 100 | | | |

[a]Source for soybeans and sunflower seeds: U.S. Department of Agriculture, Agricultural Statistics, 1993.

[b]Source: U.S. Department of Commerce, 1982, Table 42.

[c]Source for cotton: U.S. Department of Agriculture, 1992.

## Flaxseed

Flax production has fallen dramatically since the introduction of petrochemicals. As late as 1955, nearly 4 million a. of flax were grown in the United States, and 28 million bu of flaxseed produced. By 1975, this production had decreased to 8 million bu grown on about 800,000 a. In 1990, production had dropped to 3 million bu produced on 253,000 a. (U.S. Department of Agriculture, 1988a updated by Carter, 1991).

Only three states reported significant planted acreage in 1990: North Dakota (215,000 a.), South Dakota (35,000 a.), and Minnesota (minimal acres). North Dakota yields generally are below those of the other two states, but North Dakota still accounted for more than 90% of total production in 1990. Total production increased to about 280,000 a. in 1991 (Carter, 1992).

## Canola

Canola production of 179,300 a. in 1991 was distributed among 32 states, only 7 of which reported more than 10,000 a. Production is divided approximately equally between spring and winter cultivars. The midwestern states of Indiana, Kentucky, Michigan, and Ohio accounted for more than half of winter acreage. The spring crop was concentrated in Idaho, Montana, and North Dakota and accounted for 84% of spring acreage. Although canola and other rapeseeds have been grown widely in Canada and in Europe, significant canola acreage in the United States has developed only recently, doubling between 1989 and 1990.

Because canola is a new crop in rotations on U.S. farms, a./farm usually are fewer than 100, and farmers often begin on an experimental basis with only 20. The market channel is developed poorly in the United States, but farmers increasingly are interested in canola as they search for new crops to increase diversification and for profitable alternatives as commodity prices fall (Dotson, 1991).

# Organization of the Market

## The Market Channel

Most oilseeds follow the general market channel from farm to first-handler to processor. Some do not. Soybeans follow a market channel similar to the feed grain channel in that both include country elevators, river and inland subterminals, and processors or exporters. Export demand has a greater influence on the market channel for soybeans than for other oilseeds, however.

Exceptions to the traditional sequence are cottonseed, which moves from cotton gin to crushers, and flaxseed, which usually is delivered directly to specialized processors. Safflowerseed moves directly from farms to processing plants in California and is stored at country elevators as directed by the processor. In Montana, most of the crop moves through country elevators. Those who process the seed into oil and meal also export limited quantities.

Sunflowerseed is moved by truck directly to the nearest crushing plant or to a country elevator. Seed for export is trucked to Duluth/Superior if destined for Europe, or to El Paso and Laredo, Texas if destined for Mexico. Both truck and rail transport is used. United States sunflower oil destined for export moves via New Orleans (75%), Laredo (11.2%), the Great Lakes (7.4%), and the West Coast (5.8%). Exported confection seed moves mainly via the Great Lakes (87%). The remainder exits via the other coasts (Anonymous, 1991b).

## Pricing Practices and Strategies

### Soybeans

Contracts for soybeans, soy oil, and soy meal all are traded on the CBOT, with a great volume in cash and futures transactions in these commodities. (For an excellent discussion, see Johnson, 1988).

For the most part, price is set by the market. For finished products, however, price, based on a premium over the crude oil market price, often is negotiated between buyer and seller. There is a futures market on the CBOT for soybean oil, and a daily (hourly) spot market for oil, as well.

Contracts are traded actively on the basis of expected price changes and profit opportunities. The main function of the futures market is to establish price and to reduce volatility. Most firms buying, selling, or processing commodities hedge purchases and sales to protect against unexpected price changes. Although prices respond to many economic and psychological factors in the United States, the futures market is not dependent solely on what happens in this country. Rather, the market reacts vigorously to international climatic, economic, and political events. Most hedging is done by the highly skilled traders of large firms. A few farmers, however, also use futures markets to reduce risk of price change.

Prices paid producers by country elevators are set by supply and demand in the local area, as well as by general price level reflected in price movements on the CBOT. Price bids from processors or exporters are received at country elevators, where merchandizing margins are subtracted and results posted as the daily bid price for base quality—usually No. 1 in the domestic market.

Farmers may price and deliver soybeans at harvest or store them on the farm or in an elevator for subsequent sale. Forward pricing, delayed pricing, and forward contracts are alternatives to pricing at delivery time. Processors purchase some soybeans directly from farmers, but most of the crop goes through the country elevator, where price, delivery, and payment occur simultaneously.

The 1990 Farm Bill established a loan rate for soybeans, providing a minimum price support. Unlike corn and wheat farmers, soybean farmers rarely used CCC loans, because market prices seldom dropped to the loan level. The most soybeans ever in government storage was 6.3 Mt in 1987—11% of production that year.

In the United States, farmers store soybeans on the farm, transport them to elevators, or move them directly into the market channel. Although farmers have options as to where and when they will deliver soybeans, for the most part they are delivered to the local elevator offering the best price. Depending on the location, farmers may be able to deliver soybeans to one of several country elevators, a subterminal elevator, a processor, a terminal elevator, or a river elevator. All elevators transport soybeans through the domestic market or into foreign markets by truck, rail, barge, or ship. Some processors also function as merchandisers, selling excess soybeans to other domestic or international buyers.

In the export market, most soybeans are traded on the basis of No. 2 Grade. Premiums seldom are offered for quality better than No. 2. If the lot fails to meet the requirements for the grade specified, penalties are assessed based on the contract covering the sale. The export contract for nearly all international transactions includes the phrase "origin weights and grades final." In short, the official grades and weights determined by the USDA–FGIS during loading of the vessel are the only legal basis on which to base disputes. Complaints about weight or quality losses measured at destination must prove negligence by the captain of the vessel or incorrect value determination at original inspection.

Crude soybean oil is sold on the basis of cash or spot market unless there is a contract for delivery in hand. The National Oilseed Processors' Association (NOPA) rules spell out the adjustments for settlement of differences regarding loss, color, settling, moisture, and volatiles. The same arbitrations are in effect for all grades of soybean oil (Anonymous, 1989c). Often the matter of disagreement between buyer and seller is settled by a third party, the Official Referee Chemist, whose laboratory must meet the requirements of the Examination Board of the American Oil Chemists' Society (AOCS) and who must be certified.

If the oil is rejectable under the rules, the seller must replace it as outlined by them. The price is agreed on between buyer and seller before the oil is delivered, but often there are adjustments, as outlined, if the oil fails to meet one or more standards. For value-added products such as shortenings, frying fats, and margarine stocks, specifications are developed by buyers and agreed to by producers. Many such products have relatively strict performance requirements that are proprietary and have a direct bearing upon the price/value relation agreed to by buyer and seller/producer. Again, many measurement methods used are those of the AOCS although proprietary testing methods also are used.

### Cottonseed

Cottonseed millers purchase seed from farmers at prices determined by product value, production and milling costs, investment return, and competitive profit. Overriding factors, however, are competitive pressure from other mills and from competing products, and supply and demand of cottonseed.

Cottonseed meals compete with other protein sources, and hulls compete with hay and silage. These commodities are not listed in the futures market, but cottonseed meal is listed on the cash market.

Between 1984 and 1990, the price paid farmers for cottonseed ranged from $66 to $118/t. More recently, supply has exceeded demand, exerting downward pressure upon price. Crushers had insufficient capacity to process all the available seed, and seed was stored in piles, exposed to the weather, and greatly damaged. Price-quality relations for cottonseed are spelled out in the Rules of the National Cottonseed Products Association (NCPA) (Appendix A). A base price is offered for seed graded 100 on the Association's quality scale.

Settlement terms for crude oils are spelled out in Article 3 of the NCPA Trading Rules. Buyers pay premiums for Above Grade oils, and sellers discount Below Grade oils (Anonymous, 1989c).

The rules provide for no settlements between buyer and seller of domestic refined oils. Such rules usually are negotiated at the time of delivery and are spelled out for export oils in Chapter VIII of the NCPA Trading Rules. The seller is required to give discounts for oils not meeting grade, quality standards, or delivery time.

The market bases the prices for cottonseed cake and meal on the competitive feedstuffs available in the given area. Quality/price relations are spelled out in trading rules. Price/quality relations also may be set by contract between buyer and seller. At times, price may be arbitrated if quality and/or quantity of delivery fails to meet contract specification.

### Sunflowerseed

Most sunflowerseed is sold on the open market rather than under contract. Pricing is tied closely to the futures price for soybean oil, and most processors hedge using soybean oil futures. Currently, the export market for the seed is quite thin, so export prices have little effect on U.S. prices. Occasionally, when the crop is short, demand for the oilseeds as bird seed can affect price. Price-quality relations for sunflowerseed depend almost entirely upon the oil content of the seed inasmuch as 75 to 80% of its value is in the oil. An oil content of 40% is used as the base, and a 2% price premium is used for each percentage of oil above 40.

### Safflowerseed

The small number of safflower processors results in a relatively thin market, and price depends on local supply and demand. Essentially all safflowerseed is produced under contracts between the processors or exporters and the growers. Prices, discounts, and premiums are specified in the contract. Prices are based on an estimate of the returns from crushing and/or exporting the seed, whose primary export market is Japan. Price/quality relations are well established. The oil carries the majority of the seed value, so seed with high oil content commands a premium.

Seed quality is assessed at country elevators and crushing plants, and by terminals preparing it for export. Premiums and discounts are assessed for oil content; limits or discounts are used to control moisture and dockage loads. Oil quality is assessed by the processors and their customers—either refiners or shippers exporting the crude oil. Grade factors are spelled out in the National Institute of Oilseed Processors (NIOP) rules, and oil not meeting specification is subject to penalty.

### Flaxseed

Flaxseed is listed on the CBOT, where trading seems based primarily on the Canadian crop. Pricing methods are simple, and alternative strategies few. Canadian import prices set an upper limit for the two processors buying U.S. production. Farmers have little choice of market outlet. Because most producers (approximately 98%) are in the farm program, they receive an allowance bringing their return to about $5/bu.

There is some minor export of edible (yellow) flaxseed to the EEC. This cleaned and bagged seed yields about $8/bu, but volume is limited. Price differentials for quality delivered to crushers are based primarily on dockage, which usually involves immature, unfilled seed and a straight percentage-for-percentage discount (Carter, 1992). Processors and country elevators establish price payable upon delivery.

### Canola

Canola is purchased from farmers by processors or by country elevator managers, at prices based on both market demand and estimated margins. Because canola is a new, low-volume crop, handling margins at country elevators have been significantly higher than those for other grains and oilseeds. Some canola is produced under contract, with prices fixed through negotiations between processors and producers. Canada's export volume and prices, as reported on the Winnipeg Exchange, constrain U.S. domestic prices. Price of canola oil is influenced by prices of competing oils, and thus the price of canola is related to both cash and futures prices of soybeans on the Canadian Board of Trade.

Price discounts suggested by the U.S. Canola Processors Association often are followed by processors and elevators, but these discounts and the factors measured are subject to change, depending on market and crop years.

## The Processing Industries

### Soybeans[25]

Soybeans are cleaned, dehulled, conditioned, and flaked before oil is extracted in large-volume processing plants. Oil is removed from soybean flakes and collected by being dissolved in hexane to form a mixture called *miscella*. The miscella is drained from the meal, and the oil recovered by evaporation of the hexane solvent. Meal is treated in a desolventizer-toaster, which removes traces of hexane and improves meal digestibility. Many large crushers have integrated plants in which oil and meal can be processed into end products such as edible salad oils and animal feeds.

Although the Soybean Bluebook listed approximately 90 soybean crushers and refiners in the United States in 1990, the industry here is dominated by a few large firms (Anonymous, 1990c). In the past few years, crushers have consolidated when several large participants were purchased by other firms. The few large firms that crush most of the soybeans also market the meal. Like beans and oil, meal has a futures and a cash market. Vertical integration in the industry is incomplete, but some large firms do operate feed processing plants and poultry production units.

Many large operations are located in the Midwest and the Southeast, close to the supply of raw material. These large firms buy soybeans on the open market or take delivery on contracts, processing or selling these contracts to overseas customers.

Most large firms process soybeans into oil and meal, and many refine and convert oil to end products such as salad oils, frying and baking fats, and margarine stocks. These firms also may produce some animal feeds from the meal. Although some farmers contract directly with Japanese buyers to produce special soybean cultivars for use in human foods, total volume of food-quality soybeans in the market channel is relatively small. Transactions often are conducted outside the commercial market channel, and contracts often are used to specify cultivar, quality, transportation, and pricing (Griffis and Wiedermann, 1990).

Soybean buyers have become increasingly sophisticated. Most know the quality characteristics needed for their process and are aware of the difficulties of disposing of Off-Grade beans. Price and quality-related price differentials are well publicized, and processors use purchasing and quality-control departments to search for the highest yield at the lowest price. Export customers are especially critical of exporters who blend so as just to meet grade and contract limits.

Like the soybean crushing industry, the soybean oil industry is dominated by a number of large firms. This industry has been consolidated over the past

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[25]See Schaub et al. (1988).

several years (Haumann, 1988), and the number of individual refineries probably will continue to decrease as large cost-efficient companies prevail. The market channels are straightforward. Great amounts of oil are purchased on contract as well as on the cash market. Many large U.S. concerns are integrated vertically to the extent that the crude oil purchased is processed into end products. In other instances, the refiner is a supplier of salad oils and hydrogenated stocks to food processors. It is difficult to categorize precisely the activities of companies selling both consumer products and ingredients to other food companies.

### Cottonseed[26]

Cottonseed is a by-product of the cotton fiber industry. (See Chapter 11.) Farmers deliver raw cotton to a cotton gin, where fiber and seed are separated and seed is delivered to a crusher. Because transportation is costly, crushing plants generally are located in the production region. Most seed is trucked to seed houses that store it at a controlled temperature and under controlled moisture until crushed. The seed is cleaned mechanically of trash, leaves, dirt, etc., delinted, and dehulled. Shakers and separators are used to separate seeds from hulls, which are sold in bulk or in bags. The kernels (meats) are ready for oil recovery by means of solvent extraction similar to that described for soybeans.

The cottonseed crop is seasonal, with harvest occurring from July to mid-January, depending upon the area. Cottonseed is quite bulky and, depending on its condition, can deteriorate rapidly. Mills have seed houses specially equipped to store the seed and to maintain it at optimal temperature and moisture. Because the seed can deteriorate rapidly, most is processed in the first few months after harvest. By March, more than 70% of the previous year's crop will have been crushed. Thus, mills may be equipped to process other oilseeds, e.g., sunflower.

The marketing system and the industry organization for cottonseed cakes, meals, and hulls seem uncomplicated. Meals (cake, flakes, or pellets) and hulls (bulk or pelleted) are sold by mills directly to end users, to brokers, and to feed manufacturers. Meals move freely to various users, but hulls, unless pelleted, have such low bulk density and value that they must be consumed in the producing area (Anonymous, 1990a, 1991a).

With consolidation of oil mills and improvement in transportation, fewer than 50 processing plants now operate in the United States. Texas has 14 mills; Mississippi, 8; Arizona, 5; California, 4; Georgia, 3; and all other producing states, 1 or 2 (Anonymous, 1991a). Processors sell oil to brokers and/or to refiners. Refiners move the oil on to customers or process it for sale to wholesalers or retailers. After being packaged or incorporated into foods, oil moves through normal wholesale and retail channels to the consumer (Jones and King, 1990).

Geographic concentration of firms in the refining industry is somewhat similar to that of the milling industry. Oil refiners and brokers work throughout the United States. Currently, the NCPA lists 26 U.S. refiners of cottonseed oil (Anonymous, 1991a), but the list omits those refining for their own use.

The geographic concentration of firms handling cake and meal seems similar to that for oil mills. Brokers and dealers are concentrated in states that are the major processors of cottonseed.

Although vertical integration and contract production are uncommon in this industry, localized seed production, transportation cost, and seed-quality instability make it likely that many mills have a captive source of supply. Many large food-processors also are refiners providing a captive market for edible oil. Any potential market power is countered by a number of cooperative oil mills, whose gins and mills are responsible ultimately to member farmers. It seems that common interests would tie such groups together.

Because cottonseed has a longer history in the United States than does any other oilseed, buyers are quite sophisticated in price and quality determination. Moreover, this is a fairly close-knit industry, and information about substandard lots soon spreads.

### Sunflowerseed

Because sunflowerseed has quite a low density, crushing plants are located near growing areas. To improve oil and meal properties, most operations clean and dehull seed. And because the kernel has quite a high oil content, oil is recovered by prepress-solvent extraction. Meal as a cattle ration is in demand by farmers; hulls generally are burned to produce steam and power for the processing plant. The four major U.S. crushing plants for sunflower oilseeds are located in North Dakota and report crushing capacities of 1,000 to 1,500 t/d. Other smaller plants, one in Montana and several in Texas and Oklahoma, have capacities of 200 to 300 t/d.

The buyers and the processors of sunflowerseed are few, highly specialized, and sophisticated. Be-

[26]cf. Anonymous (1990a) and Jones and King (1990).

cause this is a high-value oilseed, with more than 40% oil the norm, both buyers and processors must be astute in judging the quality characteristics influencing yield and value.

### Safflowerseed[27]

Only four major firms process safflowerseed in the United States, and their plants are small relative to those of soybean processors. Safflowerseed mills range in production from 180 to 300 t/d. Two firms process other oilseeds and occasionally may process safflowerseed. In the domestic market, processors sell the oil to food manufacturers or directly to bottlers, who package and wholesale the oil into the retail markets. Processors ship mostly in bulk, by rail or by truck. Most meal and hulls are sold as ingredients for cattle feed.

Because this commodity is handled by a small, specialized industry, buyers are sophisticated about product and value. Quality is important inasmuch as there is a mystique associated with "healthful" oils. An approach used by at least one bottler is *cold pressing*, i.e., extracting the oil not by solvent but by pressure. Having received minimal processing, such oil can be promoted as having had little or no exposure to chemicals. The end product is not different chemically from solvent extracted products, but the cold pressed idea evidently is an effective marketing tool.

### Flaxseed[28]

Because flaxseed is a very small-volume-crop in the United States, most moves directly to processing plants although the market channel may include country elevators. Only two processing plants exist in the United States: one in North Dakota and one in Minnesota. The production volumes of the two plants have not been made public although together they seem to process all the flaxseed grown in the United States. The parent companies are two of the largest international oilseed processors and traders.

Because this is a narrow, small, and concentrated industry, it can be assumed that, again, buyers are sophisticated about the quality of products, the selection of suppliers and their abilities to deliver high quality, and the effect of quality differences on product yield. Buyers know both markets and price-quality relations.

[27]See Gyluai (1992) and Smith (1991).

[28]See Carter (1991).

### Canola[29]

Because a small volume of canola is produced in the United States, development of a processing industry has been discouraged. The only U.S. processing plant is located in Augusta, Georgia. Most western and midwestern production is delivered to Canadian processing plants located in Windsor and in Hamilton, Ontario. The small supply scattered over a wide geographic area and the lack of competing processors in production areas limit competition. Country elevators in the producing regions must take wide margins to cover costs associated with low volume and segregation in market and in storage. Price risks in a thin, noncompetitive market also must be covered by wide margins at the first-handler level.

# Measurement of Quality in the Market Channel

## Important Quality Attributes

### Overview

All oilseeds are produced for the oil and the protein meal that can be derived from them. Quality attributes affecting quantity or quality of oil and meal obtained during processing therefore are important for all oilseeds. The most obvious characteristic is the quantity of oil and protein contained in the raw product.

Oil yield is influenced by moisture content, foreign material, and seed damage; oil quality, by damage, acidity, and seed color. Bright green often is indicative of immature seed, which contains high levels of chlorophyll, which in turn ends up in crude oils. Chlorophyll is difficult to remove during processing and can, under certain circumstances, carry over into finished products and reduce their values. Immature soybeans also contain high levels of nonhydratable phospholipids, which are not removed from oil during degumming and cause processing and flavor problems in the oil.

Grades and therefore market discounts seldom take into account intrinsic properties such as chemical composition. The factors included in government and private grades generally are used as the basis for price premiums and discounts. These factors do not always include all attributes considered important. For example, although a survey of soybean proces-

[29]See Dotson (1991).

sors rated protein, oil, moisture, and foreign material the most important quality attributes, only foreign material is included in grades.

Processors have identified several other characteristics influencing quality. Seed color, hilum color, wrinkled seed coat, odor, flavor, and acidity are processor concerns for one or more of the major oilseeds. But the official or unofficial grades providing the basis for market price differentials rely primarily on physical attributes.

Cottonseed (Anonymous, 1990a; Jones and King, 1990), safflowerseed (Anonymous, 1984), canola (Ameri-Can, 1992), and flaxseed engender quality concerns similar to those engendered by the other edible oils. Concerns differ only in terms of increased emphasis on odor and flavor.

## Grades and Standards

### Soybeans[30, 31]

The marketing channel relies primarily on the five grade factors of (1) damage, (2) foreign material, (3) heat damage, (4) splits, (5) test weight, and one nongrade standard, moisture, in its determination of price discounts to producers. Buyers of soybeans for foods have additional quality concerns about seed size, hilum color, and fiber content.

Soybean grades administered by the USDA–FGIS include four grades determined by five grade factors and applying equally to the two classes of beans: yellow and mixed. Yellow soybeans have yellow or greenish-tinged coats and consist of no more than 10% beans of other colors. All other soybeans are mixed.

*Damaged kernels* are weather, disease, frost, germ, heat, mold, sprout, insect, ground damaged, and/or otherwise materially damaged.

*Foreign material* includes all material passing through an 8/64-inch (in.) round hole sieve and any material other than soybeans remaining on the sieve. Foreign material may be dirt, weed seeds, stems, or pieces not removed at first cleaning.

*Heat damaged* soybeans usually are the result of overheating that occurs during storage at moisture levels and temperatures conducive to fermentation. Heat damage occasionally is caused by excessive heat in grain drying equipment. Buyers shun such beans because they will yield inferior oil and meal.

*Splits* are defined in U.S. grades as soybeans from which more than one-fourth of the bean has been removed and which otherwise are undamaged. Splitting usually occurs during harvesting and handling, especially when moisture content is below 12%. If splits are processed promptly, they have little or no effect on oil. If beans with splits are stored for long periods, however, deterioration of seed oil may occur.

*Test weight* is a measure of weight/unit volume that reflects kernel density and packing characteristics. In the United States, it is recorded as lb/bu.

*Other colored* soybeans include those with green, black, brown, or bicolored seedcoats. In cross section, soybeans with green seedcoats also can be green. Bicolored seedcoats will be brown or black, and the color can cover more than half the seed surface.

In addition to the five grade-determining factors, moisture is included as a nongrade standard, meaning that it is defined in the standards and must be measured and recorded whenever an official grade is assessed. Since 1989, the USDA–FGIS also has been providing, on request of buyer or seller, information about oil and protein contents.

In early 1994, USDA–FGIS published changes in the soybean standards to be effective September 1, 1994. These changes are splits to be recorded in tenths of a percent; sample grade criteria for stones were reduced from eight to four and aggregate weight for stones changed from 0.2% by weight to 0.1%; pieces of glass were reduced from two to zero; grade limitation on purple or mottled soybeans was eliminated and a special grade, Purple, Mottled, or Stained was established; the grade for materially weathered soybeans was eliminated; reference to mixed soybeans was clarified; and a cumulative total of factors causing a sample to be designated U.S. Sample Grade was established. The proposal to require reporting of oil and protein levels on inspection certificates was not adopted (*INFORM*, 1994).

Federal grades cover only raw soybeans. Standards for oil and for meal are available from trade organizations. (See Appendix A.) The key attributes of crude oil are free fatty acids (FFA), moisture and volatility, neutral oil loss, color, and flash point. Standards for meal usually specify protein, fat, and fiber contents.

Soybean-meal grades and standards have been developed by the NOPA, which has had years of experience with such products. Grades and standards were adopted in 1933 and are updated, amended, and approved routinely by members of NOPA (Anonymous, 1990d). Depending on the type of negotiation

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[30]See U.S. Department of Agriculture (1988b).

[31]See *Federal Register* (1994).

between buyer and seller, many other sets of trading rules can be used for soybean meal transactions, particularly in international trade. Most such rules are quite similar in spirit, if not in letter, to those of NOPA.

Methods used to analyze meal are primarily those of the AOCS. But, as for other commodities, methods have been developed by many other organizations around the world. Classical protein, fat, fiber, and moisture analyses are used, but many new techniques are under study because more rapid, equally accurate methods are expected to cut costs and to increase analytical efficiency. The applicability of nuclear magnetic resonance (NMR) spectroscopy to seed, oil, and meal analyses has been investigated for some time, and its adoption will speed certain routine but time-consuming analyses.

## Cottonseed[32]

Grades, standards and trading rules developed by the NCPA (Anonymous, 1989a) regulate the buying and the selling of cottonseed. There are no government grades for cottonseed, but an index for quality has been developed and is used widely for setting price differentials throughout the industry.

Because no government grades exist, quality concerns tend to be those identified by processors and often are included in their contracts with farmers. The relative importance of attributes depends on the relative prices of oil and meal and on the average composition of seed. At current prices, oil accounts for approximately 40% and meal for about 33% of the seed value of cottonseed.

Cottonseed grades are based on a numerical value constructed from two index numbers—a *Quantity Index* based on chemistry and a *Quality Index* based on purity and soundness. Grade value is calculated by multiplying Quantity Index by Quality Index (described subsequently) and dividing the product by 100. A base price is established for seed with a grade value of 100, and premiums or discounts are assigned grade values deviating from 100.

The Quantity Index for upland cottonseed is four times the percentage of oil, plus six times the percentage of ammonia, plus five. For example, the Quantity Index for American Pima cottonseed is four times the percentage of oil, plus six times the percentage of ammonia, minus 10. The Quality Index for cottonseed is an index of purity and soundness calculated from the percentages of moisture, foreign material, and FFA in the sample. Cottonseed that by analysis contains no more than 1% foreign material, no more than 12% moisture, and no more than 1.8% FFA in its oil is Prime Quality cottonseed and assigned a Quality Index of 100. For cottonseed containing foreign material, moisture, or FFA in excess of these levels, the Quality Index is reduced

1. four-tenths of a unit for each 0.1% FFA in excess of 1.8%,
2. one-tenth of a unit for each 0.1% of foreign material in excess of 1%, and
3. one-tenth of a unit for each 0.1% of moisture in excess of 12%.

Cottonseed treated by chemical or mechanical means other than the usual cleaning, drying, and ginning (except for USDA-required sterilization), that is fermented or hot, or that contains more than 12.5% FFA, 10% foreign material, 20% moisture, or 25% combined foreign material and moisture, is graded Off-Quality. Cottonseed with a calculated grade poorer than 40 is labeled *Below Grade*, and no numerical value is indicated.

## Sunflowerseed[33]

The USDA–FGIS grades for sunflowerseed are based on four factors, and limits allocate quality among two numerical grades. Sample Grade is assigned samples not meeting the limits for Grade No. 2 or evidencing serious defects not specified as a grade factor, e.g., mustiness, sourness, heat, or toxicity.

Grade factors are test weight, heat damage, total damage, and percentage dehulled seed. Definitions of these factors are the same as in soybean grades. Grades similar to USDA grades have been established by the NCPA, the NIOP, and other organizations around the world. Grades and standards of the NCPA (Anonymous, 1989a) are typical of those used and are shown in Appendix A.

Seed delivered by farmers usually meets most of these requirements although the levels of foreign material and admixture often exceed the limits set by the National Sunflower Association (NSA). Test weight, oil, and moisture values usually are within the standards, as FFA is when measured.

The crude oil from sunflower seed has the key attributes of FFA, moisture and volatiles, neutral oil

[32]See Anonymous (1990a; 1989a) and Jones and King (1990).

[33]See Anonymous (1989a).

loss, color, and flash point. Relevant standards are available from many organizations in the United States and around the world. (See *Appendix A* for details.)

Confection-type sunflowerseed seems to have no published specifications, but as the NSA noted (Anonymous, 1991b), these sunflowers are grown primarily under contract with the processors; thus, requirements undoubtedly are imposed on farmers. One would assume that such requirements would pertain to foreign material and to damaged seed and include off-flavor or odor.

Sunflowerseed meal with protein levels of 28 to 38%, depending on manufacturer, is traded in world markets under the Grain and Feed Trade Associations Rule 100 (Anonymous, 1991b). The contract specifies minimum values for protein and fat contents.

## Safflowerseed

There are no federal grades for safflower, but the industry operates under the NIOP rules (Anonymous, 1984) modified in 1990. Safflowerseed for export is sold under terms made effective June 1, 1965 by the Official Standards of the California Department of Agriculture and as subsequently amended. The sample is on the basis of clean seed, and all dockage is deductible from delivered weight. The NIOP rules specify that oil content shall be 34% with no moisture adjustment. The FFA shall not exceed 1%. Iodine value shall be between 140 and 155, and the seed shall contain no more than 3% dockage. Seed failing to meet these specifications is Sample Grade. If moisture content exceeds 8%, the producer is responsible for drying costs.

Specifications for Sample Grade safflowerseed and reasons for rejection of a lot also are given in the NIOP rules. Safflowerseed shall be rejectable if (1) it contains treated seed, toxic seed, chemicals, or other harmful or objectionable materials; (2) FFA exceeds 4%; (3) dockage exceeds 6%; or (4) iodine value is smaller than 140 or greater than 155. There are additional specific premiums and deductions listed for all types of seed. Requirements for domestic safflowerseed of the regular cultivar are the same as those for export.

During the last 20 yr, an industry specializing in the growing and marketing of high-oleic acid safflowerseed has developed. The oil in these cultivars contains a high proportion of oleic acid and thus is quite stable during frying. This seed is sold under the same standards as regular safflowerseed is, except that the iodine value of the extracted oil must not be smaller than 85 nor greater than 95.

## Flaxseed

Grades for flaxseed are established and administered by the USDA–FGIS. Two numerical grades and a Sample Grade are determined according to only three factors—test weight, heat damage, and total damage. The limited number of buyers and sellers and the small volume allow for individual negotiations upon implementation of these very simple standards, and additional factors likely will be included by processors at point of purchase.

## Canola[34]

Grades for canola were proposed by the USDA–FGIS on May 3, 1991 after members of the service consulted with representatives of the industry and of the Canadian Grain Commission, which had standards in place (*Federal Register*, 1991a). The U.S. grades and standards were finalized and published on January 29, 1992, to become effective February 28, 1992 (*Federal Register*, 1992). Because production potential is quite limited and industry trading rules have been operating satisfactorily, official standards for rapeseed, of which canola is one cultivar, were not proposed.

The three grades for canola are determined according to these factors: (1) damaged kernels, with subsets of heat damage and distinct greenness; (2) conspicuous admixture, with a subset of *Sclerotinia*; and (3) inconspicuous admixture. In addition to these grade-determining factors, moisture and dockage are reported on every official inspection. Test weight is omitted from grades for canola because it is "extremely variable and has not been shown to be correlated to the end-use value of seed" (*Federal Register*, 1992).

To distinguish canola from other cultivars of rapeseed, the USDA–FGIS requires that each official inspection include a nongrade-determining screen test to distinguish between high- and low-glucosinolate levels. Low levels of glucosinolates are desirable for canola meal.

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[34]See Dotson (1991).

# History of Grades and Standards

## Soybeans

In the fall of 1924, the first tentative standards were issued and suggested for use by commercial exchanges and others (Barr, 1928, 77). The proposal to introduce federal grades was supported by many agencies, including the National Soybean Growers' Association (the 1924 forerunner of the American Soybean Association [ASA]).

The USDA established five grading factors for soybeans, including test weight, moisture content, splits, damage, and foreign material. In September 1925, soybean grades based on these factors were issued on a purely voluntary basis. Soybeans were classified into one of four grades plus Sample Grade, on the basis of factors believed to influence value in use and in marketing. Early grades were based on the notion that "quantity of products made from soybeans, oil and meal, for example, are in direct proportion to the percentage of sound beans in a given lot" (Barr, 1928, 78).

As a result of debate concerning the effect of splits on yield of oil and meal, a compromise was reached in which the No. 2 limit remained at a fairly high level (10%) but a restrictive limit of 1% was set for the No. 1 Grade, to identify high-quality Choice lots for buyers desiring sound whole beans (Barr, 1928, 82).

Effective September 2, 1926, the voluntary grades of 1924 became official grades under the USDA's Hay, Feed, and Seed Division. In 1940, soybean grades were brought under the aegis of the USDA Grain Division, and several factor limits were changed during the subsequent year. After several conferences on the appropriateness of current grades, test weight for No. 4 soybeans was reduced, additional moisture restrictions were placed on Grade Nos. 1 through 3, and limits on splits were increased for No. 1 from 1 to 10% and for No. 2 from 10 to 15%. A dockage principle also was introduced, and *foreign material* defined as all material other than soybeans remaining on an 8/64-in. sieve. Material passing through the sieve was defined as *dockage*.

In September of 1949, standards were revised again, and the dockage concept was removed. All material passing through the 8/64-in. sieve plus nonbean material picked from it was included in the definition of *foreign material*. Moisture content was removed as a grade-determining factor in 1985. In 1989, the USDA–FGIS began reporting oil and protein contents of soybeans at the request of buyers or sellers.

Limits on the various factors have changed often throughout the history of soybean grades. Sixteen different definitional changes and eight factor-limit changes occurred between 1940 and 1985 (U.S. Department of Agriculture, 1986). Proposals for additional changes continued as the USDA–FGIS reviewed performance and adequacy of soybean grades in light of the purpose of grades and standards that was set forth in the U.S. GSA. The latest changes were published in 1994 (c.f., p. 96).

## Cottonseed

Grades for cottonseed were included in the first book of rules published by the Interstate Cottonseed Crushers Association (ICCA) in 1898. These five pages of rules have expanded dramatically: the 1989–1990 rules of the NCPA (successor to the ICCA) occupy 257 pages.

These rules are amended as needed at the association's annual conventions. In the first rules, neither methods of analysis nor definitive standards were specified. Today, it seems that all points are covered in the rules, and trade of cottonseed and its products is orderly.

An interesting sidelight to the organization of the ICCA was the organization of a group in 1909 that in 1910 became the Society of Cotton Products Analysts (SCPA) (Anonymous, 1947). With only 20 charter members, the SCPA evolved into the AOCS, which now has more than 5,000 members worldwide.

## Sunflowerseed

Sunflowerseed is a relative newcomer as an oilseed crop in the United States. Oilseed cultivars were introduced in the 1960s, and trading was conducted under various trade-group rules. When production increased in the 1970s, processors developed individual grades and grading practices, and nonuniform quality description and discounting resulted. Thus, the USDA was requested to develop official grades, which it did after numerous discussions and hearings and after examination of research conducted by the USDA–FGIS. The new grades were adopted by that service and went into effect on September 1, 1984.

## Safflowerseed

Safflowerseed production developed slowly in the United States, and minor amounts were produced between 1949 and 1955. Seed production had increased to more than 140 million lb by 1956 and continued to increase until 1986. Trading rules and specifications for safflowerseed were established by the NIOP and are the basis for trade. The only attempt to introduce other standards was the recent suggestion that safflower be accepted in the loan programs as Sample Grade. This distinction was unimportant because little or no safflowerseed is placed under loan.

### Flaxseed

Flaxseed is one of the oldest oilseed crops in the United States, and the industry developed factors on which to judge quality many years before the USDA promulgated official grades, which were made effective on August 1, 1934. The official grades evolved from industry and trade practices used for many years (Carter, 1992). Maximum moisture allowed in any grade was lowered from 11 to 9.5% in 1965. Moisture was removed as a determinant of Sample Grade in 1986. The 1965 change also added limits for heat damage and lowered limits for total damage from 20 (Grade No. 1) and 30% (Grade No. 2) to 10 and 15%, respectively—a significant tightening of quality requirements (U.S. Department of Agriculture, 1986).

### Canola

Adapted from previous grades for rapeseed, canola grades were established in Canada in the 1970s. The chief differences, however, were in the requirements for low levels of erucic acid in the oils and of glucosinolates in the meals. The history of grades in the United States consists primarily of efforts by the U.S. Canola Association (USCA) and producers to develop grades with research and assistance from the USDA. Such efforts led to adoption of grades for canola in February 1992.

## Measurement Technology

For most crops, the technology for measuring physical properties relevant to oilseed quality is determined by the USDA–FGIS. Dockage and BKFM are measured with sieves; moisture is measured with electronic meters calibrated to the air oven; and damage is determined by visual comparison with USDA–FGIS-approved line slides illustrating different types and degrees of deterioration.

Because oil and protein are major determinants of the value of raw oilseeds, these characteristics also are included in many quality evaluations. Technology for measuring oil and protein includes reflectance NIR for ground or whole grain analysis, transmittance NIR for ground and whole grain, and several methods for chemical analysis in the laboratory. Researchers continue to develop increasingly rapid and accurate measurement methods for commercial use. Some examples are NMR analyses for oil and moisture in oilseeds and several automated or instrumental analyses for oil content. Many methods used are those of the AOCS.

The measurement technology for soybeans, cottonseed, and other oilseeds is well documented in the two-volume series entitled the *Official Methods and Recommended Practices of the American Oil Chemists* (Anonymous, 1989b). In addition to examining all the classical methods used in the cottonseed industry and in other oilseed industries, technical committees and subcommittees of the AOCS continually explore new and improved methods for the many analyses required in this field.

The techniques for measuring safflowerseed quality are spelled out in detail in the NIOP rules and for the most part are based on official methods of the AOCS (Anonymous, 1984).

## Issues and Problems Related to Quality

### Issues Common to All Oilseeds

Many issues related to grade and to quality determination are common to all oilseeds. The debate over voluntary industry grades versus government mandated grades is especially relevant because grades and standards for oil and meal generally are set by industry trade associations. Several oilseed industries (soybean, flaxseed, canola, and sunflower) use official grades established under the authority of the U.S. Grade Standards Act. Cottonseed and safflowerseed industries use quality specifications established by industry or trade associations.

Although climate, geographic location, weather, and field insects influence quality, the major factors under the producers' control are cultivar, harvest technology and timing, harvest and storage moisture contents, and storage practices. Of these factors, moisture content and storage practices cause the most important problems. Farmers and mill operators recognize these problem areas and attempt to minimize their effects. There are five primary issues common to all oilseeds:

1. **Identifying factors that measure value.** Nearly all oilseeds are processed for a single purpose—oil and meal production, so quality char-

acteristics indicating value are more narrowly focused than those for feed grains. Historically, oilseed grades have relied on the same factors to identify quality and value as feed grains have. The importance of oil and protein contents in determining product value, however, has encouraged measurement of chemical properties into quality evaluations including USDA standards. Other measures such as FFA or neutral oil loss also are considered important, but rapid reliable measures as yet are unavailable for use in the commercial market. Which factors to include in grades, which to use only for information, and which can be estimated from correlated physical attributes are unresolved. The primary determinants of value in all oilseeds are contents of oil and of protein. Few factors in the current grades are correlated with either. Grades for flaxseed, sunflowerseed, and soybeans all contain factors for heat damage, total damage, and foreign material. No other factors are common across the three. Consistency in definitions and in factor limits among oilseeds thus would be desirable.

2. **Defining factors**. In official grades, the definitions of *test weight*, *damage*, and *foreign material* are quite similar among the three oilseeds. But these definitions have changed over time, and debate continues over their specifics, especially as regards foreign material and dockage. The former is a grade factor for neither sunflower nor flaxseed, but is one for soybeans.
3. **Limiting factors for each grade.** The factor limits for soybeans have changed frequently since grades were established. Grade limits for moisture and damage were changed for flaxseed in 1965. No changes have been made in sunflowerseed or canola grades. Limits on each factor are inconsistent among the four oilseeds for which federal grades exist. No strong rationale has been offered for selecting limits for grade differences.
4. **Determining optimal number of grades**. There are two grades for sunflowerseed, four for soybeans, two for flaxseed, and three for canola. No federal grades are in place for safflowerseed or cottonseed. Producer groups, industry associations, and the USDA–FGIS have developed no criteria for deciding the optimal number of grades for these crops. Inconsistency without justification introduces uncertainty and confusion in a fiercely competitive retail market.
5. **Providing economic incentives**. Incentives for quality improvement are lacking because for many the quality attributes of primary economic importance are excluded from price differentials to farmers. There are no incentives for farmers to select cultivars with high oil and protein contents, and thus no incentives for plant breeders to develop cultivars with such characteristics. To encourage producers or marketing firms to improve quality, the characteristics influencing value must be incorporated into prices. Grades—government or private—should facilitate market price differentials for quality by describing relevant characteristics. Current grades have been criticized for failing to identify economically important attributes.

These five areas of concern exist for all oilseeds. The relative importance of these issues and the action required for resolution differ among the five oilseeds and will be discussed for each crop in turn.

## Crop-Specific Issues

### Soybeans

The USDA–FGIS completed its mandated review of soybean grades and published 12 proposed changes in the *Federal Register* (1991b). Of these only Nos. 4, 5, 6, 7, 8, 10, and 11 were adopted (*Federal Register*, 1994).

1. Change minimum test weight/bu from a grade-determining factor to a nongrade-determining factor.
2. Reduce the foreign material limits for Grades U.S. Nos. 1 and 2 to 0.5 and 1.0%, respectively.
3. Reduce the grade limits for splits to 5, 10, 15, and 20% for U.S. Nos. 1, 2, 3, and 4 soybeans, respectively.
4. Report the percentage of splits in tenths of a percentage.
5. Reduce the tolerance for stones from eight to four, and eliminate the aggregate weight option.
6. Reduce the tolerance for pieces of glass from two to zero.
7. Eliminate the grade limitation on purple mottled or stained soybeans and establish a special grade, i.e., Purple mottled or stained, in the standards.
8. Eliminate the grade limitations on materially weathered soybeans.
9. Create a new grade and associated grade limits for U.S. Choice soybeans.
10. Clarify the reference to mixed soybeans in the standards.
11. Establish a cumulative total for factors possibly causing a sample to be designated U.S. Sample

Grade.

12. Report oil and protein contents on all official lot inspection certificates for export soybean shipments.

The USDA–FGIS further proposed to revise the inspection plan tolerances for soybeans, based on changes made in the grades.

The proposal for change generated vigorous debate and a request for more information on costs and benefits. The most controversial issue was the reduction of the maximum limits for foreign material in Nos. 1 and 2 soybeans from 1 and 2% to 0.5 and 1.0%, respectively. Years after publishing the preliminary ruling, FGIS reduced the 12 proposed changes to seven and and issued a final ruling.

These changes, generated in part by the mandatory 5-year review, left unresolved the issues of the commercial technology for measuring oil and protein, the grade limits for splits and for foreign material, and the appropriate definition of damaged beans. The media also have raised concerns over blending practices at country elevators. The importance of the export market to the soybean industry has focused attention on the ability of the United States to compete with other exporting countries. Increasing the levels of oil and protein, and lowering the levels of damage and foreign material often have been promoted primarily because of their potential effect on export market share.

#### Cottonseed

Cottonseed is a by-product from the ginning of cotton fiber, and changes in the crop are made with little attention to the effect on seed quality. Geneticists are reluctant to select for seed quality because there is a risk of adversely affecting the fiber. Efforts to improve seed quality by increasing oil and protein must take into account the need to maintain yield and fiber quality.

Currently, there is a great excess of cottonseed in the United States, and this, coupled with inadequate crushing capacity, has severely reduced prices offered farmers. Additionally, neither export nor direct feeding of seed has grown significantly. Overproduction has forced storage under less than ideal conditions and in this way has brought about diminished quality. Quality improvement in cottonseed is receiving little attention.

#### Sunflowerseed

Quality related needs do not seem major factors in the primary sunflowerseed growing regions. The crop is well adapted to the regions, and pest and bird problems are controllable. Dockage and foreign material are the factors of greatest concern. Expansion of the crop into more temperate regions has created some quality related problems because of increased insect and bird activity. No changes in grades are under consideration.

#### Safflowerseed

Regular cultivars of safflowerseed have no major quality problems other than those of dockage. Most seed is grown in areas without excessive moisture. Because the regular cultivars have tough seedcoats, they suffer little from handling. Certain high-oil content cultivars with thin hulls do suffer some damage in transport and handling. If there are early killing frosts and the seed fails to mature, high chlorophyll content can occur in seed and oil. Quality concerns are resolved between producers and processors.

#### Flaxseed

A major problem is that of early frosts or of insufficient moisture causing incomplete seed fill. Empty seed coats are assessed as dockage, and excess dockage is subtracted from the weight of seed delivered by farmers. In this manner, crop value is reduced. The USDA–FGIS will review grades as required, but neither producers nor processors have requested changes.

#### Canola

Significant canola production in the United States is of such recent origin that few relevant quality issues have been generated at the national level. Judging from Canadian experience, one would anticipate that dockage, particularly weed seeds, could become a major quality problem. The incidence of immature seed increases when canola is used as part of a double cropping system. Immature seed leads to undesirable green coloration due to high levels of chlorophyll. The importance of measuring oil quantity and quality in canola at the time of delivery from producers will increase with crop size. Grades will be developed and defined as the industry grows.

## Information Dissemination

### Price and Quality Information

Price and quality information for soybeans is circulated by the CBOT on an almost continual basis during trading hours. Long-run supply and demand statistics, as well as outlook information, are made available by governments, universities, and private agencies in the United States and abroad. Country elevators usually post daily prices and discounts. The ASA and the USDA–FGIS publish summaries of average qualities by region. These data include chemical composition as well as grade and factor value. Information about quality related price differentials seldom is distributed beyond the local market although quotes usually are available upon request. Responsibility for identifying quality discounts before delivery rests with the producer.

Price and quality information about the other oilseeds seldom is disseminated beyond the realm of producers, processors, and traders dealing in these specialty crops. Exceptions are canola and flaxseed, in which there is an active futures trade on the CBOT. This trade is based primarily on the Canadian crop.

## Promotion and Advertising

Perceived quality often is influenced by information provided to consumers. Promotion and advertising of meal and oil, especially at the retail level, may alter the value of products in consumers' eyes. *Quality*, if defined as customer valuation and satisfaction, is determined in part by the promotion generated in each oilseed producer and processor group.

### Soybeans

The ASA in conjunction with the USDA–FAS, carries out worldwide promotion and use seminars, as well as trade fairs and demonstration projects for soybeans and their products. It conducts aggressive advertising programs worldwide and sponsors research to develop new uses and new products such as soy diesel, soy ink, and soy milk.

The USDA through the FAS, the Economic Research Service (ERS), and the ARS, provides information about production, marketing, and related statistics. The NOPA also actively promotes soybeans and soy products.

Although soybean oil is the most widely used vegetable oil, it has quite a low recognition index by U.S. homemakers. Many other oils are promoted more widely, particularly by food manufacturers. Thus, lesser-used vegetable oils enjoy wider recognition. The ASA has recognized this problem and has expended considerable effort to improve the "image" of soybean oil around the world. If and when industry recognizes the advantages of promoting soybean oil use, there should be a positive change. Currently, however, such a change seems unlikely, and the responsibility of information dissemination probably will continue to rest with the USDA, the ASA, and the NOPA.

### Cottonseed

The main source of information about cottonseed is the NCPA. The USDA, through the ARS and the ERS, also provides some information. The main thrust of current educational efforts is the promotion of direct feeding of cottonseed as a high-energy source for dairy cows. Production and marketing information is included in USDA statistics.

### Sunflowerseed

Most activities promoting this crop have been undertaken by the NSA and by the companies involved in crushing and in exporting sunflowerseed. Three of the four major crushing plants are owned by companies that are international in scope and that undertake major oilseed activities throughout the world. These companies thus have a vested interest in promoting the highest-quality product commensurate with economic return. Sunflower products must compete with all other oilseed products. Thus, there is incentive to maintain the best quality at the lowest cost to end users.

The NSA carries out international promotional and educational programs about both sunflowerseed and sunflower oil. Producers of retail products incorporating sunflower oil also undertake considerable promotion because of the current interest in diet and health. Production statistics are included in USDA statistics.

### Safflowerseed

Because most of the crop is grown under contract, major educational activities for farmers have been provided by contracting companies. Some local programs devoted to safflower have been offered by universities. At one time, a program focused on safflower and providing data as well as educational information was offered by the USDA–ARS. A few companies that package and sell safflower based retail products do advertise, with programs aimed mainly at the health-diet market, which stresses high-quality, cold pressed oils.

### Flaxseed

The U.S. Flax Institute, at Fargo, North Dakota, is a source of information and educational material. Current promotional activities for flaxseed are limited to the two companies producing the industrial grades. There is underlying excitement about the possibility of edible flaxseed oil, but promotional efforts are rather limited. Although quality has little to do with these efforts, a high-quality edible product likely must be produced to encourage such use.

#### Canola

The USCA is promoting the crop and providing production and marketing information to producers. Several large oil processors and packagers are promoting canola oil for diet and health.

## Anticipated Changes in the Industry

### New Products and Uses

#### Soybeans

New food products from soybeans are being developed and introduced into the market. Small-scale extrusion equipment as well as full-fat soybeans in feed provide potential new markets. These changes, however, will involve a small portion of the total crop. Quality measurement required for specialty crops probably will not be introduced into the mainstream of grades and standards. Changes in oil or protein composition can be achieved by plant breeding and biotechnology and may open additional markets such as direct feeding to livestock or other food uses. New technologies and products may require identification of additional attributes of soybean composition.

#### Cottonseed

Efforts to develop gossypol-free seed have led to the use of cottonseed protein for human nutrition. *Gossypol* is a poisonous yellow pigment produced in cottonseed glands. If farmers accept the new cultivars of cotton, such as those with low gossypol content, this will provide a supply of cottonseed with unique qualities suitable for food use. At present, the market provides no incentive for change at the farm level. But if gossypol-free cottonseed is developed, aflatoxin contamination will need to be controlled carefully because the meal will be intended for consumption by humans (Park et al., 1988).

#### Sunflowerseed

No major changes affecting quality are anticipated in the products of regular oilseed sunflower. Previous recognition and demonstration of the value of high-oleic acid cultivars of sunflowerseed in human diets may have an effect on this industry (cf. Purdy, 1986). Sunflowerseed oil has great oxidative stability when used in frying, and the present emphasis on the efficacy of oleic acid in health may be a significant advantage of this sunflower cultivar. Some high-oleic sunflower is grown under contract. Its eventual adoption by the industry would lead to overall improvement in oil quality and to some drastic changes in oil specifications, not unlike the changes occurring in Canada when low-erucic acid rapeseed cultivars were adopted.

Changing to high-oleic sunflower cultivars should not affect the remainder of the industry although there would be some modification of grades, standards, and analytical methodologies. Conceivably, emphasis would increase on health related issues discussed in educational and promotional literature provided by both public and private sectors.

#### Safflowerseed

No changes in production or in consumption are anticipated although there is some interest in developing high-oleic acid cultivars adapted to a relatively wide geographic area. New production regions could create quality-control problems.

#### Flaxseed

Although the nutritional community is quite interested in low-linolenic flax cultivars because they offer another edible oil, this development is unlikely to alter either the market channel for the major uses of or the quality preferences regarding this predominantly industrial grade oil. Introducing a food-grade oil would require major capital investment to upgrade the processing plants designed to produce industrial grade linseed oil.

#### Canola

Many new developments, including biotechnological advances, promise additional possible uses of canola oil. These new uses may require additional quality specification in grades, e.g., oil quantity and composition, and new technology for measuring such attributes.

### New Processes

#### Soybeans

Perhaps the most exciting developments in soybean processing are the use of expanders to process soybeans and the introduction of super degumming of oils. The former reportedly permits relatively complete extraction of oil, leads to economies of extraction, and improves meal and oil quality. The latter has the potential to improve refining of crude oil and to decrease the by-products adding to pollution loads and requiring expensive disposal technologies.

Processors have reacted to customer needs by adopting new processing techniques that have proved effective. Inert atmosphere protection may be extended to crude and degummed oils and could be adapted to provide increased flavor quality and stability. Metals catalyzing autoxidation are avoided widely, but individuals involved in all phases of oil processing, transport, and use must recognize the need for this precaution and avoid carefully copper and copper-containing metals.

The adoption of relatively sophisticated methods of predicting crude oil stability may become part of the standards. Currently, some EEC customers rely on the TOTOX (Anisidine Value plus 2xPV [PV = Peroxide Value]) method to identify poor lots of oil. This method is not used widely in the United States, but its adoption might be warranted in certain situations. Other attempts at predicting the quality of a given lot of crude oil have been made, and as additional research and testing are conducted, some of these methods may become applicable as well. All improvements in prediction would assume that the price of a superior oil entails a premium.

#### Cottonseed

Cottonseed oil processors have worked long to improve the quality of oils. As new approaches have been proved economically sound, they have been adopted. Although the direct solvent extraction-mescella refining approach has been shown to produce superior oils, because of the capital investments required, not all processors have adopted it.

Small-scale attempts at new cottonseed-processing methods have promised to improve meal quality. To date, however, these have been unsuccessful commercially. Current methods for processing cottonseed are entrenched due to extensive investment. No significant economic incentive exists to modify any system substantively.

#### Sunflower, Safflower, Flaxseed, and Canola

All these oilseeds are processed with equipment designed and/or adapted for a certain seed. Currently, no new processes seem to exist to alter either product or quality requirements in raw oilseeds.

### Quality and Export Demand

#### Soybeans

The U.S. soybean market will continue to be influenced by exports. Simultaneously, the importance of soybeans to value of exports and to U.S. balance of trade will continue to attract the attention of producers, processors, and Congress. The desire to capture an increased share of the world market will drive U.S. efforts to improve quality as a competitive tool.

Buyers of soybeans, especially foreign buyers, will continue to criticize excess foreign material, broken and split beans, and damage. Quality improvements made by farmers or handlers will affect exports positively. Additionally, as the organizations involved in promotional and educational efforts continue to offer strong quality programs, the major negative influences, e.g., damage and foreign material, on U.S. exports of soybeans should continue to diminish.

As noted, there has been no incentive offered in U.S. markets for high-oil or high-protein soybeans, so it is unlikely that there will be a rush to develop such cultivars in the near future even though these are ongoing concerns of foreign customers.

#### Cottonseed

Only a small volume of export business occurs in this oilseed because it neither keeps nor travels well. Furthermore, no major complaints about quality or threat of lost market share due to quality related problems seems to exist. Other countries dominate world trade in cottonseed meal, and quality probably is not an issue in determining U.S. market share.

#### Sunflowerseed

Currently, the U.S. export market is quite small. This undoubtedly is a result of the production of sunflower in many countries throughout the world. Seed for export, however, must meet buyers' quality expectations, especially with respect to oil content and to dockage. Nevertheless, improved quality would have little effect on total volume.

#### Safflowerseed

This oilseed has a long history as a U.S. export crop, particularly to Japan. Quality standards are well understood by both buyers and sellers. Neither standards nor markets are expected to change markedly in the near future.

#### Flaxseed

Currently, the United States is a net importer of flaxseed. Barring any dramatic change in agronomic or market circumstances, no changes are anticipated.

### Canola

This crop is struggling to become established in the United States, whose oil needs currently are satisfied by imports from both the EEC and Canada. Until the crop is planted on significant U.S. acreage, concern about export quality probably is unnecessary. If production reaches volumes permitting export, quality will become an issue.

## Changes in Production

### Geographic Shifts

Production regions for soybeans, safflowerseed, flaxseed, and cottonseed have been quite stable for many years. Only small shifts in local regions are likely, but production of sunflowerseed has been expanding into relatively temperate regions. This expansion has created certain quality related problems because of increased insect and bird activities. In the new areas where sunflowers have been introduced not only has quality been affected, but yields have diminished greatly.

Canola still is without a well-defined geographic production region inasmuch as farmers in several states continue to experiment and to diversify. Quality problems may arise as the crop is introduced into new areas of the United States. Because there are both winter and spring cultivars, some cultivar selection problems have been reported along with some quality differences.

## Genetic Changes

### Soybeans

Plant breeders are beginning to search for means of achieving greater oil and protein contents in soybeans without precipitating yield loss. If economic incentives become explicit in the market, plant breeders will respond by selecting for composition as well as for yield and for agronomic characteristics. Genetic engineering has the potential to change chemical properties, for example, by reducing trypsin inhibitors or altering fatty acid composition.

A soybean oil with low levels of linolenic acid has been introduced in limited quantities for evaluation because it has the potential for improved oil flavor stability. There are other attempts to alter the chemical compositions of soybean oil to meet specific product needs or to facilitate development of new products, but it is difficult to predict future quality requirements.

### Cottonseed

If farmers adopt new cultivars of cotton, such as those with low gossypol contents, changes in cottonseed quality will occur.

### Sunflowerseed

Certain potential genetic changes in sunflowers may affect oilseed quality. High-oleic oil sunflowers are being grown under contract. These cultivars were developed by means of straightforward chemical mutation research. Biotechnology as well as traditional plant breeding makes development possible with respect to oil composition, yield, and minor components, particularly those affecting meal quality.

### Safflowerseed

Past breeding studies of safflower have led to the development of high-oleic oil safflowerseed and to that of thin hulled, high-oil content cultivars. But until additional work on this crop is in demand, further developments are unlikely.

### Flaxseed

Because of the smallness and the limited geographic scope of the flaxseed crop, it is difficult to visualize any significant changes affecting quality. Discovery and development of low-linolenic-acid flaxseed (Green, 1986; Haumann, 1990) may offer farmers an opportunity to develop an edible oil crop, but without a unique composition this oil would be faced with competition from either safflower or sunflower oil. Although such a flaxseed oil would have a much better flavor and odor than regular flaxseed oil does, commercial development is unlikely.

### Canola

A crop only recently under development, canola already has undergone exciting genetic transformations, most of which have involved the ability to produce oils with unique fatty acid compositions. If specialized cultivars with unique characteristics are developed, the problems of determining composition and quality of canola at time of delivery will present a challenge to the entire industry, from farmer to end user. If several types are introduced into commercial use, segregation will present a major challenge throughout the entire chain.

# Opportunities for Improvement

## Impediments to Change

### Soybeans

Sound, whole, and normal-colored soybeans are well recognized throughout the market chain. And it is the use and the ultimate disposal of poor soybeans that pose problems. Perhaps evolution and strengthening of grades and standards will alleviate this problem, but concomitant improvements in measurement technology will be necessary. Moreover, price and quality of soybeans will continue to be related closely to penalties assessed for Below Grade beans (Bader, 1988).

Impediments to quality improvement have an economic basis. Unless soybean farmers and handlers understand the advantages of growing soybeans with higher protein and oil contents and with less foreign material, damaged kernels, and splits, U.S. exports will continue to suffer.

The magnitudes of estimated costs and benefits differ widely depending on assumptions about producer response, price effect, market demand, and competitor response. Dockage, storage damage, and handling damage all are factors controllable to a degree by handlers. These problems originate on the farm, where weed management and harvesting/handling/storing practices have much to do with the condition of the product delivered to elevators.

Harvest of wet, immature soybeans poses insurmountable problems. But the farmer must harvest wet, immature soybeans when an early killing frost and wet conditions occur. In most instances, however, the practice of blending such soybeans into sound, dry soybeans should be avoided. Of course, the great volume of soybeans handled by one elevator operator in a given season makes it quite difficult to solve such problems.

Additionally, a farmer may hold carryover soybeans in piles that have been protected inadequately. The soybeans suffer from age, frost, dampness, and possibly heat. If they enter the market channels, unless handled as an individual lot, they likely will be blended into higher-grade soybeans and cause production problems. A better solution is to divert carryover soybeans to direct animal feeding, but doing so provides the farmer with less return. The structure of grades and the practices of handling and pricing control the extent to which damaged soybeans should be blended with good.

Improvement of soybean quality requires a concerted communication effort on the part of all industry associations and governmental bodies involved. If changes in the best interests of producers, processors, and exporters are identified, a concerted effort by all associations may result in the implementation of proposed changes.

### Cottonseed

Removal of the glands (gossypol) in cottonseed requires an economic incentive. But it is unclear whether adoption of the necessary technology can be justified in terms of possible return. If the value of cottonseed proteins in human foods can be demonstrated, changes may prove economically feasible.

### Other Oilseeds

The lack of incentive for change and the absence of major concern about quality improvement in other oilseeds eliminate the need to evaluate other impediments to change. A review of official grades for soybeans, sunflowerseed, flaxseed, and canola would reveal a lack of consistent quality among the four crops even though they are similar with respect to production, marketing, processing, and final use. Grades for these crops also fail to include direct or indirect measures of oil and protein. The lack of national uniform grades for safflowerseed presents a minor problem for that industry. But the small volume purchased, the predominate use of contracts, and the small number of buyers and sellers make grades economically impractical.

# Alternative Solutions

## Soybeans

The USDA–FGIS recently has completed an extensive review of grades and standards for soybeans. Its recommendations partially adopted in 1994 only resolve some of the problems surrounding description of soybean quality. A more drastic proposal is to replace the current four grades with two—Good soybeans, equal to the present U.S. No. 1, and Poor soybeans, equal to the present Sample Grade. Another alternative is creation of an Export Grade, with limits or defects set to match the international competitors' best offer. This Export Grade probably would be close to the current No. 1 Grade or to the current practices of most importers, who specify U.S. No. 2. (See Mounts et al., 1990, for a comparison of the quality of U.S. soybeans with that of competitors'.) Such changes undoubtedly would result in different pricing strategies and would affect price level as well as discounts.

Effects of the grade changes continue to be debated by both proponents and opponents of change. The data of neither adequately prove whether grade changes can improve quality or whether improved quality can enhance U.S. competitive position vis à vis other exporting nations. The costs and benefits of many proposed changes have been the basis of heated debate, and no solution has been embraced unanimously.

### Flaxseed

Currently, grades and standards seem adequate for regular flaxseed cultivars. Altering oil quality is possible technologically, but there are potential pitfalls in the development of low-linolenic types. Seeds will need to be segregated, and standards based on iodine value and on linolenic acid content must be developed. Genetic and biotechnological approaches well may provide new opportunities for changing product characteristics, and such research should be supported and funded. Scientific and educational efforts will be required to solve the problems of excess dockage and damage resulting from harvesting, handling, and storing.

## Role of Public Policy and Private Initiatives

The most effective role of public policymakers is that of setting rules and creating regulations under which the private market must operate. These necessitate uniform grade standards as well as research and information distribution. Antitrust rules specify the parameters within which processing, marketing, and exporting firms may conduct business. The private sector sets prices and price differentials within the regulatory environment. Competition and market forces establish incentives, and the decisions of thousands of individual farmers, business firms, and managers determine actual quantity and quality of products delivered to both domestic and export markets and to final consumers.

In all oilseed industries, research at public institutions provides new genetic material as well as new product forms requiring quality identification. The benefits of uniform grades and standards accrue to all buyers, sellers, and consumers and therefore must be the responsibility of public agencies. Notwithstanding, some oilseed industries involve such small volumes and so few participants that the cost of government mandated grades and standards is unjustifiable.

The current balance between government and private responsibilities for grades and research probably is appropriate for all oilseeds except soybeans. Continued research to improve measurement of physical properties relating to end-use value is an important goal and should be a government responsibility for soybeans and perhaps sunflowers. Private industry in all six oilseeds evaluated in this chapter must accept responsibility for maintaining incentives reflecting true-value differences back through the market channel and for responding to competitive pressure to maintain efficiency.

## Glossary

**Canola.** Name coined in Canada for the low-erucic-acid, low-glucosinolate varieties of rapeseed.

**Cold pressing.** Extracting oil not by solvent but by pressure.

**Damaged kernels.** Weather, disease, frost, germ, heat, mold, sprout, insect, ground damaged, and/or otherwise materially damaged kernels.

**Foreign material.** All material passing through an 8/64-inch round hole sieve and any material other than soybeans remaining on the sieve.

**Gossypol.** Cottonseed gland.

**Heat damaged soybeans.** Result of overheating that occurs during storage at moisture levels and temperatures conducive to fermentation or by excessive heat in grain drying equipment.

**Miscella.** After oil is removed from soybean flakes and collected by being dissolved in hexane, a mixture with this name is formed.

**Other Colored soybeans.** Beans with green, black, brown, or bicolored seedcoats.

**Splits.** U.S. grade factor for soybeans for which more than one-fourth of the bean has been removed and which otherwise are undamaged.

**Stearine.** Cloud of solids formed by salad oil at refrigerator temperatures.

**Test weight.** Measure of weight per unit volume, reflecting kernel density and packing characteristics. In the United States, recorded as lb/bu.

**Winter/Winterized oil.** Stearine occurring naturally in the winter; hence, clear oil taken from the tops of tanks.

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# 9 Nuts

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## Introduction

This chapter discusses quality issues relevant to commercial nut production in the United States. These issues reflect diversity in plant environmental adaptations and versatility in use. Additionally, the economic consequences of quality differ greatly among industries.

Almonds, walnuts, pecans, hazelnuts, pistachios, macadamias, and peanuts each will be discussed. Although botanists consider peanuts a legume, the public considers them a nut and often substitutes them for tree nuts.

Nut quality is sensitive to environment, harvesting, processing, and consumer handling. Quality losses usually are the result of high oil content. Depending on growing conditions, oil content—even of the same nut cultivar—may vary from season to season. But early harvesting and proper handling and storing at all market levels ensure high kernel quality. The next sections describe how to protect and to maintain nut quality so as to achieve consumer satisfaction with and continued acceptance of nuts.

## Production and Use of Nuts

### Major Uses

Tree nuts averaged less than a 2% growth in annual retail sales during the second half of the 1980s (*Progressive Grocer*, 1990). Thus, any increase in sales will be accompanied by innovative product development and aggressive promotion.

#### Almonds

For almonds, *direct consumption*, i.e., consumption by retail consumers, represents a small part of total consumption. Specifically, the in-shell almond market represented only 1.4% of total almond consumption in the 1983–1984 marketing year. These almonds are sold primarily during the holidays.

Shelled almonds are used widely as a main and as a supplemental ingredient in numerous high-value products. Almonds are sold raw, roasted and flavored, and manufactured, e.g., sliced, slivered, chopped, or blanched, for both direct consumption and home cooking.

Table 9.1 presents the distribution of shelled almond use in 1983–1984. Confectioners, the largest domestic users, are followed by mixers and salters. Ice cream manufacturers, cereal manufacturers, and bakers also use small quantities of almonds.

The U.S. almond industry operates under a federal marketing order limiting domestic supply. Dwarfing the domestic market, the export market remains the dominant outlet for California shelled almonds.

Almond exports, which are limited by annual production, began with a shipment of 10 t to Japan in 1955 (Payne, 1988). Since then, exports have increased gradually, reaching 10,000 t in 1965 and 50,000 t in 1975. During the late 1970s and in the 1980s, almond exports continued to increase, reaching 128,000 t in 1984. Almonds were eligible for export financing under the CCC Export Credit Sales Program (Anonymous, 1977b).

#### Walnuts

Domestic in-shell walnut consumption represents less than 30% of walnut sales (Villata, 1991), which are concentrated between the fall and winter holidays. The in-shell share of sales has been stable for several years (Table 9.1).

Raw kernel sales at retail outlets represent approximately 20% of domestic shelled walnut sales (Villata, 1991; Table 9.1). Most shelled walnuts are sold as raw kernels and as pieces for home use (Table 9.1). Bakers use approximately 12% of walnuts produced, and confectioners and ice cream and cereal manufacturers account for some marginal use. The volume of shelled walnut kernels used by industrial manufacturers is small compared with the volumes of almond and pecan kernels, and the walnut industry has attempted to expand kernel uses.

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The in-shell walnut market is primarily an export market, and 70% of exported walnuts are in shell. Walnuts have been exported from the United States for decades. During the 1950s, walnut exports were less than 2,100 t annually, except in 1954 and in 1958. Annual exports remained less than 2,100 t until 1968, after which they accelerated. Average volume had quadrupled by the late 1970s. Walnut exports continued to increase during the 1980s although at a slowed pace. In 1986, 26,295 t of walnuts were exported from the United States. The largest market for U.S. walnuts is Europe; the largest importer, Germany.

### Pecans

Retail sales of pecans represent a supplemental and a dispersed market. Both in-shell and shelled pecans are marketed at retail outlets; the former are available primarily before the holidays. The latter are available year round although especially great quantities appear during the harvest and the holidays.

Shelled pecans are used in a multitude of commercially manufactured products and in homemade foods. Pecan use by manufacturing has changed slowly. Table 9.2 presents the percentage shares of pecan distribution, by end user. A relative decrease in use by bakers and a relative increase in use by ice cream manufacturers and gift packers are indicated (Hubbard et al., 1990a; Powell, 1975; Woodruff, 1967). Retailers' shares of shelled pecan distribution have remained stable. (Data on pecan distribution only approximate actual distribution.) Pecans distributed by wholesalers may be used in several products. Year-to-year variations in pecan use are influenced by supply and price.

Mail order shipments of pecans are small and fairly constant, and volume sold through mail-order catalogs has ranged from 1,000 lb to 2.25 million lb (Mosteller, 1980). More than 75% of mail order sales typically are of shelled pecans. An average shipment is a 3-lb box of plain shelled halves. Quality is crucial for the success of any mail order operation, which depends on repeated purchases by satisfied customers.

During the 1950s, pecans led U.S. tree nut exports although exports never have played a major role in the U.S. pecan industry. The greatest volume of pecan exports, 2,665 t, was recorded in 1982 (Table 9.3). Since then, exports have declined while imports have increased considerably. The net trade balance became negative in 1983 and in 1985 amounted to 3,728 t, a figure greater than that of the U.S. maximum export volume of 1982.

### Hazelnuts

Direct consumption is a major end-use of U.S. hazelnuts, which are large and attractive. Approximately half of domestically produced hazelnuts are sold

**Table 9.1. Utilization of almonds, walnuts, and pistachios**

| | Almonds | | Walnuts | | Pistachios | |
|---|---|---|---|---|---|---|
| End user | In-shell | Shelled | In-shell | Shelled | In-shell | Shelled |
| Mixers and salters | 0.5 | 4.7 | 2.0 | — | 23.2 | 2.4 |
| Wholesalers | 0.4 | 1.5 | 12.0 | 22.7 | 12.8 | — |
| Retailers | — | 4.8 | 1.0 | 5.5 | 13.8 | — |
| Exports | 0.5 | 56.6 | 19.6 | 5.1 | 11.0 | 4.4 |
| Other food | — | 2.1 | — | 10.1 | 14.7 | 1.2 |
| Manufacturers | — | — | — | — | — | — |
| Other fruit handlers | — | — | — | — | 10.6 | — |
| Gift packers | — | — | — | — | 1.2 | — |
| Others[a] | — | 2.8 | 1.0 | 1.4 | 1.4 | 0.4 |
| Confectioners | — | 12.2 | — | 2.7 | — | 0.5 |
| Ice cream manufacturers | — | 4.4 | — | 1.0 | — | 1.0 |
| Cereal manufacturers | — | 3.7 | — | 0.8 | — | — |
| Bakers | — | 3.3 | — | 11.8 | — | 1.4 |
| Rock jobbers | — | 2.5 | — | 2.9 | — | — |
| Other shellers | 0 | 0 | 0 | 1.2 | — | — |
| Total | 1.4 | 98.6 | 34.8 | 65.2 | 88.7 | 11.3 |

[a]Includes for almonds: gift packers, mail orders, and food services; for walnuts: cooperatives; for pistachios: fruit stands, rock jobbers, and mail orders.

**Table 9.2. Utilization of pecans**

| End user | Percent of utilization according to Woodroof[a] | Powell[b] | Hubbard et al.[c] | NPSA[d] |
|---|---|---|---|---|
| Bakers | 36.0 | 25.5 | 25.0 | 17.5 |
| Confectioners | 19.0 | 21.9 | 12.0 | 7.8 |
| Retailers | 24.0 | 15.3 | 22.0 | 7.2 |
| Ice cream manufacturers | 15.0[e] | 4.9 | 7.0 | 7.8 |
| Exports | —[e] | 4.8 | NA | 1.8 |
| Gift packers | —[e] | 4.7 | 10.0 | 2.3 |
| Mixers and salters | —[e] | 4.1 | NA | 7.7 |
| Other | —[e] | 9.2 | 6.0 | 15.4 |
| In shell | 6.0 | 9.6 | NA | 17.7 |
| Wholesale distributors | NA | NA | 14.0 | 5.8 |
| Food service outlets | NA | NA | 4.0 | NA |
| Mail orders | NA | NA | NA | 8.1 |

NA = Not available

[a]Woodruff, 1967.

[b]Powell, 1975.

[c]Shelled pecans as reported by Georgia shellers in Hubbard, et al., 1990a.

[d]NPSA = National Pecan Shellers Association.

[e]Ice cream manufacturers, exports, gift packers, mixers and salters, and other totaled 15% as a single category in this study.

in shell, alone or in a mix with other tree nuts.

Hazelnuts are shelled by three of their seven or eight major handlers. Occasionally, in years of great output, growers temporarily may assume the role of handlers and shell portions of their own crops. Hazelnut users include bakers, confectioners, cereal manufactures, and salted- and mixed-nut producers.

Because of their attractiveness, U.S. hazelnut exports usually are in shell. Although in-shell nut exports make up a small portion of total world hazelnut exports, the United States is a major supplier.

**Table 9.3. Pecan imports and exports, 1975–1987, metric tons (t) U.S. Department of Agriculture, various years)**

| Year | Imports | Exports | Net |
|---|---|---|---|
| 1975 | 1,192 | 1,660 | 468 |
| 1976 | 1,417 | 1,065 | −352 |
| 1977 | 218 | 1,637 | 1,419 |
| 1978 | 564 | 1,540 | 976 |
| 1979 | 272 | 1,539 | 1,267 |
| 1980 | 436 | 2,021 | 1,585 |
| 1981 | 200 | 1,896 | 1,696 |
| 1982 | 347 | 2,664 | 2,317 |
| 1983 | 2,082 | 1,548 | −534 |
| 1984 | 1,335 | 929 | −406 |
| 1985 | 4,696 | 968 | −3,728 |
| 1986 | 3,938 | 1,229 | −2,709 |
| 1987 | 5,345 | 1,961 | −3,384 |
| 1988 | 1,043 | 2,676 | 1,633 |
| 1989 | 3,901 | 4,082 | 181 |

t = 2,204.59 lb.

### Pistachios

Ninety percent of domestically produced pistachios are sold in shell. Major in-shell users include mixers and salters, who use one-fourth of the annual crop. Other large in-shell users include retail and wholesale traders, who account for another one-fourth.

Shelled pistachios represent a minimal portion of the nut's annual disappearance. Mixers and salters, cereal manufacturers, and ice cream manufactures are the primary users of domestically shelled pistachios. Small quantities are used by other food manufacturers, gift packers, and mail order companies. Exporters use the greatest percentage.

Since 1980, domestic pistachio production has expanded rapidly, with exports rather quickly becoming an important outlet for U.S. production. The most important market for shelled pistachios (Table 9.1), exports exceed imports by several times.

Before the political crisis of the late 1970s, Iran supplied the United States with pistachios. During the 1980s, in-shell pistachios (81% of total pistachio imports) were imported from China, Hong Kong, and Turkey; smaller quantities, from Israel and Pakistan. The greatest volume had been imported in 1983–1985 from Hong Kong and Turkey. But the 1987 trade embargo against Iran in effect cut off U.S. pistachio imports from that country. Subsequently, shelled pistachios have been imported from Afghanistan, Mexico, Turkey, and Pakistan.

### Macadamias

Since 1948, macadamia production in the United States has increased slowly but steadily. In the early 1960s, U.S. annual per capita consumption of macadamias was only 0.01 lb. Gradually, this figure increased to 0.05 lb in the 1980s. Past consumption rate increases suggest that the nut's share in per capita consumption likely will grow.

California grown macadamias are consumed directly in rather small quantities, primarily during the fall and winter holidays. But direct consumption of in-shell nuts, which are quite hard, requires that buyers have a specially designed nutcracker. Because parrots enjoy macadamias and prefer those with thick shells, a new market for parrot owners exists.

Approximately half of California grown macadamias are processed by the Gold Crown growers' cooperative. This co-op purchases 65,000 lb of in-shell nuts annually and sells half as in-shell nuts, primarily to wholesalers. The co-op cracks the remaining nuts, and a contracted company separates meats and pieces from shells. Shelled macadamias are sold to bakers and to candy manufacturers. Hawaiian macadamias are used to produce macadamia nut brittle, chocolate covered macadamias, salted nuts, and other products. Spoiled kernels are crushed, and oil is used by the cosmetics industry. Shells commonly are used as fuel by processors.

In-shell exports of U.S. macadamias are small. From 1981 to 1990, the greatest volume—135 t—was exported in 1988. The greatest export volume to a single country was sold in 1989 to Australia, which imported 81 t. Other countries importing in-shell macadamias in that year included Guatemala, Brazil, Malawi, Zimbabwe, and Germany. Most in-shell exports were seeds. In-shell macadamias also were exported to Canada, Hong Kong, Taiwan, and Japan. Currently, Japan is the world's largest importer of macadamias and a primary importer of the U.S. crop.

Exports of shelled macadamias increased steadily from 1981 to 1990. In 1982, 248 t were exported. By 1990, world exports had grown to 2,287 t, and U.S. exports amounted to 392 t. In the first half of the 1980s, the world's major macadamia importers included Kenya and the Republic of South Africa. The importance of both countries in terms of macadamia importation decreased in the second half of the 1980s, when Malawi and Costa Rica increased their imports. Throughout the 1980s, Australia and Guatemala consistently were among the major buyers of U.S. macadamias.

In 1990, macadamia processors imported 5 million lb of kernels. Imports have been increasing because the domestic supply at times has been insufficient, the wholesale prices of imported kernels have been considerably lower than the Hawaiian prices, and the quality of imported kernels has improved.

### Peanuts

In-shell peanuts represent about 10% of the U.S. peanut market. A primary use of in-shell peanuts is for snack food although the size of this market has decreased relative to that of other markets.

Confectioners, mixers, and salters use shelled peanuts in several products (Table 9.4). But most consumption of peanuts occurs in the form of peanut butter. A native North American product, peanut butter now is known throughout the world. Shelled peanuts not consumed domestically or exported are crushed for oil before the new crop harvest, as mandated by existing governmental peanut support program.

Most exports have been to developed industrial countries, including Canada, the EC, and Japan (Florkowski and Fletcher, 1990). Export volume is influenced mainly by annual supply and peanut price. Average annual volume exported during the 1980s was 334,000 t.

Peanut imports are regulated carefully because the governmental support program sets the base quota. The effective farm quota was 1.665 million lb in 1992. The difference between the base quota and the effective quota is called *undermarketings*. Because of exceptionally poor peanut production in 1980–1981, the quota was changed to allow imports of 182,000 t.

Peanuts contaminated by aflatoxin are crushed for oil because in that state contamination can be removed. Surplus peanuts also are crushed. Peanut oil exports from the United States depend on peanut supply. The destination of such exports has been in flux: in the 1980s, major shipments of U.S. peanut

**Table 9.4. Utilization of raw shelled peanuts**

| End user | Percent |
|---|---|
| Confectioners | 21.2 |
| Mixers and salters | 24.7 |
| Peanut butter | 51.5 |
| Other | 2.6 |

oil were destined for the EC and for Central America.

### Summary

Nuts can be in shell, shelled, or broken. The processing of tree nut kernels and pieces and the crushing of peanuts also yield meal.

Most nuts are consumed as shelled kernels or as pieces. The former are used by bakers, confectioners, and ice cream manufacturers. large kernels are used as salted and roasted nuts sold alone or in a mix. Shelled nuts also are sold raw.

For some nut industries, in-shell sales of nuts generate more revenue than shelled sales do. The hazelnut and pistachio industries are dependent especially on the market for in-shell nuts, which are sold directly to consumers.

The domestic market is of most importance to the pecan and macadamia industries. The almond, walnut, hazelnut, pistachio, and peanut industries depend on both domestic and export markets.

## General Production Description

### Almonds

Almond production is concentrated in California's San Joaquin and Sacramento valleys. The ten leading counties in terms of almond production are Kern, Stanislaus, Merced, Fresno, Butte, San Joaquin, Madera, Tulare, Glenn, and Coluse. Approximately 6,700 growers operate orchards ranging in size from a few to several hundred acres. The average orchard comprises 60 a. The four major almond cultivars include Nonpareil, Carmel, Texas/Mission, and Merced.

### Walnuts

Walnuts are produced primarily in California; small quantities are produced in Oregon. A 40 a./orchard minimum is recommended by the industry, and an average operation extends from 60 to 100 a. Available to growers are numerous walnut cultivars, which differ in terms of kernel maturity, shell thickness, kernel color, and size. Because of cultivar differences, some nuts are produced for the in-shell and others for the shelled market. A popular in-shell cultivar is Harley; the most popular shelled cultivar, Serr. A grower may select a cultivar or cultivars according to the marketing strategy and the resources available for harvest. Many cultivars are harvested from Labor Day through early November.

### Pecans

Pecan plantings expanded during the 1920s (Wood et al., 1990). Pecan orchards range in size from a few trees to large plantations. Recent plantings tend to be large orchards with thousands of trees. Because of the long productive lifespan of pecan trees, however, orchards come in a variety of sizes. That numerous small pecan orchards have been abandoned in Georgia, North Carolina, Alabama, and Louisiana, however, suggests economies of scale in pecan production.

Pecan-bearing trees are either improved or unimproved, the latter being either seedlings or natives. *Unimproved* trees propagate without human interference, usually along riverbeds in Texas and Oklahoma. *Improved* trees are propagated through seeds. Because they do not propagate true-to-seed, grafting has become a commonly-used propagation method (Crocker, 1983). Grafted trees are known as *improved cultivars*.

Dozens of improved pecan cultivars differ in terms of maturity, disease resistance, yield, and quality characteristics. The most popular cultivars planted in the southeastern United States include Stuart, Desirable, and Schley (Hubbard et al., 1988a). Cultivars recommended for the western United States include Wichita, Desirable, and Western Schley.

### Hazelnuts

Hazelnuts, introduced to the Pacific Northwest in 1883, now are produced primarily in the Willamette Valley of Washington and Oregon. The Clackamas, Washington, Yamhill, Marion, Lane, Polk, Linn, and Benton counties of Oregon produce 95% of the nation's crop.

A commercial hazelnut orchard can be comprised of anywhere from five to several hundred acres. As harvest method has changed, orchard size has increased. Hand harvesting, for example, limited orchards to 10 to 15 a. But mechanical harvesting requires at least 50-a. orchards to exploit economies of scale. Most orchards extend from 40 to 100 a.

The four most prominent hazelnut cultivars planted in Oregon are Barcelona, Ennis, Butler, and Daviana. For many years, only the first was available commercially, and it remains by far the most popular. Daviana is used as a pollinating cultivar for Barcelona (Growing Hazelnuts in Oregon, 1985). A cultivar gaining recent popularity is Ennis.

### Pistachios

The pistachio industry began with plantings in California in the late 1960s and the early 1970s. Although California is the primary producer of this nut, sizable amounts also are produced in Arizona. Utah, New Mexico, Nevada, and Texas produce small quantities. In California, the state's Pistachio Commission divides producing area into three districts. Most production originates in District I, which includes counties Kern and Tulare. Counties Madera, Kings, and Fresno are the largest producers of pistachios in District II. Counties Glenn, Butte, and Yolo are the largest producers in District III, which includes many other counties. This district produces fewer pistachios than either of the other two production areas.

Approximately 560 growers produce pistachios in California. Total acreage planted with pistachios has been increasing at a decelerating rate. The average size of an operation fluctuates between 90 and 100 a.

Pistachios are propagated through grafting. Several root stocks are used, the most popular of which is Pioneer Gold, known for its resistance to *Verticillium* wilt. The most popular cultivar is Kerman.

#### Macadamias

Introduced to the macadamia by Australia in 1892, Hawaii is the primary macadamia producing state. In the early 1950s, only two U.S. companies were processing this nut (Anonymous, 1952). Although there are 650 growers in Hawaii, production now is dominated by fewer than ten corporate farms (Anonymous, 1991).

The sizes of macadamia orchards differ greatly. Even corporate farms usually do not operate a single orchard, but rather several orchards scattered across the islands. The average orchard operated by small growers consists of 11 a.

California's macadamia orchards, first planted in 1946, also differ widely in size. Members of the Gold Crown co-op may own from 500 to 1,200 trees, with the majority operating between 40 and 100. About 325 members of the California Macadamia Society (CMS) resided in that state in the early 1980s (Rosengarten, 1984).

Commercial orchards in Hawaii plant only grafted trees (Rosengarten, 1984) of the smooth-shell type. Pahan, Keauhou, Nuance, Kohala, and Kakea cultivars were developed in the late 1940s. Since 1971, Kau, a brown cultivar, also has been available. Keauhou and Ikaika are commercial cultivars suited for processing (Menninger, 1977). Two promising new cultivars are Meika and Makai.

#### Peanuts

The agricultural production diversification program advocated by state commissioners of agriculture early in this century (Holland Braund, 1989) introduced peanuts into the Southeastern United States on a large scale. This program sought profitable alternatives to cotton production in the South, where domestic peanut production still is concentrated, especially in Alabama, Florida, Georgia, North Carolina, Oklahoma, Texas, and Virginia.

Total acreage planted with peanuts remains fairly stable at 1.5 million a. Peanuts usually are grown on numerous small 50-a. plots (McArthur et al., 1982). But high export prices encourage increasing allocation of land to peanut production. Approximately 26,500 growers produce peanuts on 42,100 farms.

Each peanut cultivar produced in the United States can be placed in one of four groups. Production of each concentrates in a different geographic area of the country. Runner cultivars, which dominate U.S. peanut production (Carley and Fletcher, 1991), are grown primarily in Georgia, Alabama, and Florida. An especially popular cultivar is Florunner. Virginia peanuts are grown in Virginia and North Carolina; Spanish peanuts and Runners, in Texas and Oklahoma; Valencia peanuts, in New Mexico.

Cultivar genetics influences oil content, which ranges from 35 to 50%.

## Organization of the Marketing System

### Overview of the Market Channel

The market channels for tree nuts and for peanuts are fairly similar. A grower delivers harvested nuts to the handler of choice. In most instances, this is an independent handler although in some tree nut industries it also may be a grower-owned marketing cooperative. The first-handler assembles the product and enhances its value through cleaning, drying, sorting, sizing, and storing. The handler also may polish and color the shells of nuts sold in shell.

When first-handlers are shellers, they shell delivered nuts, sort kernels and nutmeat pieces according to applied grades, and package and ship nuts to storage or to buyers. Buyers include wholesalers, retailers, and food processors using nuts as a major or a supplementary ingredient. Wholesalers and food processors may offer nuts and nut products to retailers or to food distributors. The latter may repackage before delivery to retail outlets.

## Unique Characteristics of Shellers and of Marketing Firms

### Almonds

The presence of numerous growers operating orchards ranging widely in size has supported development of marketing cooperatives and of independent almond handlers. Currently, the Blue Diamond is the only marketing cooperative. It also is the largest handler, claiming about one-half of California almond growers as members. Marketing almonds through a co-op enhances the value of a specialized crop for small growers. Each of the approximately 110 almond handlers in California operates independently—purchasing in-shell or shelled nuts and shelling, processing, and marketing them either directly to wholesalers or retailers or through brokers.

### Walnuts

Growers sell crops to approximately 60 walnut handlers, the largest of which is the Diamond Walnut of California cooperative. Handlers shell walnuts or prepare in-shell walnuts for subsequent sale, store walnuts over extended periods, and control carry-in as the new harvest begins.

The largest walnut handlers process more than 40,000,000 lb of nuts annually. The top five process 75% of the annual crop. Several smaller handlers process the remaining 25%.

### Pecans

Pecan handlers include accumulators and shellers. Because pecan orchards differ greatly in size, the need for unique intermediaries called "accumulators" arises. Pecan sales to accumulators are especially important to small growers, nearly 62% of whom sell to these agents (Hubbard et al., 1987). Assembling pecans from small growers, accumulators conduct postharvest tasks such as cleaning, sorting, sizing, and grading. In Georgia, accumulators sold 69% of pecans to shellers and 24% to wholesale distributors in 1989 (Hubbard et al., 1990b).

A sheller may process from several thousand to several hundred thousand pounds of pecans annually. The National Pecan Shellers' Association (NPSA) registered 29 shellers in 1991. Four major pecan shellers process about 70% of the crop.

### Hazelnuts

Hazelnuts are sold by growers to eight major handlers. The number of smaller handlers fluctuates annually in response to production changes. A bargaining association contracts with major handlers and thus equalizes prices received by growers. Any price differences result from adjustments caused by quality defects.

Hazelnut handling companies differ in size. The largest processes 35 to 40% of the annual crop; the smallest, 2 to 3%. Hazelnut processing is quite concentrated. The top two handlers process 60% of the crop; the top four, 85%. Remaining nuts are handled by a few smaller companies, each of which processes 5 to 6%.

### Pistachios

Approximately 18 pistachio handlers operate in the United States, primarily in California. Two companies are so-called secondary processors, which primarily shell pistachios and process shelled kernels. A few suppliers are located in the East.

Pistachio handlers, too, differ in size, which is influenced by quantity of nut purchased. Frequently, handlers limit an operation to the volume of nuts produced in owned orchards. Two pistachio handlers process nearly 80% of an average crop in California. Plants are located near major production areas, and some large handlers operate more than one plant.

There is no bargaining association organized within the pistachio industry, which is not subject to a marketing order.

### Macadamias

C. Brewer & Co., Ltd., is the world's largest grower, processor, and marketer of macadamia nuts and products (Rosengarten, 1984). Mac Farms operates several thousand acres of orchards and processes macadamias in its own facilities. Shelling and processing macadamia nuts into an array of products, Hawaiian Holiday, another large company, purchases nuts from independent growers. Among these products are chopped and ground macadamia nuts. The two largest macadamia processors in Hawaii process at least 70% of the crop. In California, the Gold Crown cooperative is the largest macadamia processor.

### Peanuts

Numerous handlers are allowed to purchase and to process peanuts. Growers can deliver peanuts to any of 400 buying points, approximately half of which are scattered throughout the Southeast. A buying point purchases peanuts for only one sheller and handles nuts within the government peanut program. At the buying point, where a commission is charged, peanuts are cleaned, dried if necessary, sorted, and stored before being shipped to the warehouse.

In recent months, six southeastern shellers formed a limited partnership. Henceforth, the top three peanut shellers are expected to process 80% of the average crop, and the number of shellers is expected to decline from 31 to 25, not including custom shellers for seed.

### Pricing Practices and Strategies

How the specific nut industry is organized affects price discovery. Among the major tree nut industries, only the pecan industry remains unregulated. The almond and the walnut industries operate under marketing order, as does the smaller hazelnut industry. The peanut industry is subject to government regulation. The pistachio and the macadamia industries are not.

The controlled supply of many nut types limits downward price fluctuation. Fluctuations during harvest are restricted further by bargaining associations and by marketing cooperatives. Nut growers often are guaranteed a price during harvest, regardless of time of sale. For example, walnuts sometimes are contracted several weeks before harvest. Exact price, however, is established at delivery, when lot quality is determined. Delaying the harvest of other nuts also may cause quality defects leading to low prices.

Prices of pecans are discovered through negotiation. But a survey of pecan growers (Hubbard et al., 1987) indicated that they frequently felt a lack of negotiating power. Accumulators report that more than 70% of transactions are conducted at the buyer's asking price, whereas only 9% are conducted at the grower's. Shellers report that 45% of pecan purchases from growers and 54% of purchases from accumulators are at negotiated prices.

Peanut farmers benefit from the government support program ensuring minimum price. This program establishes the peanut quota for the domestic market each year. Only the volume specified in the quota, including peanuts for seed and undermarketings, and buy back peanuts can be marketed domestically. For accepting the quota, peanut farmers are guaranteed a minimum price. But in response to supply and price changes, farmers may choose to sell at a different price.

Peanuts produced above the quota cannot enter the domestic market and must be exported. The contract price of peanuts produced above the quota, so called *additionals*, is determined by world peanut supply and demand.

Prices for delivered nuts are adjusted for quality. In some industries, this adjustment is implemented not by discounting prices but by subtracting a determined volume from that delivered. Some handlers use an elaborate system of discounts for major quality defects, and the system allows a grower to sell rather low-quality nuts at a considerable discount.

Beyond the first-handler, price seldom is adjusted for quality. Nuts are delivered according to prespecified quality requirements, and discounts are granted only if, despite attention to quality, it is below the specified level upon delivery. For example, pecan shellers are granted discounts if weevil larvae are present among pieces (Florkowski and Hubbard, 1991).

The macadamia industry suffers from insufficient processing capacity. During peak harvest season, the separating of spoiled from good kernels delays drying (Anonymous, 1991) and thereby increases loss because wet in-shell macadamias cannot be stored without diminution of quality.

Little is known about price adjustments due to quality problems in export markets. In the past, discounts have been granted because of quality problems. Quality disputes in export markets are infrequent, however.

Prices are disseminated by nut industry organizations, trade press, electronic mail, and telephone hotlines. The USDA–Federal-State Market News Service (FMNS) gathers and disseminates price information during the pecan harvest. Method or methods used differ from industry to industry because of differences in the price discovery mechanism. Domestic price information is essential in any nut industry. And world nut price information is required by industries depending heavily on export markets, as do the almond, walnut, peanut, pistachio, and hazelnut industries. World prices of peanuts, almonds, walnuts, and hazelnuts are available through *Edible Nut Market Reports*, published by Man-Producten, Rotterdam, BV.

## Summary of Price-Quality Sophistication

The relation between price and quality of nuts depends largely on overall uniformity of quality. Uniformity is influenced by the genetics of major cultivars, the growing conditions as determined primarily by climate and cultural practices, and the methods of harvest and preparation.

Proper genetic makeup of cultivars planted by an industry is essential to quality. When a few cultivars dominate production, as they do for almonds and hazelnuts, the nut industry can predict the quality of the crop accurately and determine an acceptable price. This also is true of peanuts, whose cultivars are region specific. Genetic diversity in pecans is pronounced. Nuts are produced from different cultivars, and variable quality is reflected in price structure (Westberry et al., 1989).

Climate and growing conditions, e.g., precipitation, relative humidity, temperature, and sun hours, also influence nut quality. And changing growing conditions influence nut development and chemical composition. In some nut industries, chemical composition including oil content affects grade. Oil content also affects subjective quality measures such as flavor. Climate stimulates or delays disease outbreaks or insect infestations and thus diminishes quality. For example, growers of peanuts or pecans in the humid southeastern states report quality problems different from those reported by growers in the drier western states. Quality differences are measured in terms of insect damage, size, and kernel color.

Preparation of nuts for sale improves quality and lowers marketing costs. Cleaning, removing foreign material or visibly damaged nuts, drying, and sorting by cultivar increase prices received by growers.

Nut industries located in a single well-defined geographic area are characterized by fairly uniform genetic stock. Both location and genetic uniformity stimulate the organization of cooperatives and the implementation of marketing orders. Moreover, the quality of nuts from a single area is more uniform than that of nuts from many areas. When nut quality is uniform, relatively limited sophistication is required to account for quality differences, and a fairly consistent price structure results.

### Sectors Included in Analysis of Quality Issues

The sectors discussed in the quality analysis include growers who through cultivar selection and through cultural and postharvest practices determine nut quality. The discussion also involves handlers, or the buyers of in-shell nuts. First-handlers assemble, transport, and improve quality through cleaning, sizing, separating cultivars, etc. Second-handlers shell nuts and sell halves and kernel pieces. In many industries, the functions of first-and second-handlers frequently are combined. In the pecan industry, the former is called an *accumulator*. This handler sells pecans to shellers and may sell some in-shell nuts to other buyers.

The government's role also is discussed because of its importance in the peanut industry. The largest nut industry by volume and by product value, the peanut industry depends on buying points for the purchase of raw peanuts.

## Quality Measurement in the Market Channel

### Important Quality Attributes

The differences in uses of in-shell and shelled nuts and the importance of domestic and export markets influence quality interpretation. Ability to meet quality demands is subject to the genetic potential of different cultivars and to the postharvest handling of nuts.

Nut cultivars differ in terms of quality attributes, the importance of which depends on consumer and end user. Appearance, including shell shape, color, and size, is important for nuts marketed in shell.

For shelled nuts, the set of common quality attributes includes factors affecting shelling and marketing costs. Because the nut is sold primarily in shell, in-shell size, a major quality attribute to shellers because it indicates kernel size, is an important factor in hazelnut sales. large in-shell walnuts bring the highest prices. A common practice of measuring pecan size is count, or the number of nuts/lb (Hubbard et al., 1988b; Hubbard et al., 1988c). Figure 9.1 illustrates the price-count relation. In general, the greater the number of nuts/lb, the lower the price. The largest in-shell grade for pistachios is at least 10% more expensive than the next. Indeed, the premium for size can be as great as 50%, depending on supply and demand. Even low-grade pistachios if large are sold at high prices.

The shell-out ratio determines the proportions of halves and of pieces yielded/unit of weight during shelling. Shellers' revenues and profit margins are affected directly by this ratio, which the nut indus-

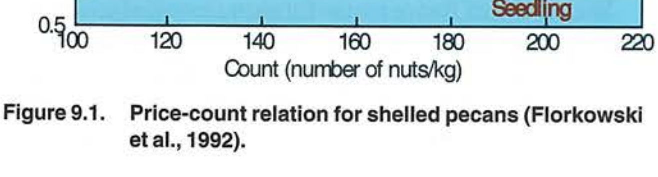


**Figure 9.1.** **Price-count relation for shelled pecans (Florkowski et al., 1992).**

tries also call *meat yield*, or *crack out*. In industries with many cultivars, uniformity helps maintain consistent shell-out ratio. In the walnut industry, major cultivars sold as *shelled* are 50 to 56% halves and pieces; those sold as *in-shell*, are approximately 40% halves and pieces.

The shell-out ratio for pecan cultivars ranges from 42 to 62% (Table 9.5). Figure 9.2 illustrates the relation between shell-out ratio and price. The importance of the former is reflected in the price that accumulators pay growers. Upon grower inquiry into pecan purchase price, an accumulator contracts a sheller who also is a potential buyer. The sheller indicates the price that the accumulator would receive for delivering pecans of a given shell-out ratio. For example, a sheller may offer an accumulator $1.09/lb of shelled pecans, given a 50% shell-out ratio. The sheller's offer translates into $0.95/lb for the accumulator ($1.09 × 0.5 = $0.95), who adjusts the price for handling costs. Thus, the accumulator can offer the grower a price of, say, $0.90/lb.

Prices of macadamias received by members of the Gold Crown co-op are influenced by shell-out ratio, the only criterion used to grade pecans. Among the Grades A, B, C, and D, C is the base, and the market determines price. Premiums or discounts are added or subtracted for higher and lower grades. Each discount, or the premium between the two nearest grades, is $0.15. For example, if the price of Grade C is $1.00, then the price of Grade A is $1.30. The shell-out ratio of most peanut cultivars ranges from 68 to 73%. Premature kernels have a small shell-out ratio.

Moisture level is an important quality measure and must be controlled to ensure high quality. Weather conditions during harvest directly affect this level. In the walnut industry, nuts with too great a moisture content must be dried before sale or, in the pecan industry, must have a deduction calculated for moisture exceeding a prespecified level. Mature macadamia nuts contain a great percentage of moisture (Rosengarten, 1984); as much as 30% of the husk is water. Other parts of the nut contain 10 to 25% water. Dehusked macadamia nuts are dried, and dried in-shell nuts contain 1.5% moisture. Overdrying may lead to quality defects; for example, peanuts with less than 8% moisture have off flavor. In some industries, wet weather may be beneficial. For example, warm, wet harvest weather facilitates almond shelling.

Wet orchard floors cause foreign material to adhere to the outer shells of nuts. And nuts with much foreign material require additional cleaning. More important, nuts lying on wet orchard floors or in windrows are susceptible to mold, which diminishes

**Table 9.5. Approximate shellout ratios and counts for selected pecan cultivars (Goff et al., 1989)**

| Name of cultivar | Approximate count | Approximate shellout ratio |
|---|---|---|
| Barton | 53 | 56 |
| Caddo | 68 | 57 |
| Candy | 70 | 50 |
| Cape Fear | 57 | 55 |
| Cheyenne | 63 | 59 |
| Chickasaw | 63 | 55 |
| Choctaw | 45 | 60 |
| Colby | 70 | 49 |
| Curtis | 95 | 60 |
| Davis | 51 | 50 |
| Desirable | 49 | 53 |
| Elliott | 77 | 55 |
| Farley | 61 | 55 |
| Forkett | 55 | 62 |
| Giles | 74 | 53 |
| Gloria Grande | 48 | 48 |
| Greenriver | 80 | 50 |
| Hirschi | 72 | 49 |
| Hodge | 48 | 53 |
| Jackson | 42 | 60 |
| Kiowa | 45 | 58 |
| Major | 78 | 51 |
| Melrose | 55 | 53 |
| Mohawk | 43 | 58 |
| Moneymaker | 68 | 44 |
| Mahan | 48 | 52 |
| Mobile | 69 | 41 |
| Moreland | 60 | 60 |
| Owens | 50 | 48 |
| Peruque | 65 | 60 |
| Posey | 68 | 54 |
| Rome | 54 | 42 |
| Schley | 73 | 56 |
| Shawnee | 57 | 59 |
| Shoshoni | 50 | 54 |
| Stuart | 49 | 48 |
| Success | 48 | 50 |
| Sumner | 55 | 53 |
| Wichita | 52 | 60 |

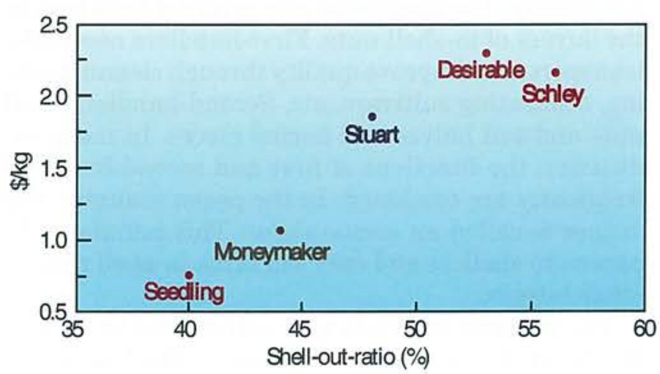


**Figure 9.2. Shell-out ratio for pecan cultivars (Florkowski et al., 1992).**

quality and therefore is unacceptable to industry. Delaying harvest also increases the incidence of mold or changes kernel color (Mastin et al., 1975). Any indication of insect damage likewise is unacceptable. Color of shells and of kernels is an important quality attribute. In the tree-nut industries, bright shell and skin colors are preferred to dark. Color is determined by genetics and influenced by weather and handling practices. Nut flavor is evaluated indirectly, and quality attributes related to appearance dominate quality evaluation. Flavor is affected by drying, storage, chemical composition, and processing.

Differences in oil and sugar contents exist among numerous macadamia cultivars. In general, California grown cultivars are characterized by low oil and high sugar contents. The high sugar content of California cultivars makes necessary unique processing procedures during roasting. For example, roasting temperature must be lowered approximately 50°F to prevent burning. Because of the low oil content, relatively long storage of California in-shell macadamias at low temperatures does not cause detectable flavor changes.

Although shell pieces and foreign material are removed carefully, they occasionally cause problems for the nut industry. Poorly filled kernels, blanks, or shriveled kernels considered detrimental to quality are removed by shellers during processing.

## Quality Control

### Almonds

According to federal marketing orders, almonds delivered to any handler must be inspected for quality by USDA officials, who draw a sample of nuts for each delivered lot.

During unloading, the sample of shelled almonds is taken automatically on a continual or a periodic basis from a conveyer belt. Alternative means of drawing samples include using a cylindrical probe (similar to a grain probe) of an adequate diameter. This probe is inserted into a bin holding 2,000 to 24,000 lb of kernels.

Each sample is evaluated for edible and inedible kernels. The percentages of both are determined in each delivery. Only the weight of edible kernels is used to determine shell-out ratio, which influences price received by growers. Inedible kernels are weighed, and inedible weight obligation is determined. Handlers are required to dispose of inedible kernels through accepted users (oil crushers, feed manufacturers, or livestock feeders).

Independent almond sampling is conducted to test for the presence of aflatoxin. A 10-lb sample is obtained at retail outlets or from handlers, and aflatoxin level is determined by an independent lab. These procedures aim to ensure functioning of the industry's quality control program.

### Walnuts

Harvested walnuts range in moisture content from 8 to 40%. Nuts with moisture levels above 10% must be dried because handlers refuse to receive them. One method of drying is to batch dry with ambient air. Although several days are required to dry walnuts in bins, blowing air or lowering walnut loads may speed the process. Another method is to dry until the wettest walnuts contain 9 or 10% moisture. Moisture can be equalized in a lot by storage in bins (Anonymous, 1984).

The lot of nuts delivered by a grower is weighed, and a sample drawn periodically during hand unloading. A 5-lb sample is drawn from a 45,000-lb lot, or a sample set of 100 nuts is drawn at random. In-shell nuts are evaluated for cracked shells and for material adhering to shells.

Nuts are categorized as jumbo, large, medium, or baby. Discounts are assessed if less than 80% or more than 5% babies are present in the lot.

The sample is cracked by hand, and shells are separated from kernels and inspected visually. Presence of insects and mold damage are evaluated. Shelled walnuts are assessed discounts if more than 5% show worm or mold damage. Similar discounts are applied for more than 5% shriveled kernels or blows. At least 60% of walnut kernels also must be light in color.

A separate sample of 500 to 1,000 gram (g) is drawn from the initial 5-lb sample. The second sample is cracked and evaluated for shell-out ratio.

Information from the quality test is used to determine grade. If a grower disputes the results, another test is conducted, often by an independent party, for example, the Dry Fruit Association (DFA).

### Pecans

In-shell pecans are evaluated for size, uniformity, and light-nut number (an indication of poor filling). Also measured are moisture content, damaged nut number, and foreign material. Growers therefore enhance nut quality by removing foreign material. In Georgia, 94% of growers clean (Florkowski et al., 1990) and attempt to remove light-weight nuts. Eighty-six percent remove visually damaged nuts.

On the other hand, few growers consider size and uniformity. Only 32% size nuts and only 33% sell uniform nuts, that is, nuts from the same cultivars.

Although the necessary equipment is offered for sale, lack of equipment is the reason for limited sizing. Uniformity is more difficult to achieve because tree planting requires mixing cultivars.

Before delivering pecans to an accumulator, some growers test one lot for shell-out ratio. In a survey of Georgia growers, 61% reported conducting such tests (Florkowski et al., 1990). Shell-out ratio is tested again upon delivery of the lot to an accumulator. Indeed, these tests may be conducted several times to ensure accuracy. During shell-out testing, the accumulator visually inspects the sample for damaged kernels. For example, kernels with discolored spots indicative of insect damage are removed. Removing nuts causes shell-out ratio to decrease and negatively affects price received by the grower.

Sample testing by the accumulator focuses on shell-out ratio and on visual color assessment. The accumulator also will evaluate in-shell lots of pecans for foreign material, size, uniformity, and moisture.

When small volumes of pecans are purchased from small growers, the accumulator may limit inspection to visual assessment. Occasionally, as one surveyed grower put it, an accumulator may limit quality assessment to a "kick of the sack."

Shellers practice quality evaluation much as accumulators do but generally are better equipped with measuring devices. The equipment used by shellers allows relatively accurate quality measurements. Specifically, shellers test for moisture content and reduce lot weight by 1.2% for each percentage of moisture greater than 6 (Goff et al., 1989). Thus, for each percentage of moisture exceeding this limit, weight is decreased 12 lb for each 1,000 lb of nuts delivered. Yet not all growers dry nuts. For example, in Georgia, only 65% of growers reported drying nuts before sale (Florkowski et al., 1990).

By testing nuts purchased from growers or accumulators, shellers are reassured of nut quality. And to ensure high-quality shelled pecans, shellers condition or moisten pecans before cracking them. Conditioning, which prevents harmful bacteria from contaminating shelled pecans, is accomplished through dipping in-shell pecans in chlorinated or hot water. Shellers follow the "Good Manufacturing Guidelines for the Pecan Shelling Industry" (National Pecan Shellers and Processors' Association, 1984) to handle, to store, and to control the quality of processed pecans.

### Hazelnuts

Upon delivery to a handler, the lot of hazelnuts is evaluated for insect and mold damage. Heavily infested lots are isolated and processed separately. Nut samples are collected after cleaning. One collection method involves a conveyor belt with a cup drawn across it. Seven or eight cups are collected for each lot delivered. Ten pounds of cleaned nuts are dried to 9% moisture. Weight is adjusted if moisture content exceeds this level.

The sample is sized by dividing in-shell nuts into four categories: jumbo, large, medium, and Small. Three 100-nut samples are drawn, cracked, and tested for defects. Results from each sample are averaged. Payment to the grower is determined after defects have been discounted. If defect levels exceed tolerance levels, a sorting charge in addition to discounts is subtracted from the payment. Testing is conducted by an independent agency.

### Pistachios

Pistachios delivered directly from the orchard are inspected for moisture content, which is able to reach 33%. Nuts with high moisture content are processed separately. Pistachios should be dried until they reach 6 to 7% moisture, within 24 hr of harvest.

To provide the grower with a preliminary quality assessment, a 100-nut sample is drawn upon delivery. Testing is conducted by the DFA and by independent inspection services.

A random sample is drawn mechanically during unloading, by means of a cup drawn across a conveyor belt. A 100-lb sample can be drawn in this manner from a 40,000-lb lot. Next, a 1,000-g sample for testing is drawn from the 100-lb sample. The smaller sample is inspected thoroughly for outer or inner quality defects including discoloration, mold, decay, and blanks. Pistachios with specific defects are weighed. Each 1 g of defective nuts is converted into 1% lot defects.

### Macadamias

Processors in Hawaii follow their own procedures for sampling deliveries. Because of strong vertical integration, processors usually are assured that a certain amount of macadamias will be supplied from their own orchards and purchase nuts in response to demand. Growers perceive that the use of different methods of spoilage determination by processors is deliberate (Anonymous, 1991) and affects growers' profits.

Members of the Gold Crown marketing cooperative in California must deliver nuts with at least a 29% shell-out ratio. A sample of 20 nuts or 100 g is selected randomly from the delivered lot and cracked. Immature kernels or those with signs of damage are removed from the shelled nuts, and the sample is weighed. If shell-out ratio is smaller than 29%, two more samples are drawn. If either of the other two samples also indicates a shell-out ratio smaller than the required minimum, the lot is rejected. To prevent low-quality nuts from entering the market, co-op members agree not to sell rejected nuts outside of the co-op.

### Peanuts

Peanut plants are harvested when 70% of nuts/plant are mature (Rosengarten, 1984). Peanuts contain 25 to 50% moisture when they are dug out and their roots exposed for drying. A few days later the nuts are harvested. Once separated from vines, nuts are placed in hoppers and dried in drying wagons by means of air forced through pipes. Nuts delivered to buying stations usually have 15% moisture. But if mold growth is to be avoided, moisture content must be reduced to 10%. Upon delivery to a buying station, peanuts are inspected, sampled, and graded by the Federal-State Inspection Service.

Samples are collected by a pneumatic sampler that uses one of twelve patterns to probe delivery trucks. A sample weighs about 50 lb. Peanuts in it are mixed, and a subsample of 3,500 g is drawn. The subsample is divided into two even parts, and 1,500 to 1,800 g of peanuts are taken to the grading room. The remainder is held for additional testing, if necessary.

In the grading room, the sample is cleansed of loose shell kernels and foreign materials, and 500 g is sized and shelled. Thereafter, the percentages of hulls, splits, and kernels passing through prescribed screens are determined. Kernels passing through screens are evaluated for discoloration and damage. Discoloration of the outer skin of 25% or more of the sample disqualifies a kernel from being assigned the top grade. Kernels damaged by insects or rot are discarded.

After damaged kernels are removed, those classified *sound* and *mature* determine price received by the grower. Price is determined after discounts for excessive foreign material, splitting, discoloration, etc., are assessed. A grower or a buyer can request regrading if either disagrees with the price. An average of two samples is used to regrade. If a grower still is dissatisfied with the price offered, he or she can withdraw the load unless it is contaminated by aflatoxin. To ensure high-quality peanuts, such loads are purchased at a heavily discounted price and crushed for oil, from which the toxin can be removed effectively.

## Description of Grades and Standards

Grades and standards described in this section frequently refer to the standards developed by the USDA, at the request of individual industries. Quality attributes included usually are applicable to all nuts although some attributes are specific to certain ones.

Among the former is moisture content, which can be labeled either *dry* or *cured*. The presence or absence of foreign material, undesirable in all grades, is denoted either *foreign material* or *clean*. *Damage* or *serious damage* refers to mold, rancidity, infestation or insect feeding, decay, shrivelling, and misshapen or deformed kernels. Shell and kernel discoloration is considered a quality defect, for which each set of standards for grades lists a specific tolerance level. The number of standards for grades of in-shell and of shelled nuts and for specific quality attributes will be described briefly.

### Almonds

Almonds in the shell are classified as U.S. No. 1, U.S. No. 1 Mixed, U.S. No. 2, or U.S. No. 2 Mixed (U.S. Department of Agriculture, 1964). United States No. 1 almonds must have similar varietal characteristics and be free from loose extraneous or foreign material, with clean, fairly bright, and uniformly colored shells. The nuts must lack discoloration, adhering hulls, and broken shells. United States Nos. 1 and 2 Grades for almonds differ only in terms of increased tolerance for discoloration. United States No. 1 Mixed and U.S. No. 2 Mixed correspond to U.S. Nos. 1 and 2 but allow for the mixing of two or more cultivars.

Shelled almonds, including pieces, are classified into seven grades (U.S. Department of Agriculture, 1960). For mixed cultivar lots, standards allow five additional grades. United States fancy must be free of doubles, split or broken kernels, dust, and chipped or scratched kernels. Tolerances for dissimilar cultivars, doubles, chips, scratches, foreign material particles and dust, split or broken kernels, and seriously damaged kernels depend on the grade.

### Walnuts

In-shell walnuts are classified as U.S. No. 1, 2, or 3 (U.S. Department of Agriculture, 1976b). The first must be free from splits, adhering hulls, or broken shells. Differences among in-shell grades for walnuts are based on differences in kernel color and size (Table 9.6). At least 70% (by count) of each lot of U.S. No. 1 in-shell walnuts must consist of kernels not darker than "light amber." The lot must be free from grade defects. To be graded U.S. No. 1, at least 40% of kernels cannot be darker than "light." To be graded U.S. No. 2, at least 60% of kernels must not be darker than "light amber." The actual percentage of kernels not darker than "light" may be specified. There are no required percentages of kernels classified Light Amber or Light for U.S. No. 3 in-shell walnuts.

Shelled walnuts are classified only as U.S. No. 1 or as U.S. Commercial (U.S. Department of Agriculture, 1968). The former consists of kernel portions that must meet color and size classifications. Quality requirements for the latter are less stringent.

### Pecans

In-shell pecans are graded either U.S. No. 1 or U.S. No. 2 (U.S. Department of Agriculture, 1976a). Grade is determined according to shell color uniformity and defect tolerances. Tolerances for each grade, as specified by the standards for in-shell pecans, include shell- and kernel-defect counts. U.S. No. 1 walnuts also have specified color tolerances and kernel development.

Pecans are separated into six grades: U.S. No. 1 Halves, U.S. No. 1 Halves and Pieces, U.S. No. 1 Pieces, U.S. Commercial Halves, U.S. Commercial Halves and Pieces, and U.S. Commercial Pieces (U.S. Department of Agriculture, 1969). The first two require that a specific lot of shelled pecans meet seven quality and three size evaluation criteria. United States No. 1 pieces need not meet the criterion for color uniformity but must conform to size classifications for pieces. Neither U.S. Commercial Halves nor U.S. Commercial Halves and Pieces are required to be uniform in color or to have increased defect tolerances. For U.S. Commercial Halves, no size uniformity is required. U.S. Commercial Pieces have increased defect tolerances.

### Hazelnuts

Only one grade, U.S. No. 1, exists for hazelnuts (U.S. Department of Agriculture, 1970). Each lot of U.S. No. 1 hazelnuts must consist of similar-type filberts. Blanks or nuts containing no kernel or a small, shriveled kernel are disallowed: kernels should be reasonably well developed and uniformly large. Four size categories exist for each of the two types of hazelnuts.

The hazelnut industry has raised standards for hazelnut quality. Although following USDA standards, the Oregon Kernel Standards (OKS) lower the level of defective nuts allowable from the 1% specified in the USDA standards for hazelnut grades to 2%. The OKS are used voluntarily by the industry and cannot become a federally mandated standard because of the objections of a major hazelnut exporter, Turkey.

### Pistachios

Pistachios in the shell are graded U.S. fancy, U.S. No. 1, or U.S. No. 2 (U.S. Department of Agriculture, 1986). Each grade must meet quality criteria according to which tolerances are allowed to differ among grades. There should be no shells split off the suture, unsplit shells, or immature kernels. Kernels should be crisp and firm. The revised grades for in-shell pistachios include U.S. No. 3, which follows general quality requirements of the other three grades (California Pistachio Commission, 1992). There is a separate set of standards for grades for shelled pistachios developed in the late 1980s. Shelled pistachios are graded U.S. fancy, U.S. No. 1, or U.S. No. 2 (California Pistachio Commission, 1992).

### Macadamias

The USDA has developed no standards for macadamia grading. Neither does the industry have officially established standards or methods for testing quality. To date, macadamia processors have used their own standards.

**Table 9.6. USDA walnut size and kernel color classifications**

| | Color | | | |
|---|---|---|---|---|
| Size[a] | Light | Light amber | Amber | Dark amber |
| Oversize 55 or less<br>Extra large 56–63 to<br>Large 64–77<br>Medium 78–95<br>Small 96–120 | Mostly "golden"<br>with 25% or less<br>of the outer surface<br>allowed be<br>"light brown" | Mostly "light brown"<br>with 25% or less<br>of the outer surface<br>classified as<br>"medium brown" | Mostly "medium brown"<br>with 25% or less<br>of the outer surface<br>classified as<br>"dark brown" | Mostly "dark brown"<br>with no more than 25%<br>of the outer surface<br>very dark brown or<br>blackish-brown discoloration |

[a]Number of nuts/lb.

### Peanuts

In-shell, cleaned Virginia-type peanuts (U.S. Department of Agriculture, 1948) are either U.S. jumbo hand picked or U.S. fancy hand picked. The former consists of cleaned in-shell Virginia-type peanuts that are mature, dry, and free from foreign material. In general, no more than 176 in-shell peanuts/lb are allowed. Peanut number/lb and several tolerances by weight are criteria according to which the two grades are separated.

The U.S. fancy hand picked grade allows as many as 225 in-shell peanuts/lb. The grade also allows an 11% (10% for U.S. jumbo hand picked) content of pops, and peanuts with paper or damaged shells, loose undamaged kernels, and foreign material. But no more than 0.5% of total weight is allowed for dirt or other foreign material. U.S. fancy hand picked unshelled Virginia-type peanuts can contain as much as 4.5% (3.5% for U.S. jumbo hand picked) damaged kernels or damaged loose kernels. Both grades allow as much as 5% of peanuts to pass through a prescribed screen, but that volume of peanuts in both grades must be free from pops.

Shelled Virginia-type peanuts are classified according to four grades (U.S. Department of Agriculture, 1959). The top grade, U.S. extra large Virginia, consists of "shelled Virginia-type peanut kernels of similar varietal characteristics" (U.S. Department of Agriculture, 1959). Kernels must be whole.

Kernel number/lb is significantly different among the four grades of Virginia-type peanuts and one grade of splits. Tolerances in terms of selected quality measurements also differ. A list of quality measurements appears in Table 9.7.

Spanish-type shelled peanuts are divided among three grades: U.S. No. 1 Spanish, U.S. Spanish Splits, and U.S. No. 2 Spanish (Table 9.8). Differences among grades occur in terms of size and tolerance levels. A major requirement is that each lot of Spanish peanuts be free of peanuts with other varietal characteristics, e.g., Virginia peanuts.

Shelled Runner-type peanuts are categorized as U.S. No. 1 Runner, U.S. Runner Splits, and U.S. No. 2 Runner (U.S. Department of Agriculture, 1981). Differences among grades are based on tolerances identical to those listed in Table 9.8, which refers to shelled Spanish-type peanuts. Size requirements for Runner-type peanuts, however, differ from those for Spanish-type peanuts. U.S. No. 1 Runners consist of peanuts not passing through a screen with 16/64 x 3/4 in. openings. Peanuts graded U.S. Runner Splits and U.S. No. 2 Runners do not pass through a screen having 17/64-in. round openings.

## Sources of Authority

### Almonds

The federal marketing order outlines quality and inspection requirements for almonds. At present, quality is regulated by an inspection program. Organically-grown and nonorganically-grown almonds must meet the same quality standards. The California Farm Bureau and several other state organiza-

**Table 9.7. USDA standards of grades of shelled Virginia type peanuts (U.S. Department of Agriculture, 1959)**

| Tolerances | U.S. extra large Virginia | U.S. medium Virginia | U.S. No. 1 Virginia | U.S. Virginia Splits | U.S. No. 2 Virginia |
|---|---|---|---|---|---|
| Other varieties | 0.75 | 1.0 | 1.0 | 2.0 | 2.0 |
| Split or broken peanuts | 3.0 | 3.0 | 3.0 | NA | NA |
| Damaged or unshelled peanuts[a] | 1.0 | 1.25 | 1.25 | 2.0[a] | 2.5[a] |
| Minor defects[b] | 0.75 | 0.75 | 0.75 | NA | NA |
| Foreign material | 0.10 | 1.0 | 0.10 | 0.20 | 0.20 |
| Sound, whole peanuts of smaller than required size | 3.0 | 3.0 | 3.0 | 3.0[c] | 6.0 |
| Number of kernels/lb | 512 | 640 | 864 | NA[d] | |
| Screen openings | $^{20}/_{64}$ x 1 in. | $^{18}/_{64}$ x 1 in. | $^{15}/_{64}$ x 1 in. | $^{20}/_{64}$ x 1 in. | $^{17}/_{64}$ x 1 in. |

[a]Damaged or unshelled peanuts and minor defects for U.S. Virginia Splits and U.S. No. 2 Virginia.

[b]Provided that, in addition, any unused part of the tolerance for damaged or unshelled peanuts be allowed for minor defects.

[c]Peanuts and portions of peanuts.

[d]A lot should contain not less than 90% of splits, by weight.

NA = Not applicable.

tions certify the organic nature of products. Conditions for issuing a certificate are similar and prohibit the use of most pesticides. Use of sulfur, plant extracts, and petroleum oil is permitted. Each grower identifies his or her almonds. Such identification allows almonds to be traced from gower to end user. Thus, quality is ensured to some extent.

### Walnuts

The DFA follows USDA standards in the inspection of the quality of walnuts received by handlers. But the walnut industry advocates stricter quality guidelines. Attention to quality by handlers is interpreted as the necessary condition for promoting a desirable image.

### Pecans

Marketing opportunities in the pecan industry are limited by the lack of an established and consistent system of grades and standards (Hubbard et al., 1987). Currently, an array of public and private grade standards for shelled pecans are used in market transactions. Public standards for grades were established by the USDA in 1976, but use has been voluntary. After the USDA release, the Federated Pecan Growers' Association published its quality standards for shelled pecans (Anonymous, 1980).

Private quality standards developed by pecan shelling companies likely reflect long-term experience in pecan marketing. Private quality standards are used exclusively in dealing with buyers of shelled pecans. Despite several sets of quality standards for pecans, the industry considers no single set mandatory. Moreover, existing industry organizations lack the resources to implement a single set.

### Hazelnuts

The Hazelnut Marketing Board (HMB) is authorized to establish quality standards and to require inspection of finished products. The Board has established quality and size regulations for in-shell and shelled hazelnuts. And handlers can sell no products failing to meet these regulations. To protect product image, the hazelnut industry also cooperates with the USDA to raise kernel quality standards.

### Pistachios

The California pistachio industry began developing quality standards in 1977. In 1981, the California Pistachio Association (CPA) requested that the USDA develop standards for grading in-shell pistachios. In 1989, the Association asked that standards be drafted for grading shelled pistachios (Anonymous, 1989). It stated that the constantly increasing demand for pistachio kernels justified development of such grades inasmuch as uniform grade nomenclature would support pistachio trade.

The request suggested developing three standards: U.S. fancy, U.S. No. 1, and U.S. No. 2. Details of the proposed standards were published in 1989 and now are approved for use by the industry (California Pistachio Commission, 1992). In the same year, the CPA was renamed the Western Pistachio Association.

### Macadamias

The macadamia industry has no uniform quality standards. For many years, the industry's structure—a few large processors and strong demand—discouraged development and implementation of quality standards. But rapid expansion of domestic supply and production abroad and softening of demand depressed prices and brought quality issues to

**Table 9.8. USDA standards for grades of shelled Spanish type peanuts (U.S. Department of Agriculture, 1965)**

| Tolerances | U.S. No. 1 Spanish | U.S. Spanish Splits | U.S. No. 1 Spanish |
|---|---|---|---|
| Other types of peanuts | 1.0 | 2.0 | 2.0 |
| Sound peanuts which are split or broken | 3.0 | NA | NA |
| Damaged or unshelled peanuts | 1.5 | 2.0[a] | 2.5[a] |
| Minor defects | 0.5[b] | NA | NA |
| Foreign material | 0.1 | 0.2 | 0.2 |
| Sound whole peanuts of smaller than required size | 2.0 | 4.0 | 6.0 |
| Sound portions of peanuts smaller than required size | NA | NA | NA |
| Screen openings | $^{15}/_{64} \times {}^{3}/_{4}$ in. | $^{16}/_{64}$ in.[c] | $^{16}/_{64}$ in.[c] |

[a]Includes minor defects.

[b]In addition, any unused part of the tolerance for damaged or unshelled peanuts is allowed for minor defects.

[c]Round openings.

the forefront.

The Hawaiian Macadamia Nut Association (HMNA) (formerly the Hawaiian Macadamia Processors' Association) has stressed the need to develop and to implement standards for sampling procedures. In response, the Hawaii Department of Agriculture (HDA) has developed a set of voluntary standards for growers. The Department also drafted standards for roasted macadamia nuts in 1983. The standards defined two grades: Hawaii Grade A and Hawaii Choice, or Hawaii Grade B.

#### Peanuts

The Peanut Administrative Committee (PAC), which established peanut quality control measures, has carried out its activities since 1965 under the Peanut Marketing Agreement (PMA) (Anonymous, 1986c). The Committee determines moisture and foreign material limitations for commercially purchased farmers' stock peanuts and recommends limits for unshelled peanuts and for damaged kernels in shelled peanut lots. The Committee also has developed a system for controlling nonedible kernel sales. Nonedible nuts sold to animal feeders must carry a federal inspection certificate. The secretary of agriculture must approve the PAC's quality recommendations.

Because the National Peanut Council of America (NPCA) is interested in improving peanut quality, it initiated the task force "U.S. Peanut Quality: An Industry Commitment," which focused on methods of maintaining the United States' reputation for producing a product free from excessive foreign material, chemical residue, off flavor, and prematurely harvested nuts. Recommendations ranged from short-term solutions, e.g., increased farmer education, to long-term solutions, e.g., new technology.

Trading rules issued by the NCPA regulate the quality of peanut oil, which is traded crude or refined. Rules distinguish among five types of crude peanut oil, including a mixture of peanut and cotton oils. There are three types of refined peanut oil, and soapstock is a by-product.

### Measurement Technology

In all nut industries, moisture meters and balances commonly are used to measure moisture content of delivered lots. Depending on moisture content, nuts may require drying, which is done by either handlers or growers. In the pecan industry, handlers discount the weight of a lot if nuts contain excessive moisture; in the walnut industry, handlers refuse to accept such nuts. Experienced handlers can assess by touch whether nuts are excessively moist.

Handlers assess moisture content immediately upon delivery. Because they discount price for excessively high moisture levels, handlers also measure nut moisture during quality tests.

Samples for testing quality attributes are drawn either by hand or mechanically. Walnut handlers frequently draw samples by hand. Pecan shellers use a probe if nuts are delivered in bags. Pecans delivered in bulk are hand sampled by means of random selection. In the hazelnut and the pistachio industries, a cup drawn across moving nuts is used to draw samples from a conveyor belt. In the peanut industry, nuts/lb are counted. A cracked sample is separated into shells and edible parts. Defective nuts are removed. Edible kernel parts are weighed to derive shell-out ratio. This ratio is especially important in pecan, walnut, and macadamia industries.

Finally, edible nut parts are inspected visually. Kernel color is assessed from color charts recommended by the USDA or developed by handlers. Classification of Sample Grade is decided after testing.

## Quality-Related Issues and Problems

### Contraction and Expansion of Export Markets

Expanding exports of Chinese walnuts affect the U.S. walnut industry. Although the quality of its walnuts is poorer than that of California walnuts, China is located closer to major export markets in Taiwan, South Korea, and Japan. China's potential to expand walnut production currently is limited by low yields and underdeveloped infrastructure.

Export markets are important to in-shell walnut sales. Preparation of in-shell walnuts for sale involves bleaching to brighten the outer shell. Recently, in-shell walnut exports to Germany have been in jeopardy because bleach had penetrated the outer shell and affected kernels. The walnut industry, in cooperation with German authorities, has worked to prevent recurrence of the problem and to ensure high-quality future exports.

The pecan industry may suffer a loss of export markets if Mexico increases pecan production. Conditions for such an increase are favorable, given land and labor costs. On the European market, American pecans already compete with Australian and Israeli pecans.

By selling as much as 30% cheaper than the Iranian competition, California pistachios have gained a reputation for quality and garnered increased sales in the Pacific Rim.

## Vulnerability to International Trade Disputes

Members of the walnut industry were made involuntary parties to the dispute over exports of hormone treated beef from the United States to the EC. The EC threatened to impose a 100% ad valorem duty on imported in-shell walnuts if the dispute over hormone-treated beef was not solved according to the EC's wishes. Although the proposed duty was not imposed, the vulnerability of nut industries to victimization by international trade disputes was made evident.

Of major concern to the U.S. pecan industry has been pecan imports from Mexico. These imports, both shelled and in-shell, were subject to a tariff that since has been suspended. The suspension has led to complaints within the U.S. industry and perhaps to increased imports. Net U.S. pecan exports had decreased, and NAFTA may lead to even more extensive pecan imports by Mexico. Integration of U.S. and Mexican pecan industries could follow.

The U.S pistachio industry benefitted from the banning of Iranian imports. Notwithstanding, some Iranian pistachios may be imported through third countries. Thus, the U.S. industry advocates legislation requiring labeling for country of origin. Passage of such a law may limit pistachio imports to those from specific lesser developed countries for which exports are important.

Changing import tariffs expanded and contracted sales to India of U.S. almonds and pistachios, both of which were known for quality and low price among Indian consumers (Anonymous, 1981). Changing import tariffs and universal import licensing led to decreased U.S. exports because the tariff structure provided Afghan and Iranian exports privileged access. For example, the tariff on U.S. almond kernel exports was 43% more than that on Afghan exports.

The issue of unfair competition from overseas hazelnut exporters also was addressed by the International Trade Commission (U.S. International Trade Commission, 1985).

## Advantages and Disadvantages of Irradiation

Irradiation (ionization) in nut marketing may inactivate pathogens. For example, *Salmonella* spp. and fungi producing aflatoxin are inactivated by ionization, which also can eliminate insects and inhibit sprouting (Urbain, 1986). Irradiation may lead to the development of undesirable flavors, however, as a result of accelerated lipid oxidation. The tendency to produce such flavors depends on the nut. Almonds and peanuts, for example, are unaffected by doses of as great as 1 kilogray. Such a dose has prevented peanuts in storage for 10 mo from becoming infected with aflatoxin and has prevented insect infestation in almonds, walnuts, and peanuts.

Irradiation is an alternative to chemical fumigation with methyl bromide, carbon dioxide, or phosphine. But in terms of killing insect larvae, the efficacy of irradiation is less than that of chemical fumigation. Limited protection against reinfestation exists after irradiation because insects have been sterilized. This fact is important, for reirradiation is prohibited. Irradiation causes no known hazards to consumers and has been applied for decades in quality control of other foods in many countries. Still, its use is prohibited in the U.S. nut industries.

## Complexity of Standards for Grades

Standards for grades for different nut types limit numbers of grades and restrict changes in tolerance levels. Standards for grades used by certain industries are quite complex. For example, pecan quality standards developed by the USDA list several sizes, colors, and damage types to define a specific grade.

Private quality standards are simpler because the description of each grade frequently is illustrated with a picture. Private quality standards can use inconsistent terminology to describe different quality grades. For example, pecan halves can be classified as Mammoth by one shelling company and as jumbo by another. Several sets of standards for pecan grades and changeable specifications for grades impair communication about pecan quality.

## Change of Form

Isolation of a grower from an end user is caused by changes in nut form. End users communicate with handlers about quality. Likewise, to improve the quality of supplied nuts, handlers must inform growers about quality attributes desired by end users.

The main concern expressed by pecan accumulators and shellers during early studies (Hubbard et al., 1987; Hubbard et al., 1988b) was that growers were unfamiliar with grades. On the other hand, growers suggested that accumulators bought subjectively, according to their own perceptions about grades. Accumulators also could apply a different set of quality criteria when selling pecans to shellers.

This example from the pecan industry illustrates a major barrier to communication about grades. A grower always delivers in-shell nuts to a handler. Most in-shell nuts, except for pistachios and hazelnuts, are shelled, for most domestic and overseas end-users are interested in shelled nuts. This change in form requires that a new set of quality measures be applied.

A handler, in fact, has the option of preparing in-shell nuts or shelled nuts. Thus, growers must be aware of quality attributes required in any market at the time of sale. If unable to determine on which market to sell nuts upon delivery, handlers may price nuts by considering the greatest market risk and making a conservative price offer.

## Shell-Out Ratio

A major criterion of nut lot value is shell-out ratio, also called *crack-out* or *meat yield*. Although this ratio is the link between in-shell and shelled nuts, no existing standards for grades list shell-out ratio as a quality attribute.

Shell-out ratio is used by pecan, walnut, macadamia, and hazelnut industries to determine the price paid a grower. Nuts with excellent in-shell appearance frequently have a small shell-out ratio. In years of great supply and saturated demand for in-shell nuts, growers may sell in-shell nuts at a discount. But because of variations in supply and demand, growers may have no incentive to replace one cultivar with another.

## Genetic Differences

Shell-out ratio, shell color, and kernel color are influenced by tree genetics. For example, handlers prefer brightly colored pecan and walnut kernels. Yet a study has indicated that consumers are unable to detect flavor differences between bright and dark pecan kernels (Heaton et al., 1973). On the other hand, dark walnut kernels taste better than bright ones do.

Halves of certain pecan cultivars continue to darken after harvest (Forbus et al., 1980). Moreover, delayed harvest of nuts from wet orchard floors can contribute to darkening.

One factor affecting color of Stuart halves has been kernel moisture. These halves are brighter when kernel moisture is greater (Heaton et al., 1982).

## Residues

More frequently than in the past, consumers demand that the residue of any “unnatural” substances in food be eliminated. In nut industries, chemical residues can enter a kernel during growth, processing, or distribution. Pesticides used to protect growing crops may leave residues on nuts. Thus, pesticide application is tested and its use limited to certain periods before harvest. California almond production, for example, is subject to a routine monitoring program.

But for many nuts there is no established procedure for or habit of residue testing. Testing can be costly, and growers assume that by following application guidelines they can be guaranteed a wholesome product. This approach places the responsibility for ensuring safety on the chemical producer.

In the past, pesticide producers have applied for permission to use chemicals on nut crops. But increasingly stringent regulations and requests for supporting data have increased the cost of registering chemicals for use on nuts. Many nut industries are small, and chemical companies may elect not to perform the tests necessary to register pesticides. In recent years, several pesticides labeled for use on nuts have been withdrawn. Some growers suggest that limiting pesticide use limits production of quality nuts. But new developments in this area can be expected. For example, the effectiveness of pest biocontrol methods are being tested.

During processing, in-shell nuts may be soaked in hot water, brine, alcohol, or water mixed with bleach. These methods attempt to improve the appearance of an in-shell nut, to eliminate harmful bacteria, to separate insects from kernels, or to aid kernel grading. Some procedures, however, may leave residues. Current standards contain no provisions for residue testing, and easy, accurate tests often are unavailable.

## Storage

Temperature, package, and storage time are three major factors affecting nut quality. Variable fatty acid content and stability make some nuts quite susceptible to spoilage. Pistachios, almonds, peanuts, and macadamias store well for long periods because fatty acid stability and the shell both protect quality. Pecans, walnuts, and hazelnuts are more likely to be affected by these three factors, even by exposure to room temperature or to oxygen.

Although more expensive than room-temperature storage, cold storage is necessary to maintain quality of certain nuts. High storage cost increases price. And nuts requiring cold storage must be transported and displayed carefully at retail outlets, which frequently display nuts in one nonrefrigerated section. Although consumers may purchase nuts labeled U.S. No. 1, the nuts are of a lower grade in terms of appearance and kernel quality because in-store handling has been improper.

### Physical Properties and End Uses

Nuts are used in-shell or shelled; in halves, pieces, granules, or meal; as a main or as a supplementary ingredient. The array of related products implies a variety of emphases on quality attributes. And standards do not distinguish among end uses. For some buyers, quality attributes stressed in standards are relatively unimportant. Others supplement a list of quality attributes by specifying additional kernel or piece properties. The diversity of uses may limit the applicability of uniform standards for grades.

The pecan industry exemplifies an industry in which different end-users demand nuts with a variety of physical properties. Pecan shellers have reported (Hubbard et al., 1990b) that the color of halves is the most important quality to retail grocers and to wholesale distributors. Shellers also have reported that, to bakers, confectioners, gift pack traders, ice cream manufacturers, and food-service buyers, size is the most important quality. The seeming importance of color among shellers differs.

## Information Dissemination

Information on production and production value of tree nuts is collected by the USDA and is published in *Noncitrus Fruits and Nuts* and in *Cold Storage* every 6 months (mo).

### Price and Quantity Information

#### Almonds

Crop production data are reported by the Almond Board of California (ABC). Bearing and nonbearing acreage statistics are collected by the California Agricultural Statistics Service (CASS). Information about producer delivery is based on receipt reports. Almond disappearance data are based on handler reports. Both almond production by county and export by country of destination are reported by handlers. The information is disseminated by the ABC.

Information about farm and parity prices is obtained from the USDA. Average parity price is published once a year by the ABC, which collects and disseminates monthly shipment and commitment figures.

#### Walnuts

In July and September, the Walnut Marketing Board (WMB), USDA publications, and the CASS forecast walnut crop production. Forecast accuracy varies but generally is within 10% of final production.

#### Pecans

Annual production data for pecan seedling and improved cultivars are available through the USDA—NASS. Crop predictions are issued in September, November, and December. The first estimate is crucial because it directly affects price at the beginning of harvest. Any significant departure of the crop estimate from the actual crop causes loss to some segment of the pecan industry.

An error in the first usually cannot be corrected until the second estimate. The delay is caused by a lack of statistics about the volume of pecans marketed early in the harvest. Certainly, timely information about the quantity of pecans marketed would improve market efficiency by limiting losses originating from slow price adjustments (Shafer, 1989).

During harvest (mid-October until early February), pecan price reports are issued 2–3 times/week by the Federal-State Market News Service. Occasionally, in response to weather and crop size, reports begin later or end earlier. Outside the harvest season, no pecan prices are reported. And insufficient price information limits the effective uses of statistical methods to forecast pecan price (Epperson and Allison, 1980; Florkowski, 1988).

The importance of marketing pecans during harvest is underscored by pecan price behavior. Prices for early pecans are higher than those for late (e.g., *Pecan Marketing Summary*, 1981). High prices early in the harvest are typical for improved cultivars. Prices for seedlings and for native pecans may deviate from this pattern in response to crop size and quality.

#### Hazelnuts

In its annual report, the HMB publishes price and quantity information. Price information includes prices received by growers, parity prices, and wholesale in-shell prices. The value of hazelnut exports also is published.

The annual report contains detailed quantity information including domestic production and hazelnut imports and exports. The report also includes information about quantities of nuts available at different marketing stages, volume by grade, and shipment by grade. Detailed information about export shipment by grade and destination in the annual report is provided by handlers. Information about crop size and import market is obtained from the USDA.

### Pistachios

Information about production, bearing and nonbearing acreage, and world pistachio production is published in the California Pistachio Industry (CPI) annual report. Volume information is supplied by processors. Acreage information is collected by the CASS. World production data are gathered by the USDA.

Information about domestic and export shipments of in-shell and shelled pistachios is reported by the California Pistachio Commission (CPC), which also reports export data by country of destination.

### Macadamias

Annual information is published by the HDA. During harvest, however, prices are published sporadically. Some large processors use the press to announce the schedule of base prices at the beginning of harvest. Development of both a code-a-phone system to deliver information to growers and an industry-funded crop forecasting unit has been suggested as a means of alleviating communication problems within the industry (Anonymous, 1991).

### Peanuts

Domestic price information is available through the *Federal-State Market News*. The *News* publishes a weekly Peanut Report, which contains information about regional prices, by peanut type and size. Prices of peanut oil and of meal also are quoted. The report includes information about U.S. peanut exports by destination. Exports are classified as either "edible peanuts" or "oil stock."

## Storage Information

### Almonds

Carry-in and salable carry-over almond inventories are reported by handlers. Reports are based on kernel weight.

### Pecans

If quality is to be maintained, pecans must be stored at temperatures below freezing. Because of their high oil content, pecans stored at high temperatures may turn rancid quickly, and commercial value may be lost.

Pecans in cold storage are owned by shellers and by the owners of storing facilities. Storage allows shelling at any time and thus delivery of freshly shelled pecans. It also allows separation of shelling and marketing functions. In this manner, opportunities for gain from price can be taken advantage of between harvests.

The cost of commercial cold storage is a time dependent per-unit fee such as ¢/lb/mo. There also is a handling fee paid when the commodity is placed in and retrieved from storage. Total cost of cold storage can be reduced by limiting shipment number.

### Hazelnuts

Information about hazelnuts in cold storage is published by the USDA and is disseminated by the HMB. Promotion and extension materials advise hazelnut users to dry in-shell nuts to 10% moisture. Dried nuts should be stored in sealed plastic liners in boxes at temperatures below 70°F (Growing Hazelnuts in Oregon, 1985). Refrigeration extends storage life for as long as 2 yr, as does freezing. Before the new crop, handlers report carry-in data and use of carry-over inventories.

### Pistachios

Carry-in and carry-out inventories are reported in the CPI Annual Report. Carry-out is the difference between total marketable volume of pistachios and domestic and export consumptions. Carry-in is the ending inventory of the previous year.

### Macadamias

Wet macadamia nuts harvested in Hawaii require drying to maintain quality in storage. No information about macadamia inventory is published, however. California macadamias are relatively easy to store because of their low oil content and thick protective shells. If stored in a dry place, macadamias require no cold storage for as long as 12 mo. The Gold Crown co-op rents cold storage space, and then only for storing shelled nuts.

### Peanuts

Information about peanut stocks is published by the NASS. The report *Peanut Stocks and Processing* provides information about commercial peanut stocks, shelled peanut stocks, shelled peanut uses, and seed stocks. Storage information also is available by peanut type, regional farmer-stock peanuts, and edible grade use.

## Quality Information: Education

### Almonds

The marketing order implemented in the almond industry supports research and extension activities through a check-off fee. Annual production and research conferences are organized in different locations so that information reaches the largest possible audience and experts can educate growers about new production methods.

The ABC disseminates information in a monthly newsletter and in an expanded quarterly newsletter, which is sent to all almond growers. Several handlers publish a growers' newsletter. Information about the almond industry also is disseminated through articles in agricultural publications and in monthly newsletters of the Cooperative Extension Service (CES). Educational efforts have been credited with a decrease in pesticide use of 40%.

Consumer education is achieved through distribution of nutritional information about almonds and about comparisons of the nutritional values of almonds with those of other foods. Recipes using almonds also are distributed.

### Walnuts

Educational efforts are ongoing by the CES, the WMB, and the California Walnut Commission (CWC). Growers and handlers receive interim and annual reports from the Commission. Meetings presenting production and marketing information to growers are organized several times each year. Press releases are issued regarding various aspects of the walnut industry.

### Pecans

Education of pecan growers is a goal of the CES. Meetings of growers are held regularly off season in Georgia, Alabama, New Mexico, etc. Presentations provide information about cultural practices, pest management, quality, and marketing. State pecan growers' associations hold annual meetings that involve presentation of research results concerning pecan production and marketing. Regional associations such as the Southeastern Pecan Growers' Association and the Western Pecan Growers' Association invite speakers to their meetings, which educate growers about new developments in production and promotion. The papers presented are published in proceedings and distributed among growers. Members of the NPSA also participate in growers' meetings.

### Hazelnuts

Hazelnut growers depend on the CES to educate growers about the relation between cultural and postharvest practices and nut quality. Grower meetings and publications of the Service are means of disseminating information about pest control and other aspects of the industry. Consumer education about quality is accomplished through promotional programs.

### Pistachios

Quality is a multidimensional concept for the pistachio industry. In addition to instructing growers about pest control and postharvest physiology, the CES disseminates experimental results relevant to maintaining nut quality. For example, scientists from the University of California have developed drying curves for pistachios and dehulling procedures for limiting shell staining and have evaluated cultivars for chemical composition and sensory attributes (Kader et al., 1982). Information about these and other practices is disseminated at growers' meetings. The county based CES works directly with growers to transfer quality information from academia to industry.

### Macadamias

The CES educates growers about macadamia quality. Field days are organized on large corporate farms. Annual meetings of the HMNA include activities to increase knowledge of quality. University of Hawaii scientists contribute to these activities.

The CMS, which disseminates information about production technology, is the primary organizer of educational activities for growers. It publishes an annual yearbook and a newsletter. A field day is held annually, as is a meeting at which production related papers are presented. The Society cooperates with the University of California at Riverside.

### Peanuts

Information about how to produce quality peanuts is disseminated through the CES. Two major meetings deal with quality each season. At the first meeting, which takes place before planting, growers are informed about proper agronomic techniques and their relations to quality. Another meeting is a harvesting seminar, which, among other things, reviews procedures to check peanut maturity before digging and demonstrates how combines are adjusted.

Domestic consumer education is accomplished by means of promotional and advertising campaigns organized by processors and by growers' and shellers' organizations. Consumer education abroad is organized by the NPCA, which disseminates information about the nutritional value of peanuts and their products.

## Promotion and Advertising

### Almonds

Promotion and advertising in the almond industry is carried out by the ABC. The Board spends part of its annual budget on marketing promotion. Under the federal marketing order, almond handlers are assessed for, among other things, genetic promotion of almonds. For the 1991 crop year, the assessment was $0.005/lb.

Handlers also are required to spend from $0.01–$0.0075/lb for brand advertising. To satisfy these assessment obligations, handlers can claim credit for paid media advertising and market promotion, distribution of generic packages of almonds to charitable and educational outlets, payments to the Board for generic promotion, selected costs of organizing mail-order promotion, and purchases of promotional materials from the Board.

The California Almond Board publishes a wide variety of informational and promotional materials, including consumer recipe leaflets, retail store promotional materials, school and food-service recipes, bakery formulations, etc. It also publishes nutritional information, advice for almond users, and descriptions of almond products.

The almond industry has targeted Pacific Rim and West European countries. The TEA program reimbursed exporters for as much as half of their expenses for approved promotional activities (Anonymous, 1986b).

### Walnuts

Promotions of Diamond Walnut Growers, Inc. have focused on its brand since 1912. Branded walnuts have an identifiable trademark that was updated for redesigned consumer packages in 1991.

The WMB heads industrial promotion and public relations on the domestic market. Promotional materials include leaflets and brochures containing quality characteristic descriptions, kernel color reference photographs, and nutritional information. Recipes incorporating walnuts are part of these promotional materials. The WMB operates a free telephone line for consumers interested in recipes using walnuts and in tips on walnut use in cooking. The Board regularly schedules in-store promotions and magazine promotions through coupon offers and printed recipes.

The CWC, which organizes advertising and promotion of California walnuts, developed a logo promoting California walnuts and another featuring walnuts in the center of a quality seal promoting "California Quality." The Commission consists of four committees, including a Market Development Committee and a Domestic Marketing Committee, and its activities are funded by a $0.005/lb check-off fee and by sales of USDA certificates. Growers are informed of promotions through an "Interim Report" published by the Commission.

The actual budget of the Commission amounted to $8.1 million in 1982–1983. Export market development was a primary target. Advertising and promotion expenditures in Europe, the Pacific Rim, Australia, and Israel amounted to $7.3 million and emphasized market developments in Germany and Japan. Funds from the TEA supported promotion of brand identified shelled walnuts. The promotion focused on the U.K.'s almond market, which until recently had been dominated by China and by India (Anonymous, 1988).

### Pecans

Despite widespread use, pecans are sold under no widely recognized brands. In a previous Georgia study (Hubbard et al., 1990a), interviewees were asked to name the brand of pecans most widely known to the U.S. public. A common response was that there is none. Only 13% of growers, 38% of accumulators, and 40% of shellers named a brand.

Industry promotion was the task of the National Pecan Marketing Council (NPMC) until 1992. The Council designed, organized, and executed promotions targeted at carefully selected pecan users, primarily at institutions. Its promotional budget has been limited, however. Pecan advertisements have been placed in trade magazines and newspapers. Targeting the food-service sector has led to thousands of requests for recipes using pecans. Pecans also have been promoted in a combined effort with chocolate and milk processors. Since 1992, promotion and advertising of pecans have been the responsibility of the Pecan Marketing Board.

Some state growers' organizations promote pecans. For example, the Georgia Pecan Growers' Association organizes a promotional booth at the state's annual agricultural exhibit. Over the years, Texas and Georgia organizations have competed to bake the world's largest pecan pie. The Georgia State Department of Agriculture and the NPSA (1984) also promote pecans by publishing recipes, nutritional information, and selection and storage tips.

The approved two-year marketing agreement was designed to allow collection of funds in the fall of 1992 and 1993. These funds were to be used, in part, to finance advertisement and promotion supported by growers and shellers (Hubbard et al., 1990a). The $0.005/lb check-off fee for in-shell pecans collected $1.5 million in a better than average year, e.g., 1988, but only $0.9 million in a poorer than average year, e.g., 1980.

Differences in total check-off funds collected each year may affect the amount of money spent on advertising and promotion: funds will increase in years of ample and decrease in years of short supply. But continuity of promotional efforts depend on grower willingness to pay the check-off fee. Some may be unenthusiastic about paying this fee in years of diminished revenues from sales. Others may question the need for promotion in years of high pecan prices and large revenues. Nonetheless, to have a lasting effect on consumer behavior, promotional efforts should be continual.

### Hazelnuts

The promotion of hazelnuts is conducted by the HMB and by the Oregon Filbert Commission. The former publishes promotional material concerning nutrition, storage, product types, and uses. The latter publishes materials concerning use, quality control, and research. The Commission also has developed an "Oregon Hazelnut" logo and has drafted a set of quality standards known as the "Oregon Grade Standards" for kernels.

### Pistachios

Promotion and advertising campaigns are directed by the CPC, the annual budget of which is approximately $3.5 million. Funds are spent, in part, on developing domestic and international markets.

Promotion and expansion in export markets, especially in the Pacific Rim countries, are assisted through the Market Promotion Program (MPP), formerly the TEA Program. The MPP helped implement pistachio promotion programs in Japan, Hong Kong, Malaysia, Singapore, and Taiwan. This action was justified by Iranian pistachio production and export subsidization (Anonymous, 1986a). Promotion of California pistachios abroad has been effective, according to consumer awareness and export shipment statistics. The CPC claims that, for example, in 1990, 97% of consumers in Singapore were aware of pistachios, a percentage greater than that aware of either peanuts or cashews.

### Macadamias

In 1977, an extensive advertising campaign was launched to promote the brand name "Mauna Loa." The promotion was organized by C. Brewer and Co., Ltd., the largest U.S. grower and processor of macadamias (Anonymous, 1977a). The new name was used as a substitute for "Royal Hawaiian," the name used since 1965. Complimentary packets of "Mauna Loa" nuts were given by some airlines to passengers travelling to Hawaii.

The HMNA has been discussing a check-off program. Revenue from a $0.01/lb check-off fee would support promotion and research. This program has yet to be approved by the industry.

The Gold Crown co-op in California has no budget for promotion and advertising but receives free publicity from interested media. Some advertising and promotion campaigns are conducted by retailers. California macadamias are grown without chemicals because of low pest pressure and, as such, can be promoted as organically grown.

During the 1991 meeting of the HMNA, it was suggested that the industry fund promotion and market research. To raise revenues for that purpose, the HMNA needs to increase collections from 0.1 to 1% of gross sales.

### Peanuts

Since 1906, the year of establishing the "Planters Peanut Company," promotion has depended on good quality and brand name (Rosengarten, 1984). Over time, peanut production and processing has increased.

Today, the peanut industry has a well-organized system of advertising and promotion for exports. The NPCA promotes peanut exports. Promotion is organized according to an export market development program, the purposes of which are to present the United States as a reliable supplier of quality peanuts and to increase peanut consumption. Promotion is financed by state peanut growers' and shellers' associations. The NPCA has received TEA funds since 1986. In fiscal year 1991, the Council received $4.62 million from the FAS.

Promotional programs have involved branded nuts, processed products, and generic nuts. Programs for branded nuts are organized by the processors of U.S. peanuts. These processors must use only U.S. peanuts in a promoted product. Processed-product promotion programs are aimed at developing peanut and peanut butter markets abroad. The generic promotion program, which has used TEA funds to target the U.K., Germany, Italy, and France, has focused on increasing international awareness of the United States as the supplier of the highest quality peanuts.

## Anticipated Industry Changes Influencing Quality

### Utilization

Shelling yields—in addition to halves—pieces, granules, and meal. Standards for grades have been developed for in-shell nuts, halves, and pieces of certain sizes. Pecan granules are small pieces used as coating in confectionery and bakery products (National Pecan Sheller's Association, 1984). Although shellers maintain that pecan granules can partly replace fat in formulae and can add flavor, consistency, and color and that pecan meal can partly substitute for wheat flour, some shellers indicate a small market for granules and meal.

A new product based on unwanted granules or meal is reconstituted pecan pieces, which are shaped like natural pieces and have improved quality characteristics (Santerre et al., 1991). Specifically, their stability may be greater than that of whole pecans and their susceptibility to rancidity less. The value of pecan meal also may increase when it is converted into reconstituted pieces.

New products can be expected from users of shelled pistachios. Standards for grades of shelled pistachios would increase quality consistency. Increased supplies of quality kernels would make pistachios more available to ice cream manufacturers, confectioners, and food product marketers.

### Production Changes

An important support for growers is the USDA Pecan Breeding Program, which releases new cultivars with desirable quality characteristics. Certain newly released cultivars are adapted to growing conditions in regions not normally favorable to pecan promotion; thus established production patterns may change.

The role of government will remain critical in the development of new pecan cultivars. The USDA collects and maintains pecan germplasm, which is available to breeders in government laboratories and universities. The USDA is in fact the only institution with a history of continual development and release of new cultivars. The private sector has limited investment in pecan breeding.

Research on new production methods and on new cultivars is supported in part by the walnut industry. Land-grant universities and the USDA, however, are primarily responsible for walnut research.

In laboratory research, tissue culture already has been applied to pecan breeding (Merkle et al., 1987). Biotechnological techniques in pecan breeding are more costly than traditional breeding is—thus, the importance of the government and universities to future pecan breeding programs. The uses of genetic engineering and of tissue culture in developing cultivars of almonds and walnuts are more advanced than in developing cultivars of pecans.

Genetic selection of nuts with high vitamin E contents could increase the shelf lives of nuts and their products. Vitamin E is an antioxidant retarding rancidity. And a high content in nuts could chemically stabilize their fats. Slowing chemical reactions that diminish quality is an especially important goal for retail outlets and consumers.

Cultural practices may affect peanut taste. Studies are under way to evaluate the impact of herbicide use on taste. That of roasted peanuts is affected by pyrazines, which are created by amino acids and sugars during roasting. Herbicides may decrease the volume of flavor-intensive components in peanuts. Therefore, regulating the amounts of herbicides and their sequences may improve flavor.

### Marketing Structure

Changes in marketing structure are possible in industries such as the pecan industry, in which production and processing occur in several geographic areas. large processors also can expand by processing more than one nut. This trend already has been illustrated by large processors that locate shelling plants in regions in which specific nuts are grown. In such instances, each division operating in a specific industry acts independently. The trend toward concentration of shelling operations may be strengthened by the expansion of processors across nut industries.

The need for middlemen in the pecan industry likely will decrease because of expanding orchard size, improved cultivars, irrigation, and enhanced management quality. Accumulators operating on a narrow marketing margin may be forced from the industry. large pecan producers can deal effectively with shellers.

Examples of vertical integration suggest that increasingly complete merger of pecan product and processing is possible. Some shellers are operating their own orchards. Grower cooperatives for shelling, storing, and marketing on domestic and international markets also exist. Increasing concentration in pecan shelling is evident from the decreasing number of shellers. From 1976 to 1990, this number shrank from 43 to 29.

The disintegration of the Soviet dominated political and economic alliance in Eastern Europe opens new markets to nut traders. Already, East European consumers have access to nuts in greater quantities than ever before. Opening trade has led to increased imports, and nuts have become available year round. But with the exception of peanuts, nuts have been inconsistent in terms of quality.

The U.S. nut industries will compete on a quality basis. Although the traditional nut-consumption season in East European countries is winter, pricing must take into account level and distribution of income. Notwithstanding, in preparing products, exporters must bear in mind that East European consumers are more sophisticated buyers than their average income level suggests.

## Information

Information about nut inventory should be broken down by grade. Total carry-over reported currently does not reflect quality. For example, most nuts carried over may be of low grades suitable only for selected uses. Information about the quality of stored nuts would provide growers with incentives to deliver limited supplies.

### Quality Measurement

Nut buyers are becoming increasingly likely to demand that kernels and pieces meet their needs. Development of new products and their successful introduction are costly endeavors. Nuts and their parts are used as ingredients and, as such, must enhance quality and consumer acceptance of final products.

Demands for improved uniformity of kernels or pieces likely will increase in frequency. Ingredient uniformity, which ensures final product uniformity, can be achieved through improved packaging. Thus, new packaging methods allowing shelf life extension or new uses, e.g., edible coatings, will be an important development and will require that nuts maintain an even level of moisture to prevent bitterness. New packaging methods also must ensure retardation of rancidity and increased stability of oils.

Quality factors largely ignored by nut industries may become important as competition increases as a result of increased supply. Sensory quality characteristics such as sweetness, crispness, and firmness influence overall flavor intensity. End users may demand that kernels or kernel pieces have specific properties because of their influences on flavor.

Sensory quality can be influenced by cultivar and by postharvest handling. Nut industries in which a single cultivar dominates production, e.g., the pistachio industry, may ensure uniformity of sensory qualities (Kader et al., 1982). Nut industries using several cultivars may sell kernels from different cultivars to different end-users. The only sensory quality currently included in public or private quality standards is rancidity.

### Grade Changes

Given the increasing health consciousness among consumers, nut industries are advised to measure quality attributes. Nut characteristics affecting grades are fatty acid content and composition. Both vary on the basis of fatty acids, by type and by grade.

Processing technologies using bleach may have to be changed. Bleach permeates the outer shell and deposits residue on the skin and the inside of a kernel. Kernels and pieces of some nut types are mixed with alcohol or chemical brine to remove insect larvae or to determine grade. Consumers may perceive such practices as affecting product and refuse to make a purchase.

# Glossary

**Accumulators.** First-handlers of the nuts in the pecan industry.

**Additionals.** Peanuts produced above the peanut quota set yearly for the domestic market by the government support program.

**Crack out.** See *meat yield*.

**Direct consumption.** Consumption by retail consumers, which represents a small part of total consumption.

**Improved cultivars.** Grafted pecan trees.

**Improved trees.** Pecan trees propagated through seeds.

**Meat yield.** A major criterion of nut lot value—namely, shell-out ratio, which directly affects shellers' revenues and profit margins. Shell-out ration is the proportion of halves and of pieces yielded/unit of weight during shelling.

**Undermarketings.** Difference between base quota and effective quota; used to regulate peanut imports.

**Unimproved trees.** Pecan trees propagating without human interference, usually along riverbeds in Texas and Oklahoma.

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# 10 Fruits and Vegetables

John P. Nichols[36]

## Introduction

Of all agricultural commodities, fruits and vegetables are among the most likely to be observed and evaluated by a consumer in their primary, unprocessed forms. They also are among the most likely to exhibit noteworthy quality-attribute variations, e.g., in color, flavor, or texture. These variations result from differences in growing practice, cultivar, or postharvest handling.

The appearance of fruits or vegetables gives a consumer an initial impression of freshness, ripeness, and flavor. Thus, quality attributes reflected in evident visual characteristics are given importance in classification and grading systems at packing and wholesale levels. At the same time, consumer interest in fruits and vegetables is related increasingly to concerns about nutrition, diet, and health. Nutritional attributes, however, are intrinsic and distinguished with difficulty at retail. Nor are these attributes being used in establishing standards or grading systems.

Fruit and vegetable production is a highly specialized activity, and domestic output is concentrated in a few states. But the fresh fruit and vegetable industries have become global over the last decade, with world exports increasing at a rate of 3% annually since 1979.

Quality attributes play a role in the evolution of relations among trading partners. Changes in production technology and in management and pest-control strategies also have influenced public awareness of quality attributes. Rising consumer expectations, changing production and marketing techniques, and global economic interactions create a dynamic competitive environment for fruit and vegetable growers, whose success depends in large part on product quality.

In the next sections, an overview of production, use, and marketing channels in the fruit and the vegetable industries will be provided. These include a complex set of more than 150 different horticultural commodities. Both citrus and noncitrus fruits are involved, as are vegetables (as used here, incorporating major and minor vegetable crops, melons, and potatoes) and dry edible beans, dry peas, and lentils (neither fruits nor vegetables).

The industry overview includes information on production areas, trends in uses and consumption, marketing channels, and other areas. It is followed by reviews of the quality attributes of fruits and vegetables and of the systems of grades and standards and of inspection that officially recognize quality attributes. Emerging quality-related issues are identified, and anticipated changes are discussed in relation to their potential effect on quality.

## Production and Use

Fruits, vegetables, and pulses, e.g., peas or beans, are high-value crops of growing importance to U.S. farmers, food industrialists, and consumers. Such crops accounted for 26% of cash receipts for all crops in 1989, a percentage substantially greater than in 1975 (18%) (Table 10.1). But in 1989, cropland devoted to production was approximately 8.6 million a., a modest 2.6% of total U.S. cropland (Table 10.2).

The value of fruit production, particularly of citrus, has increased more rapidly than have the values of vegetable and pulse productions over the last 15 yr (Tables 10.3 and 10.4). The value of each of these food types, however, has increased substantially faster than that of all crops over the same period.

Potatoes accounted for more than 20% of the value of the entire vegetable and pulse category in 1989; dry edible beans, for 6% (Table 10.5). After potatoes, tomatoes—valued at $1.8 billion—were the most important vegetable crop. Lettuce, onions, sweet corn, carrots, and broccoli followed in descending order of value.

Among the fruit crops, grapes, oranges, and apples each exceeded $1 billion in farm value and combined constituted nearly 60% of the total in 1989 (Table

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**Table 10.1. Share of cash receipts represented by fruits and vegetables, U.S., 1989**

| | | Share of | |
|---|---|---|---|
| Crop | (million $) | All crops (%) | Crops and livestock (%) |
| Vegetables | | | |
| (including potatoes and pulses) | 11,461[a] | 15.2 | 7.2 |
| Fruit | 7,941[b] | 10.5 | 5.0 |
| Total vegetables and fruit | 19,402 | 25.7 | 12.2 |
| All other crops | 56,047 | 74.3 | 35.2 |
| Total crops | 75,449[c] | 100.0 | 47.4 |
| Total crops and livestock | 159,173[c] | — | 100.0 |

[a]U.S. Department of Agriculture, TVS–255, December 1991b, Table 2, p. 10.

[b]U.S. Department of Agriculture, TFS–258, August 1991a, Table 2, p. 16.

[c]U.S. Department of Agriculture, 1990a, Table 575, p. 391.

**Table 10.2. Acreage devoted to production of vegetables, pulses, and fruits, U.S., 1989**

| Crop | Acreage (1,000 acres) | Share of total (%) |
|---|---|---|
| Vegetables[a] | | |
| Fresh (harvested acres, major veg.) | 1,146 | 13.3 |
| Processed (harvested acres) | 1,475 | 17.1 |
| Subtotal (vegetables) | 2,621 | 30.4 |
| Potatoes | 1,282 | 14.8 |
| Subtotal (vegetables and potatoes) | 3,903 | 45.2 |
| Pulses[a] | | |
| Dry edible beans (harvested acres) | 1,651 | 19.1 |
| Dry peas and lentils (harvested acres) | 271 | 3.1 |
| Subtotal (pulses) | 1,922 | 22.3 |
| Fruit[b] | | |
| Citrus fruit (bearing acres) | 848 | 9.8 |
| Noncitrus fruit (bearing acres) | 1,961 | 22.7 |
| Subtotal (fruit) | 2,809 | 32.5 |
| Total vegetables, pulses, and fruit | 8,634 | 100.0 |
| Total U.S. cropland | 330,000 | |

[a]U.S. Department of Agriculture, TVS–255, December 1991b, Tables 3, 50, 66, 78, 86.

[b]U.S. Department of Agriculture, TFS–258, August 1991a, Table 1.

**Table 10.3. Farm value of production (cash receipts) for all vegetables, potatoes, and pulses and U.S. total crops, 1975, 1980, 1985–1989 (million $)**

| | Value | |
|---|---|---|
| Year | Vegetables, potatoes, and pulses[a] | Total crops[b] |
| 1975 | 5,346 | 45,813 |
| 1980 | 7,307 | 71,746 |
| 1985 | 8,572 | 74,290 |
| 1986 | 8,865 | 64,005 |
| 1987 | 9,902 | 63,751 |
| 1988 | 9,786 | 72,569 |
| 1989 | 11,461 | 75,449 |
| Change 1975–1989 | +114% | +65% |
| Change 1985–1989 | +34% | +2% |

[a]U.S. Department of Agriculture, TVS–255, December 1991b, Table 2, p. 10.

[b]U.S. Department of Agriculture, 1990a, Table 575, p. 391.

**Table 10.4. Value (million $) of production of citrus and noncitrus fruit, U.S., 1975, 1980, 1985–1989 (U.S. Department of Agriculture, TFS–258, August 1991a, Table 2, p. 16)**

| | Value | | |
|---|---|---|---|
| Year | Citrus | Noncitrus | Total[a] |
| 1975 | 980 | 2,088 | 3,068 |
| 1980 | 1,905 | 3,780 | 5,686 |
| 1985 | 2,080 | 3,831 | 5,911 |
| 1986 | 1,768 | 4,204 | 5,972 |
| 1987 | 2,053 | 4,421 | 6,474 |
| 1988 | 2,619 | 5,097 | 7,715 |
| 1989 | 2,665 | 5,276 | 7,941 |
| Change 1975–1989 | +172% | +153% | +159% |
| Change 1985–1989 | +28% | +38% | +34% |

[a]May not add due to rounding.

10.6). Other important fruits, in descending order of importance, were strawberries, grapefruits, peaches, pears, avocados, and lemons.

## Production Trends

Fruit and vegetable production is quite dependent on weather, soil, and other environmental conditions. Production therefore is concentrated in the favorable geographic areas of the West Coast, Florida, the Northeast, and Texas. Fruit production is the more concentrated, with nearly 75% originating in California and Florida (Table 10.7). Ninety percent of the value of U.S. fruit production is generated by only

**Table 10.5. Farm value for vegetable crops, potatoes, and pulses U.S., 1989 (U.S. Department of Agriculture, TVS–255, December 1991b, Table 2, p. 10)**

| Crop | Value (million $) | Share of total (%) |
|---|---|---|
| Potatoes | 2,334.4 | 20.4 |
| Dry beans | 688.3 | 6.0 |
| Vegetables | | |
| Tomatoes | 1,824.0 | 15.9 |
| Lettuce | 950.3 | 8.3 |
| Onions | 538.1 | 4.7 |
| Sweet corn | 468.4 | 4.1 |
| Carrots | 297.2 | 2.6 |
| Broccoli | 276.1 | 2.4 |
| Celery | 268.3 | 2.3 |
| Snap beans | 228.2 | 2.0 |
| Cantaloupe | 209.1 | 1.8 |
| Cauliflower | 204.8 | 1.8 |
| Cucumbers | 203.2 | 1.8 |
| All others | 2,970.8 | 25.9 |
| Total | 11,461.2 | 100.0 |

**Table 10.6. Value of production for major fruit crops, U.S., 1989, (U.S. Department of Agriculture, TFS–258, August 1991a, Table 132, pp. 96–97)**

| Crop | Value (million $) | Share of total (%) |
|---|---|---|
| Citrus | | |
| Oranges | 1,848.6 | 23.3 |
| Grapefruit | 418.1 | 5.3 |
| Lemons | 234.6 | 3.0 |
| Other citrus | 163.8 | 2.1 |
| Total citrus[a] | 2,665.1 | 33.6 |
| Noncitrus | | |
| Grapes | 1,862.8 | 23.5 |
| Apples | 1,034.4 | 13.0 |
| Strawberries | 537.8 | 6.8 |
| Peaches | 360.8 | 4.5 |
| Prunes and plums | 281.3 | 3.5 |
| Pears | 253.6 | 3.2 |
| Cranberries | 164.7 | 2.1 |
| Cherries (sweet) | 136.1 | 1.7 |
| Other noncitrus | 644.7 | 8.1 |
| Total noncitrus[a] | 5,276.2 | 66.4 |
| Total[a] | 7,941.3 | 100.0 |

[a]May not add due to rounding.

seven states.

Although vegetable production is less concentrated than fruit production, the top ten states still produced 75% of the value in 1989 (Table 10.8). California and Florida were the leading production states, with 32.5 and 13.6% of value, respectively.

When relatively large scale, fruit and vegetable production uses substantial amounts of technologically sophisticated inputs in terms of pest management, irrigation, climate control, and field and harvesting operations. In many activities, fruit and vegetable production also depend on access to great pools of labor to complete intensive seasonal activities. This intensive concentrated production indus-

**Table 10.7. Leading states in production of fruit crops, U.S., 1989 (U.S. Department of Agriculture, TFS–258, August 1991a, Table 132, p. 97)**

| State | Value (million $) | Share of total (%) |
|---|---|---|
| California | 3,944.8 | 49.7 |
| Florida | 1,918.8 | 24.2 |
| Washington | 735.3 | 9.3 |
| New York | 165.4 | 2.1 |
| Michigan | 147.1 | 1.8 |
| Oregon | 133.5 | 1.7 |
| Hawaii | 120.5 | 1.5 |
| Others | 775.9 | 9.8 |
| Total[a] | 7,941.3 | 100.0 |

[a]Total may not add due to rounding.

**Table 10.8. Leading states in production of vegetables, U.S., 1989 (U.S. Department of Agriculture TVS–253, April 1991b, Table 20, p. 48)**

| State | Value[a] (million $) | Share of total (%) |
|---|---|---|
| California | 3,704.8 | 32.5 |
| Florida | 1,545.0 | 13.6 |
| Idaho | 757.9 | 6.6 |
| Washington | 583.4 | 5.1 |
| Wisconsin | 354.2 | 3.1 |
| Texas | 349.9 | 3.1 |
| Colorado | 325.2 | 2.9 |
| Arizona | 320.4 | 2.8 |
| Michigan | 320.2 | 2.8 |
| New York | 310.4 | 2.7 |
| Others | 2,822.1 | 24.8 |
| Total | 11,393.5 | 100.0 |

[a]Farm cash receipts.

try is geared to meet the demands of mass merchandising-oriented retail food chains and to respond to needs for a continual supply of great volumes of homogenous products.

In many parts of the country, part-time and specialty crop farming, which serves the needs of regional and niche markets, is common. This unique form of production endures because it exploits available resources and local demands. Nevertheless, it cannot be expected to serve the primary needs of U.S. food wholesaling and retailing systems.

Prices and revenues for specific fruits and vegetables differ substantially. Regional concentration combined with weather variation and perishability causes wide swings in industry prices and returns. And unlike major field crops, fruits and vegetables are excluded from traditional government price- and income-support programs. Most forms of government assistance to the industry are limited to activities facilitating rather than intervening in market processes. Such assistance includes crop insurance, grading, market news, and enabling legislation necessary to support marketing cooperatives, check-off programs, and marketing orders.

## Use and Consumption

Nearly half (48%) of vegetable production is directed at the fresh market (Table 10.9), a share increasing significantly over the last two decades. As measured in terms of farm value, fresh market vegetables are much more important, accounting for 77.8% of receipts in 1989, an increase from two-thirds in 1970.

A definite trend toward increased consumption of fresh vegetables is noted when use is examined on a per capita basis (Table 10.10). In 1989, annual per capita use of vegetables (excluding potatoes) was nearly 250 lb in farm-weight equivalents. More than half the vegetables were consumed fresh. For potatoes, the trend in fresh use was in the opposite direction. Total per capita consumption increased modestly, with fresh per capita consumption declining and processed product consumption increasing.

A larger share of fruit than vegetable production is directed toward the processing market (Table 10.11). In 1989, two-thirds of fruit produced moved through those channels, with noncitrus products slightly less processing oriented (64.2%) than citrus products (69.1%). This ratio has changed little over the past two decades.

Data to illustrate value comparisons are difficult

**Table 10.10. U.S. per capita use of vegetables, potatoes, and pulses, (lb, farm wt.) for fresh and processing, 1971 and 1989 (U.S. Department of Agriculture, TVS–252, December 1991b, Table 1, p. 9)**

| | Use | | | | | |
|---|---|---|---|---|---|---|
| | Fresh | | Processed | | Total | |
| Selected commodity | 1971 | 1989 | 1971 | 1989 | 1971 | 1989 |
| Selected vegetables | | | | | | |
| Tomatoes | 11.3 | 16.8 | 68.3 | 69.4 | 79.6 | 86.2 |
| Sweet corn | 7.5 | 6.4 | 20.3 | 17.9 | 27.8 | 24.3 |
| Carrots | 6.1 | 7.9 | 3.4 | 3.6 | 9.5 | 11.5 |
| Lettuce, fresh | 22.4 | 28.8 | — | — | 22.4 | 28.8 |
| Onions, fresh | 13.1 | 17.9 | — | — | 13.1 | 17.9 |
| Total vegetables | 109.1 | 139.6 | 111.3 | 109.0 | 220.4 | 248.6 |
| Potatoes | 56.1 | 50.1 | 61.7 | 77.4 | 117.8 | 127.5 |
| Sweet potatoes | — | — | — | — | 5.3 | 4.4 |
| Mushrooms | 0.3 | 2.0 | 1.1 | 1.5 | 1.4 | 3.5 |
| Dry peas and lentils | — | — | — | — | 0.2 | 0.8 |
| Dry edible beans | — | — | — | — | 6.9 | 5.5 |
| Total | — | — | — | — | 352.0 | 390.3 |

**Table 10.9. Utilization of major vegetable crops (1,000 t) for fresh and processing, U.S., 1970 and 1989 (U.S. Department of Agriculture TVS–252, 1990d)**

| | Fresh | | Processing | | Total | |
|---|---|---|---|---|---|---|
| Crop | 1970 | 1989 | 1970 | 1989 | 1970 | 1989 |
| Major vegetables (excluding potatoes) | | | | | | |
| Fresh | 7,003 | 12,032 | — | — | 7,003 | 12,032 |
| Dual use | 711 | 1,999 | 606 | 741 | 1,317 | 2,740 |
| Processing | — | — | 8,596 | 14,451 | 8,596 | 14,451 |
| Total | 7,714 | 14,031 | 9,202 | 15,192 | 16,916 | 29,223 |
| Share of total (%) | (45.6) | (48.0) | (54.4) | (52.0) | (100) | (100) |
| Value (million $) | 902 | 4,840 | 446 | 1,385 | 1,348 | 6,225 |
| Share of total (%) | (66.9) | (77.8) | (33.1) | (22.2) | (100) | (100) |

to come by. Because fruit sold in fresh markets brings a substantially higher price than that sold in processed form does, fresh production is more important in value terms than is reflected in volume figures. Substantial growth in output volume has occurred over the past two decades, most notably in the noncitrus fruit industry.

On a per capita basis, fresh fruit consumption has increased by more than 25% since 1970 (Table 10.12).

**Table 10.11. Utilization of selected fruit crops (1,000 t, fresh wt.) for fresh and processing, U.S., 1970 and 1989 (U.S. Department of Agriculture, TFS–254, August 1990c, selected tables)**

| | Fresh | | Processed | | Total | |
|---|---|---|---|---|---|---|
| Crop | 1970 | 1989 | 1970 | 1989 | 1970 | 1989 |
| Noncitrus[a] | 3,378 | 5,634 | 6,512 | 10,111 | 9,890 | 15,745 |
| Share (%) | (34.2) | (35.8) | (65.8) | (64.2) | (100) | (100) |
| Citrus | | | | | | |
| Oranges | 1,789 | 1,970 | 6,223 | 6,907 | 8,022 | 8,877 |
| Grapefruit | 949 | 1,397 | 1,236 | 1,464 | 2,185 | 2,861 |
| Lemons | 351 | 467 | 223 | 293 | 574 | 760 |
| Limes | 16 | 42 | 15 | 13 | 31 | 55 |
| Total citrus | 3,105 | 3,876 | 7,707 | 8,677 | 10,812 | 12,553 |
| Share (%) | (28.7) | (31.9) | (71.3) | (69.1) | (100) | (100) |
| Total | 6,483 | 9,510 | 14,219 | 18,788 | 20,702 | 28,298 |
| Share (%) | (31.3) | (33.6) | (68.7) | (66.4) | (100) | (100) |

[a]Excludes berries.

**Table 10.12. U.S. per capita use of fresh fruit and selected processed products, 1970 and 1989 (U.S. Department of Agriculture, TFS–258, August 1991c, Tables 109–114)**

| Product | 1970 (lb) | 1989 (lb) | Change (%) |
|---|---|---|---|
| Fresh | | | |
| Citrus | 28.8 | 25.4 | −11.8 |
| Noncitrus | 50.6 | 74.3 | +46.8 |
| Total fresh | 79.4 | 99.7 | +25.6 |
| Processed (product wt.) | | | |
| Canned | 15.6 | 13.4 | −14.1 |
| Frozen | 3.3 | 4.6 | +39.4 |
| Dried | 2.6 | 3.1 | +19.2 |
| Juice (single strength) | | | |
| Canned[a] | 7.5 | 3.4 | −54.7 |
| Chilled | 4.6 | 6.5 | +41.3 |
| Frozen citrus | 21.9 | 34.3 | +56.6 |

[a]1988 estimates.

The trend is associated exclusively with noncitrus fruits, whose per capita use has increased by more than 46%. Changes in processed fruit consumption are more difficult to characterize. Canned fruit and fruit juice consumption per capita has declined, whereas frozen, dried, and other fruit juice consumption has increased.

Fruits and vegetables, which constitute a significant portion of consumer food expenditures, were estimated to have accounted for 17.8% of consumer home food expenditures in 1988, an increase from 15.1% in 1980 (Smallwood et al., 1991).

In summary, fruits and vegetables are integral components of the current U.S. food supply. And fresh product marketing and consumption are becoming increasingly important.

## Imports and Exports

Trade data for all fruits and vegetables are difficult to assemble on a comparable basis. Aggregate estimates provided by the USDA–FAS illustrate recent growth in both imports and exports of fruits and vegetables (Table 10.13). The volume of fresh and processed vegetable exports, though smaller than that of imports, is growing more rapidly, perhaps because of the trend to reexport U.S. imports to Canada. Likewise, the volume of fruit imports is greater than twice that of exports; export volume, however, is growing at a substantially greater rate. The value of imported fresh and processed fruits, although evidencing little growth, remains significantly greater than that of exports.

Taken as a whole, these trends show growth rates outpacing changes in size of domestic fruit and vegetable production over a comparable period. Additionally, in 1989, imports of fruits and vegetables accounted for 24% of the value of all U.S. agricultural imports, an increase from 22.6% in 1985. Over the same period, exports of fruits and vegetables, including processed products, increased their share of total U.S. agricultural export value from 4.8 to 6.2%.

Concomitant with the growing internationalization of the U.S. fruit and vegetable industries, quality attributes have received increasing attention. Nontariff trade barriers throughout the world often incorporate quality characteristics as a means of influencing import level, and the United States has used this practice and been affected by it as well.

## Marketing System

Two major channels—fresh and processed—characterize the marketing system for U.S. fruits and vegetables. Although these channels sometimes have the same source of raw product at the farm level, most production is initiated for a specific channel because its cultivars, production technologies, and growing conditions are fairly unique. For a few dual-use fruit and vegetable marketing situations, grading based on quality characteristics is used to determine flow to each use.

In this section, structure and organization of the two market channels, including primary coordinating mechanisms and pricing practices, are described briefly. Quality attributes and grading systems will be discussed in detail in a subsequent section.

### Fresh Market Channels

Primary market channels are illustrated in Figure 10.1. For fresh fruits and vegetables, major markets exist at three levels: retail, terminal point, and shipping point. Wholesale terminal point markets change in scope of function, with the needs of retailers and with the sources of raw commodities. Wholesale terminal markets still provide an important link in the distribution network, but their role has diminished as direct sales and shipments have increased from the major shipping point markets to chainstore warehouses and distribution centers.

Various types of integrated grower-packer-shipper firms have evolved at the shipping point, where approximately half of fresh fruits and vegetables are marketed under some form of grower-shipper integration (Kohls and Uhl, 1990). Moreover, in 1985, 20% of sales were estimated to occur through cooperatives. large chainstore firms and cooperative buying groups usually have buying agents located at major shipping points.

Information communication among shipping point firms, wholesalers, and retailers is the focus and purpose of grading systems and grade standards in the fresh fruit and vegetables industries. Produce is graded at the point of sale from producer to first-handler. These grades are used to establish relative prices and to provide quality information throughout the system to wholesalers and to retailers. For some fruits and vegetables, grading is done at the wholesale level, where repacking operations may be carried out.

Price discovery in fresh market channels usually is accomplished through a system of decentralized,

**Table 10.13. U.S. trade in fruits and vegetables, volume, and value, 1985 to 1989 (U.S. Department of Agriculture, 1990b)**

| | Fresh/processed fruits | | Fresh/processed vegetables | | Fruit and vegetables, share of total U.S. | |
|---|---|---|---|---|---|---|
| Fiscal year | Volume (1,000 t) | Value (million $) | Volume (1,000 t) | Value (million $) | Volume (%) | Value (%) |
| Exports | | | | | | |
| 1985 | 1,445 | 1,003 | 880 | 503 | 1.8 | 4.8 |
| 1986 | 1,520 | 1,091 | 884 | 522 | 2.2 | 6.1 |
| 1987 | 1,748 | 1,284 | 928 | 592 | 2.1 | 6.7 |
| 1988 | 1,977 | 1,465 | 1,151 | 729 | 2.1 | 6.2 |
| 1989 | 2,085 | 1,539 | 1,310 | 904 | 2.3 | 6.2 |
| (1985–1989 % change) | +44.3 | +53.4 | +48.9 | +79.7 | | |
| Imports[a] | | | | | | |
| 1985 | 4,400 | 3,380 | 1,984 | 1,087 | 32.6 | 22.6 |
| 1986 | 4,568 | 3,143 | 1,999 | 1,249 | 33.8 | 21.0 |
| 1987 | 4,770 | 3,459 | 2,226 | 1,182 | 36.1 | 22.5 |
| 1988 | 4,730 | 3,551 | 2,295 | 1,237 | 36.1 | 22.8 |
| 1989 | 4,967 | 3,610 | 2,471 | 15,55 | 35.6 | 24.0 |
| (1985–1989 % change) | +12.9 | +6.8 | +24.5 | +43.1 | | |

[a]Includes bananas and plantains in total for fruit.

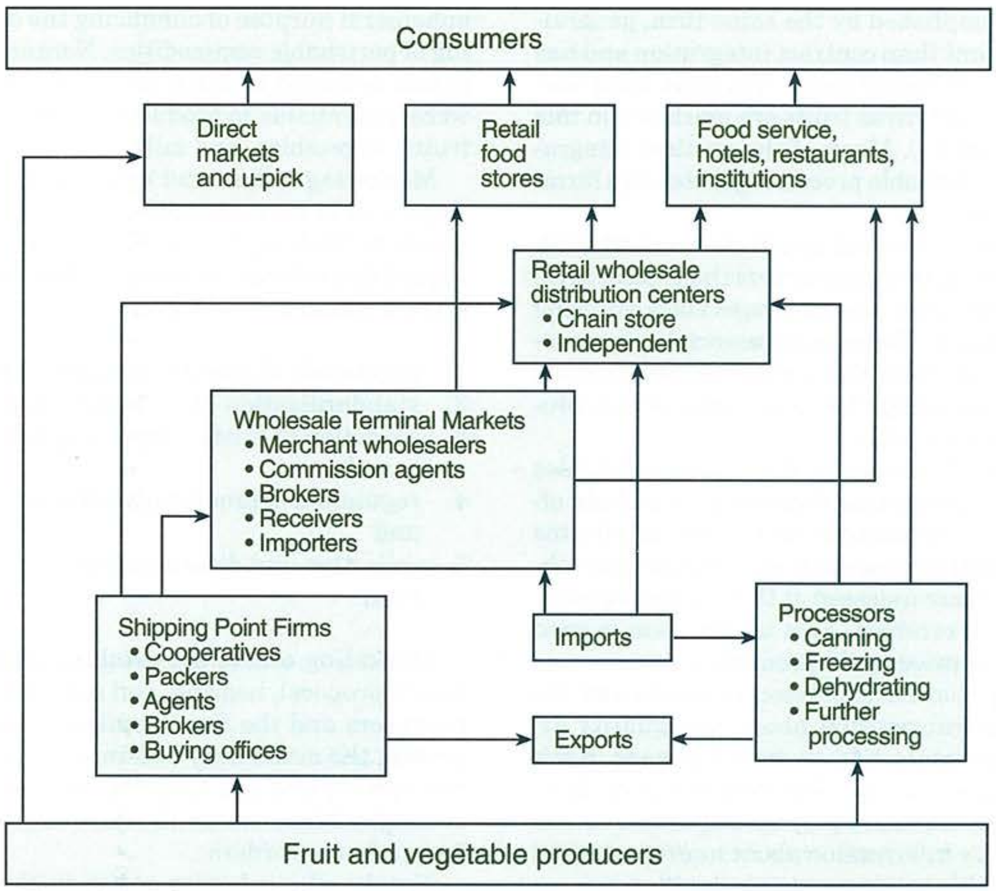


**Figure 10.1. Primary marketing channels for fresh fruits and vegetables and processed products.**

individual negotiations. Historically, wholesale markets have played a centralizing role, but their importance is diminishing as ever more sales are made directly to large retail firms.

## Processing Market Channels

Processors provide a key coordination function in the marketing channel. In 1987, more than 1,400 firms shipped processed fruits and vegetables valued at $36.3 billion and representing 11% of the value of all U.S. processed food shipments (U.S. Department of Commerce, 1990). Canned products accounted for the greatest part of these shipments, and frozen items also were of great importance. Specialty products, including prepared foods and sauces, had increased in relative value from 1982.

Processing firms are located primarily on the West Coast and to a lesser degree in the Northeast, the Great Lakes region, and the Southeast. Proximity to traditional production areas is the primary determinant of plant location.

Industrial concentration in fruit and vegetable processing differs. In the canning industry, the largest four firms accounted for 21% of industry output in 1982, a percentage little changed since 1977 (Buckley et al., 1988). In freezing, the comparable figure was 27%, 5% more than in 1977, but less than in 1972. The much smaller drying industry, in which concentration has increased more slowly, evidenced quite extensive concentration, with 42% of industry output accounted for by the four largest firms in 1982. By normally accepted standards, these levels indicate a relatively concentrated or "effectively competitive industry" on the national level.

Procurement of raw product supplies most often occurs through production and marketing contracts for processing vegetables, potatoes, and citrus (Table 10.14). Thus, coordination of production practices, cultivars, and schedules is facilitated to meet processor needs. The considerable production risk involved can be managed through use of such coordination arrangements.

*Vertical integration*, whereby production and processing are accomplished by the same firm, generally is less significant than contract integration and has increased slowly in recent years. Yet more than one-third of potatoes and citrus fruits are marketed in this manner (Table 10.14). Much of the vertical integration in fruit and vegetable processing is through farmer owned cooperatives.

Decentralized, individual negotiation in both cash markets and production contracts is the typical price discovery method for fruits and vegetables entering processing channels. Bargaining associations sometimes represent producers in collective negotiations with processors although the popularity of this process has declined recently.

Purchase specifications for fruits and vegetables moving into the processing channel may include official U.S. grade standards and other attributes agreed on in contract negotiations. Grades and other quality factors are assessed at the processing plant as the product is received. This information is used to determine the prices paid producers.

Grades also exist for processed products and are used to convey information about key quality attributes to wholesale and to retail buyers. Such grades are little known or used by consumers, however, and brands therefore play an important role in conveying quality information about many processed fruit and vegetable products at retail and consumer levels.

## Marketing Orders and Agreements

Marketing orders and agreements, unique institutional arrangements in the fruit and vegetable sector, represent a government sanctioned mechanism through which producers and marketing firms can address problems collectively. Orders and agreements established at the federal level in the 1930s had the ephemeral purpose of enhancing the orderly marketing of perishable commodities. Nonrecourse loan programs designed to assist producers of storable crops were unavailable to producers of perishables such as fruits, vegetables, and milk.

Marketing orders and agreements are especially important in the management and regulation of quality at the fresh product level. As applied to fruits and vegetables, federal marketing orders and agreements serve a number of purposes:

1. regulation of quality, maturity, and size;
2. standardization of containers and packages;
3. collection of funds supporting promotion and research;
4. regulation of product quantity moving to market; and
5. collection and dissemination of market information.

Marketing orders are established through a process of proposal, hearing, and referendum among the producers and the first-handlers affected. Once approved, the mandatory orders are administered by a committee, and the USDA is responsible for their oversight. Many states also have enabling legislation for marketing orders.

Nearly all marketing orders in the fruit and the vegetable industries involve quality-regulation provisions. These typically focus on setting permissible grade standards and size requirements in an effort to improve uniformity of produce moving into fresh market channels. As they do with other commodities, consistent grade standards support the reporting of market conditions and the disseminating of information about price and volume throughout the industry.

**Table 10.14. Share of fruits and vegetables (%) produced under contracts and by vertically integrated firms, 1970 and 1980 (Marion, 1986, p. 15)**

| Commodity | Production and marketing contracts 1970 | Production and marketing contracts 1980 | Vertical integration 1970 | Vertical integration 1980 |
|---|---|---|---|---|
| Vegetables for fresh market | 21 | 18 | 30 | 35 |
| Vegetables for processing | 85 | 83 | 10 | 15 |
| Potatoes | 45 | 60 | 25 | 35 |
| Citrus fruits | 55 | 65 | 30 | 35 |
| Other fruits and tree nuts | 20 | 35 | 20 | 25 |
| Dry beans and peas | 1 | 2 | 1 | 1 |

## Price Discovery and Dissemination

Production concentration, weather or pest induced supply variation, and fresh fruit and fresh vegetable perishability cause substantial price fluctuations. The primary price discovery mechanism used in the industry is a system of decentralized, individual negotiations.

In fresh market channels, wholesale terminal markets once played a centralizing role in price discovery. The importance of these markets has declined substantially in recent years, however, as most fresh produce has moved directly from concentrated producing regions to large retail warehouses.

Fruits and vegetables produced for processing markets also are priced primarily by means of individual negotiation. This is true both for cash sales at harvest and contracts negotiated before or during the season. Collective bargaining associations sometimes represent producers, but this practice has declined recently.

Marketing cooperatives play a significant role in certain fruit and vegetable industries. These organizations may pool fresh or processed products and negotiate prices. Producers subsequently may be paid an average pool price with premiums or discounts for quality factors.

With the emphasis on individual decentralized price-discovery, price information must be disseminated efficiently. As with most commodity markets of this type, substantial communication of price and related market information occurs through continual informal telephone, fax, and face-to-face contacts. Prices are reported by quality grades through official USDA daily and weekly market news reports, which also convey information about supply and demand conditions for key shipping points and terminal markets during the appropriate season for significant fresh market commodities. Similar market news reports for stored and processed products also provide a useful historical record and benchmark.

### Price-Quality Relations

Fruit and vegetable prices are quite responsive to quality differentials. The USDA market news reports from shipping point and terminal market locations consistently reflect variations based on grade differences. The magnitude of these price differentials depend on seasonal and daily changes in supply and demand.

Other qualitative differences also are reflected in price differentials, even when official grades are not a factor. Different types of onions or sizes of apples will bring different prices, even though they may carry the same U.S. grade designation. Fresh produce markets tend to be regional or local for some products, reflecting the effects of different growing conditions, regionally sensitive cultivars, or individual quality perceptions.

Condition of fresh produce is an ever-present quality factor influencing price. Produce becoming overripe or otherwise undesirable on its way to market often will be sold at a substantially reduced price. This eventuality is evident at wholesale and retail levels. At the shipping point, such produce often is destroyed or unharvested.

In processed product channels, quality differences are reflected in pricing premiums and discounts. Results of inspections upon delivery to the processor translate directly into discounts off of a base negotiated price for most fruits and vegetables. Contract terms negotiated in advance for processing vegetables are meant to encourage producers to meet specifications without undue price discount at harvest.

For processed consumer products, quality differentials may be reflected in brand differences. At the retail level, there often is a price difference between store brands and nationally advertised brands of the same product. Whereas some consumer product differentiation is based on psychological and advertising appeal, there frequently are differences in quality standards for the unprocessed commodity used in manufacture. Store brands and generically labeled canned and frozen fruits and vegetables provide low-price alternatives.

## Quality

In the fruit and the vegetable industries, quality is a crucial factor influencing everything from consumer satisfaction to producer return. Knowing which quality attributes are important, how these attributes can be assessed objectively, and how related information can be made available to all market participants is critical to coordinating production and marketing systems. Because there has been extensive debate regarding the nature of quality in fruits and in vegetables, this section begins with a discussion of quality attributes.

### Important Quality Attributes

*Quality* in its broadest context includes fruit and vegetable attributes with meaning and value to the user. Sensory characteristics such as taste and visual appeal are the most commonly recognized attributes, but nutritional composition and other characteristics also are important. Specifications in processing vegetable contracts may focus on production and harvest conditions thought to be correlated with product quality characteristics necessary in processing, storing, and distributing.

Shewfelt (1990) identifies several aspects of fresh fruit and vegetable quality. Appearance is a key factor involving size, shape, gloss, color, and external defect. Size often is given a premium in the market. Visual defects may result from infestation, mechanical damage, or physiological deterioration. Preference, of course, usually is given to uniformity and to absence of defects. Color, too, is important, with each product eliciting certain expectations of an ideal color correlated with good eating quality, ripeness, texture, and nutrition.

Texture and flavor are functions of cultivar, maturity, and condition and are difficult to evaluate with noninvasive grading procedures. These attributes are nonetheless important aspects of quality. Nutritive value in particular is an important aspect of fruits and vegetables, products consistently high on the list of most dietary and health recommendations. Fruits and vegetables generally are characterized as low in fat and protein and high in carbohydrates, vitamins, selected minerals, and dietary fibers. Nutritive value, however, differs greatly and is difficult to assess for use as a quality measure in the establishment of grades for guiding wholesale and retail trade (Shewfelt, 1990).

In recent years, consumers, food marketers, and producers have become increasingly concerned about pesticide residues on fruits and vegetables or in processed products. This trend also is related to quality but as discussed earlier is best categorized as a food safety issue. This discussion concerns quality attributes and related issues for fruits and vegetables already judged safe.

## The USDA Grading System

The United States has a well-established system of grading fresh fruits and vegetables. This system also is applied to many standard processed products such as fruit juices, applesauces, and canned vegetables. Current grades and standards for fruits and vegetables are administered by the USDA, under the authority of the AMA of 1946. Through this system, quality attributes are designated formally and standards established to facilitate trading and marketing.

Quality specifications also can be agreed on in contracts or in other purchasing arrangements among private parties. Standards of identity, quality, and container fill are established under the Food, Drug, and Cosmetic Act administered by the FDA. Beyond the USDA's grades and standards programs, these regulations certainly affect quality of processed products.

Grade standards are developed and maintained by the USDA–AMS. For fresh fruits and vegetables, approximately 135 grade standards have been developed, the majority of which were designed for products moving through fresh market channels (The Ohio State University, 1991). Approximately 40 grades and standards have been established as means of identification for consumers purchasing prepackaged vegetables at retail. Grade standards also have been issued for approximately 158 processed products made from 80 different fruits and vegetables (Buckley et al., 1988).

United States grade standards for fruits and vegetables and their processed products generally are applied on a voluntary basis. If a firm decides to use U.S. grades and includes that grade on the label, then the product must conform to established USDA standards. Grading of fresh fruits and vegetables may be made mandatory, however, if packing and shipping is regulated through a marketing order.

Substantial variation exists in the use of USDA grade standards. In 1990, nearly 90% of fresh potatoes and 77% of fresh tomatoes were graded at the shipping point. In contrast, one-third of fresh apples and one-fifth of fresh oranges were graded (The Ohio State University, 1991). Eighty percent of processing potatoes and only 5% of processing tomatoes were graded. Eighty-six percent of oranges and 30% of apples were graded for processing.

Indeed, grading level required depends on product nature, market demand, and coordinating mechanism such as contract or vertical integration.

Official grading is conducted by trained inspectors as part of the Federal-State Inspection Program (FSIP). At terminal markets, federally employed inspectors grade. Cooperative agreements exist in most states; grading thus becomes a joint activity, with the designated state agency providing service at the shipping point.

Staff of the USDA are responsible for developing and maintaining consistency in standards and in their applications. An official grader for fruits and vegetables, unlike graders for many other commodities, need not be present to certify grade. Producers or shippers of fresh vegetables can sort and ship under grade designation, but the product is subject to official grading at the receiving end if the buyer so requests. And if the grade is specified, the shipment must meet the appropriate official USDA standard even though no official inspection is involved.

For processed products and for fruits and vegetables moving into processing channels, a continual inspection service may be provided under contract. When this system is used, the official USDA inspection shield and certification may be displayed on the product. Fees are charged for all inspection services.

## Fruit and Vegetable Grade Standards and Nomenclature

Under the USDA grading system, a grading nomenclature has evolved. For fresh produce, the USDA has established a policy to phase-in four uniform grade names—U.S. fancy, U.S. No. 1, U.S. No.2, and U.S. No. 3. At present, significant variation in nomenclature exists due to changing circumstances and to interests prevailing at the time of establishment. For example, Florida oranges and tangelos have ten different grades, ranging from U.S fancy to U.S. No. 3. Oranges from Texas and California-Arizona have different grade standards but use similar names (U.S. Department of Agriculture, 1957, 1969, 1980). Although the number of grades in use may depend on commodity, two or three usually are sufficient to cover the range of marketable produce.

For most processed products, grade names are alphabetical and provide for three quality grades above substandard. The highest grade (U.S. Grade A) represents the quality most desired by the trade and by consumers (Buckley et al., 1988). Other grades represent quality levels that may be less desirable but are of good value and marketable through normal channels.

Determining appropriate grade names requires assessment of several grading factors in view of an established set of grade standards. Grading factors identified in the official standards for fresh fruits and vegetables are of four types: quality, size, condition, and tolerance. For certain products, additional factors may be included such as color requirements for apples or specific gravity measurements for processing potatoes. In the official grading terminology, *quality* is a term reserved for a specific set of factors even though factors such as condition and tolerance are reflections of quality to those purchasing and using the product.

*Size* refers to objective measures of diameter, length, weight, and uniformity. Not always an integral part of grade standard, size in some instances is used to describe permissible count and pack arrangements in standard industry containers, e.g., Florida oranges and tangelos. In other instances, e.g., the potatoes market, grade names are U.S. Grade A Small (Medium, Large) or U.S. Grade B Small (Medium, Large). Here, grade name includes a size specification and is intended to convey that information to consumers.

*Quality* factors include cultivar uniformity, cleanliness, shape, and maturity. Quality defects include injury or damage from diseases or insects, mechanical damage, and other defects such as cracks, sunburn, misshapenness, dirt, or foreign material.

*Condition* refers to quality factors related to changes of the product in postharvest storage and handling associated with texture, firmness, ripeness, and freshness. Mechanical, disease, or decay damage occurring after harvest also is denoted.

Inasmuch as some heterogeneity in the product is a natural occurrence and cannot be eliminated completely, tolerance also is set as part of grade standards. *Tolerances* generally are stated in terms of percentage of defects that are, generally speaking, permissible. Tolerances typically are more restrictive for fruits and vegetables moving into fresh market than into processing. An example of the description of the highest grade of fresh and processing apples is provided in Table 10.15.

Quality and condition factors also underlie processed fruit and vegetables standards. *Quality* in processed products refers to factors invariant once processing is complete, e.g., color, clarity, consistency, size uniformity, flavor, and aroma. For processed products, defects and tolerances in grade factors are given numerical scores, and the scores for all relevant factors are totaled. The greater the sum, the higher the grade classification. Minimum standard scores are set for each grade. Standards for U.S. Grade A tomato juice are presented in Table 10.16.

Minimum quality standards for many processed foods are established and administered by the FDA. These standards typically constitute the basic standards for the USDA's lowest grades for processed fruit and vegetable products.

## Evolution of Grades and Standards

The development of independent, third-party grading in the fruit and the vegetable industries parallels that in other agricultural industries. Grade standards describe the quality requirements for each grade of a specific fruit or vegetable, giving the industry a common language for buying and selling. Consequently, transaction cost is reduced, marketing efficiency encouraged, and commodity differentiated from competitors so that it can move to consumers with preferences for certain quality attributes. The primary purpose of grading in the fruit and the vegetable industries is that of facilitating wholesale trade (Nichols et al., 1983).

The development of refrigeration equipment and improved rail transportation around the turn of the century encouraged intensive fruit and vegetable production in the West, the Midwest, and the South.

Wholesale trade over these great distances from urban consumption centers was unpredictable, however, because of wide fluctuations in quantity, quality, and price.

Commission men at terminal markets provided quality sorting or grading. large dealers in urban areas sent buying agents to major production regions to oversee harvest and package of fresh produce meeting their own specifications.

Although shipper trademarks and labels provid-

**Table 10.15. Highest U.S. wholesale standards and grades for fresh apples, 1990 (The Ohio State University, 1991)**

| Fresh<br>U.S. Extra Fancy | For processing<br>U.S. No. 1 |
|---|---|
| **Quality** | |
| One variety<br>Mature<br>Carefully hand picked<br>Clean<br>Fairly well formed<br>Color specified by variety<br>Free from scab, visible water core, broken skins<br>Free from injury by smooth net–like russeting, sunburn, sprayburn, limb rubs, hail, drought spots, scars, disease, insects, or other means<br>Free from damage such as smooth solid, slightly rough or rough russeting, stem or calyx cracks, invisible water core after January 1 year following production | One variety (unless designated as mixed)<br>Free from worm holes, any other defect or combination of defects that cause a loss of 5%, by weight, of the apple |
| **Condition** | |
| Not overripe<br>Free from decay, freezing injury, internal breakdown, bruises, fresh or unhealed broken skins, internal browning, internal breakdown, scald, bitter pit, Jonathan spot | Not overripe<br>Free from decay, freezing injury, any other defect or combination of defects that cause a loss of 5%, by weight, of the apple |
| **Tolerances** | |
| For defects: 10% total, not more than 5% serious damage, including 1% decay or internal breakdown | Shall not be further advanced in maturity than generally firm ripe<br>For defects: 10% total, including 2% decay, 2% internal breakdown, 5% worm holes |

**Table 10.16. Highest U.S. standards and grades of tomato juice, 1990 (The Ohio State University, 1991)**

| U.S. Grade A | | |
|---|---|---|
| Quality factors | Points | Classification |
| Good color | 26–30 | Bright and characteristic of tomato juice; made from mature red tomatoes; not affected by caramelization, oxidation, and other means; contains as much red as, or more red than, that produced by spinning the specified Munsell color discs in specified combinations |
| Good consistency | 13–15 | The juice flows readily, has a normal count of insoluble solids in suspension, and there is little solids separation |
| Practically free from defects | 13–15 | Any defects present do not more than slightly affect the appearance or drinking quality of the product |
| Good flavor | 33–40 | Distinct tomato juice flavor and odor characteristic of good quality tomatoes that are not materially affected by stems, leaves, crushed seeds, cores, immature tomatoes, or the effects of improper trimming or processing. |
| Minimum total score | 85 | |

ed some assurance of product quality, poor communication, misinformation, and fraud persisted. For highly perishable commodities subject to rapidly changing weather and other production conditions, markets could be extremely volatile. Improved market information was necessary if both producers and buyers were to plan effectively.

In 1913, the USDA was authorized to begin studies of grade standards as a means of improving product marketing. As a result of the need to certify quality of products placed in storage during that period, the first USDA grade standards were applied to potatoes in 1917. In an effort to support prices, the Federal Reserve Bank encouraged this initial application so that member banks could accept warehouse receipts as collateral for loans.

The need for effective price reporting, which grade standards supported, also became evident during this period. Thus, the need for an independent inspection service was recognized. After 1922, the USDA had the authority both to establish voluntary standards for fruits and vegetables and to operate an inspection service. Existing independent inspection activities were reorganized into what has become known as the Cooperative FSIP.

## Assessment and Measurement of Quality Factors

Most official grading of fresh fruits and vegetables is visual. Internal and external quality typically is examined for product sample. Models, color guides, and photographs are available for graders to check for shape, coloring, and defect or damage.

Similar visual inspection is done for raw products moving into processing channels. Additionally, refractometers commonly are used to determine the sugar content of certain raw commodities. Specific-gravity tests are conducted on potatoes to estimate processing yield. Grading of dry beans and of peas is primarily visual. But electronic moisture meters are used to determine moisture content.

Mechanical aids for sampling raw fruits and vegetables are less widely developed and used than those are for grains and oilseeds. Automatic sampling in the bulk handling systems for processing tomatoes has been developed, but the sensitivity of most produce to mechanical injury has limited the degree to which such technologies have been applied, especially in fresh market channels.

Quality-factor scoring of processed products is based on both visual and objective chemical or physical methods. Acidity and sweetness can be measured objectively in many fruit juices and products. Colorimeters are used to evaluate orange juice and tomato products. Specific-gravity tests are used to determine pea maturity. Instruments also are available to measure physical properties such as the flowing quality of catsup and the consistency of applesauce. Sizing devices, color guides, and models are used. Flavor is quality rated by inspectors.

In processing, quality-factor assessment using these techniques goes beyond the need for grading. Quality-control systems meeting the firm's own product standards are based on similar measurements. Continual sampling and record keeping provide information to plant managers regarding routine process control as well as to management regarding all levels of strategic decisionmaking.

## Consumer Information and Quality Awareness

Freshness or ripeness and taste are the key considerations of consumers buying fresh produce. In a survey of 2,000 U.S. households, 96% rated these characteristics extremely or very important (Zind, 1990). Ninety-four percent rated appearance or condition equally important, followed by nutritional value (65%) and price (63%).

Appearance is the primary attribute that consumers have for judging these attributes. But senses of touch and smell may combine to add information to the overall visual appraisal. Forty percent of consumers indicated that they made purchasing decisions regarding produce only after seeing it displayed in the store (Zind, 1990). An additional 20% used only a general written shopping list to guide their purchases.

Grades used in wholesale trade generally are not displayed at the retail level (Office of Technology Assessment, 1977). A limited number of produce items may be offered in more than one size or displayed in prepacks as well as in bulk. These practices represent an appeal to different market segments, and many reflect different prices and values. Grade differences, however, usually are not evident.

Branding has differentiated fresh produce items with limited effectiveness. But for more integrated production and marketing systems, such as those for bananas and for mushrooms, the practice has had some success. Communicating an image of quality and consistency is one of the primary objectives of the branded produce concept, which is gaining interest as a result of competitive pressure and niche marketing.

Industrywide effort to promote specific produce items from a unique production region is another communication device linked to quality standards. Promotional efforts for Washington apples, Idaho potatoes, Vidalia onions, and Texas Ruby Red grapefruit are examples. Generic promotion efforts of this type usually are supported through check-off programs and are linked to efforts to provide to the market a uniform-quality product meeting high standards.

Marketing orders provide a mechanism for implementing quality standards. And in certain industries, large marketing cooperatives may link fruit and vegetable quality standards to broader market development initiatives.

Brands convey information about quality to consumers of processed fruits and vegetables. National brands produced by major food manufacturers have set, internal quality standards that reflect corporate marketing strategies. These standards often can be traced to those specified in contracts for raw products. The USDA grades for fruits and vegetables entering the processing channel are used widely. Processed product grades also appear on canned or on other processed products. Contracts for institutional purchase of processed fruits and vegetables typically are based on USDA grades or on sets of closely related specifications.

## Emerging Quality Issues

Perishability is one of the salient characteristics of fresh fruits and vegetables, and product quality is intertwined with the basic biological trait of limited shelflife after harvest. Important technologies have been introduced to increase the postharvest life of produce, e.g., the Flavr Savr tomato. Modified atmosphere packaging, postharvest treatment to reduce disease potential, rapid transportation, and improved storage environment and retail display conditions all have contributed to lengthened postharvest life. Although nature's basic laws cannot be repealed, improving the quality of fresh fruits and vegetables will remain a primary concern of producers, shippers, retailers, and consumers.

When this fundamental industry characteristic is noted, several quality dimensions emerge as significant issues affecting future industry growth and development. These issues pertain to (1) increased consumer awareness of and concern for intrinsic quality attributes such as nutritive content, (2) the best way to communicate product-specific quality factors, (3) the relation between pesticide use and quality maintenance, and (4) the interaction between quality and regulation or encouragement of international trade in fresh and processed fruits and vegetables.

### Intrinsic Quality Factors

Are all important quality attributes captured in the standards and specifications used in fruit and vegetable wholesale and retail trades? With the emergence of consumer concerns about diet and health, it is evident that important fruit- and vegetable-quality attributes are inherently nutritive. Consumer preferences are changing. But the system for sorting and selecting by quality captures little information about nutritive content and provides no price premiums or discounts to encourage producers and shippers to consider this factor.

A recent analysis of the issue for the Office of Technology Assessment (OTA) determined that if an attribute is to serve as a grade standard, it must meet three requirements (The Ohio State University, 1991). First, it must vary across the produce being graded. Second, information about the attribute must exist so that preferences can be assigned to its gradations. Third, it must be measurable.

The study for the OTA concluded that the first requirement regarding variation in nutritive content had been met. Important gaps, however, existed in the information base and in the ability to measure nutritive content efficiently in fresh produce. Thus, moving away soon from the evaluation of external characteristics by visual inspection is unlikely. For processed fruits and vegetables, significant testing of raw materials and of finished products is taking place. Nutrition labeling for processed products is a means of informing the consumer.

The issue of means of communicating nutritive content of fresh fruits and vegetables may have been resolved partly through recently passed federal legislation. Information about nutritive content will be placed at the retail level, on a voluntary basis. The industry is encouraging widespread participation, in part to avoid a more burdensome mandatory labeling system. This program will provide important information to interested consumers. It also will permit comparisons of fresh produce items.

The program, however, is not intended to ensure that the average nutritive content described is met by any specific unit of fresh produce available on a given day. In this sense, the nutritional information program is an important aid to but not a means of discriminating among alternative pieces of fruits or vegetables within a variety on display.

It seems that the changing preferences of consumers for certain quality attributes of fresh fruits and vegetables cannot be incorporated easily into standards and grading systems within the industry. It therefore must make continued efforts to address these concerns.

## Communicating Quality Information

The USDA grade standards were developed primarily to facilitate communication at the wholesale level. Extending them to the retail level has been debated periodically among buyers and sellers of various food products. The assertion among advocates is that such information, if useful to wholesalers and retailers, also is useful to consumers. Grading thus far has been voluntary. But should it be mandatory at the retail level, its nature might be altered and its cost increased substantially. Considered in the 1970s, such a public policy change was rejected.

A related concern is that of confusing and overlapping nomenclature in grade descriptions. Use of terms such as *fancy*, *extra fancy*, or *bright* in combination with numbers is confusing to consumers and to other observers. Most active traders in the market channel are familiar with the terms and their associated grade standards. But to the extent that these grades appear on retail bags and cartons, confusion among some consumers has been created.

Recently, the USDA has responded to such concerns by establishing a policy of simplifying and making uniform the nomenclature across fruit and vegetable products as other grade standard changes are being considered. The introduction of nutrition information in retail produce departments also will improve communication of quality related information.

## Quality and Organic Produce

One of the most complex quality issues to emerge is that of pesticide residue on fruits and vegetables. The focus of debate has been the emphasis on appearance factors in grade standards. Some analysts charge that this emphasis encourages overuse of fungicides and insecticides. The implied criticism is that external factors are poor indicators of nutritive content or of eating quality.

The development of organic products and the marketing of fresh produce evidence growing industry awareness of these concerns. Simultaneously, the role of the USDA grading system has been questioned. In essence, the organic produce issue constitutes a fundamental challenge to the basic attributes incorporated in the USDA system.

As discussed in previous sections, intrinsic attributes such as nutritive content or eating quality do not lend themselves to grade standards. Appearance factors represent a proxy for other, more subtle and thus less easily measured, attributes.

Some propose that tolerances for visible external defects be increased. Producers therefore would be allowed to meet revised grade standards by means of production practices incorporating less pesticide use. But producers, shippers, and retailers express concern that consumers might react negatively to increased levels of external defect.

One response to these conflicting views is development of a viable industry based on production and marketing of organic fruits and vegetables: the extent to which effective consumer demand exists for the products of such a system could be determined in the marketplace.

The FACT 1990 guides the USDA in developing national standards for certification of organic farming systems. Many states already have such programs in place. But a more fully developed and better coordinated system likely will evolve over the next decade. Many in the industry believe that organic production can achieve quality levels comparable to those now established by existing grade standards. If a separate market segment exists to support these unique, certified production systems, then a viable industry is possible.

To the extent that pesticide residue is a problem in the fruit and the vegetable industries, it should be evaluated in the context of food safety and environmental management. Retailer-initiated residue testing programs are one response. Additionally, several exhaustive independent studies of fruits and vegetables at both farm and retail have shown that less than 1% of the samples exceeded official acceptable levels (Council for Agricultural Science and Technology, 1990). Grade and quality standards should reflect what consumers expect from the system but also must be developed and applied efficiently and consistently.

## Quality Factors in Trade

Quality and grade standards have played a central role in the international trade of fruits and vegetables. On the positive side, quality standards are important in the long-run development of export markets. As the fruit and the vegetable industries expend additional resources to promote products in these markets, attention must be paid to supplying quality consistent with the level desired in each market.

Controversy, however, surrounds the use of quality restrictions as nontariff barriers to trade. As multilateral trade negotiations have moved to liberalize trade by lowering protective tariffs, many countries have substituted various health, sanitation, and quality restrictions to achieve the same protective purposes. These practices have become part of the new trade battleground.

The grade standards established and mandated under federal marketing orders have been applied to U.S. imports of the same fruits and vegetables during the designated marketing season. Authority is provided by Section 8e of the Agricultural Marketing Agreement Act of 1937.

Substantial controversy surrounds this mandatory application of grade standards. Domestic producers and shippers argue that imports are given an unfair advantage if they do not have to meet the same quality standards as domestic produce does. Firms exporting fruits and vegetables to the United States argue that they have to meet their own requirements and that the Marketing Order Committees in the United States fail to represent the interests of importers or of foreign suppliers. One charge is that the uniform grade standards discriminate against the quality attributes of fruits and vegetables produced abroad.

As a result of recently approved legislation (FACT 1990), a 60-d waiting period and notification of the U.S. trade representative are required before import regulations can be imposed under Section 8e. During this period, the U.S. trade representative must determine whether the proposed regulations are consistent with the GATT. The newly created World Trade Organization replaces the GATT and will focus even more attention on nontariff barriers such as quality regulations.

As trade expands, the importance of quality concerns will continue to mount. Harmonization and mutual recognition of food quality standards and procedures have been focal points of the emerging Single European Market being developed by the 12-nation EEC. Recent negotiations on the North American Free Trade Agreement (NAFTA) involved phytosanitary and other quality regulations and standards of significance to U.S. fruit and vegetable industries. Although uniform application of quality standards reflecting real differences in market demand will be maintained, careful scrutiny of significant changes in standards can be expected.

## Anticipated Industry Changes Influencing Quality

The nature and the definition of *quality* in the fruit and the vegetable industries likely will evolve, but the traditional emphases on appearance and condition will continue to be key competitive factors for some time. Quality long has had an important influence on fruit and vegetable production and on market decisionmaking, and it is likely that changing technology and management practices themselves will be shaped by competition to provide improved product quality. Changing production, marketing, and consumption environment will stimulate revision of quality standards, but change will be evolutionary, not revolutionary.

### Use and Consumption

One trend in fresh fruit and vegetable use is the increasing diversity of products and cultivars offered at retail. This trend reflects demographic changes and a relatively new retail merchandising emphasis on fresh produce. In addition to increasing the variety available, retail displays highlight color and fresh appearance. Federal regulation will require that increased nutritional information be provided about fresh fruits and vegetables. Quality standards used in wholesale trade are unlikely to change greatly in response to these trends, but the complexity of qualitative differences will increase, as will the care needed to communicate in an understandable and informative manner these differences to consumers.

The growing importance of organically produced food has affected the perception of essential qualitative attributes of fresh fruits and vegetables. External appearance, a key factor in established wholesale grade standards, is influenced directly by pest and disease management strategies. Those advocating growth and development of demand for produce grown without the benefit of modern agrichemicals have attempted to limit the significance of external appearance factors in grade standards and likewise in consumer decisionmaking.

Although major changes in official grade standards seem unlikely soon, consumers seem to be paying increased attention to qualitative attributes such as flavor and taste. Some packer-shippers have begun to emphasize tree-ripened flavor in an attempt to develop demand for a differentiated, branded fresh fruit product. This type of development simply reflects the fact that qualitative differences are important in fresh produce. It is unlikely that such differences can or should be captured in the official commodity grading system, beyond the firmness measures currently used.

The growing importance of the food-service industry also may affect quality. Precut vegetables and packaged salad products often are needed for distribution through market channels to widely dispersed fast-food retail outlets. This need emphasizes product characteristics supporting minimum loss of condition over extended periods. The desirable mix of quality attributes likely differs in supplying these markets as compared with traditional home preparation and use. Response to the specifications of food-service retailers will be improved cultivars, packaging, and postharvest management. New or altered grade standards will be required only if such prepared fresh products become traded widely.

Substantial growth is expected in both importation and exportation of fruits and vegetables. Export Grade standards seem a minor problem for U.S. firms attempting to develop foreign markets. Private and packer brands convey quality information important in new export markets. Consistency, too, is quite important in establishing a market reputation.

On the import side, quality management will be a function of mutually agreed on negotiated standards, especially for products competing directly with those produced within the United States. Sourcing of contraseasonal fresh fruit supplies in the southern hemisphere will grow, but imports will have to meet established U.S. grade standards. Successful negotiation of a free-trade agreement with Mexico hinges partly on an agreement that fresh fruit and vegetable imports will meet the standards traditionally used in U.S. wholesale markets.

## Production and Processing

Production of fruits and vegetables will continue to be dictated by key environmental factors. The growing importance of imports reflects change in geographic production patterns. Varietal development in fruits, e.g., peaches, has caused shifts of some production to new growing areas. Much of this shift is driven by an effort to extend market windows for fresh produce or to extend the season for use of existing processing facilities.

Even as some are produced in increasingly diverse latitudes, fruit or vegetable crops often move to areas traditionally suited to production. With the exception of border negotiations over relevant quality characteristics, evolving geographic production patterns within the United States will have only marginal effects on quality standards. As the need arises to reconsider grade standards in light of newly developed cultivars, it will be accommodated through normal USDA procedures.

Production, postharvest, and processing management systems will increase in complexity. Rapidly developing computer and information sensing technologies will allow for increasingly sophisticated and precise management of pesticide application, irrigation, harvest, and storage. Improvements in all areas have the potential to reduce losses and to improve average product quality for consumers and processors. Inasmuch as the quality of most fruits and vegetables is environmentally sensitive, improved control or mitigated environmental factors likely will yield beneficial results.

Irradiation during postharvest handling of fresh produce is in its infancy. If the practice can be marketed successfully, it has the potential to extend shelf life and to improve condition of fresh produce significantly.

## Market Structure

Concentration in food retailing during the past 40 yr has increased the volume of direct buying and shipping to distribution centers. Although quality standards have not been affected substantively by this change, the role of terminal wholesale markets has diminished. Grading and sorting by quality attributes occur at shipping point, where pricing, including grade and quality discounts and premiums, is based largely on supply and demand conditions. Yet in the quality based pricing and allocating of products, terminal wholesale markets still play a role.

These trends likely will continue. Emergence of wholesale clubs in food retailing, which include produce, reflects continued emphasis on large-scale distribution and on the economies of scale that can be achieved thereby. Packer-shippers able to supply the demands of large-volume distribution firms also need to be large. But trade and negotiation, which involve quality and grade standards, are unlikely to change radically.

Efforts have been made to introduce brands into the retailing of fresh produce. Except for unique fully integrated production and marketing systems, e.g., those for bananas and mushrooms, brand development efforts have had limited success. When they do succeed, however, it seems reasonable for qualitative attributes including flavor or nutritional characteristics to receive emphasis.

A public grading system is needed most when established brands are nonexistent or convey qualitative information ineffectively to wholesalers and retailers. If the importance of branded produce at retail grows, then grading may become less important because established-brand firms integrated back to the production level will internalize quality specifications.

### Quality Measurement

Little of the quality-measurement technology in the fruit and the vegetable industries is new. Existing technology for sorting by size or color has evolved slowly. Measurement of key factors in processing, however, is more advanced and likely will evolve apace, especially on the processing line.

Improved control over processing management may result in increased emphasis on the quality of raw materials flowing into the processing plant. This emphasis will be reflected in contract specifications. Thus, no major new directions for grading or grade standards are likely to result from changes in quality measurement technology in the fruit and the vegetable industries.

## Summary and Conclusions

Quality plays a central role in the fruit and the vegetable industries. And fresh produce, among the most perishable of agricultural commodities, is subject to both significant quality variation and rapid deterioration of condition in postharvest handling and distribution.

Fruits, vegetables, and pulses account for 26% of the value of all crops produced in the United States but for only 2.6% of U.S. cropland. Production is concentrated in a few specialized regions, California and Florida being the leading states. Other important areas include the Great Lakes states, the Pacific Northwest, and Texas.

Separate production and marketing channels have developed for fresh and processed products. Significant contracting and vertical integration exist in processing channels to facilitate coordination of production and marketing decisions, including quality considerations. To deliver the quality characteristics desired by consumers, fresh market channels depend on market forces and on grades and standards.

Fresh produce quality may be specified in either contracts or other purchasing arrangements. Official grading is carried out by the USDA–AMS and by the Cooperative FSIP. The USDA grade standards have been developed for approximately 135 fresh produce and 150 processed items. Grading is voluntary except when marketing orders have been approved by producers and by handlers.

Quality attributes used in the USDA grade standards emphasize external appearance factors such as size, shape, color, and defect. Tolerance for defect is more restrictive for products moving into fresh market channels. Much of the inspection of fresh fruits and vegetable quality is visual. Chemical and physical evaluation is more common for raw material moving into processing or for final processed fruit and vegetable products. Relevant quality factors in this context may include sugar content, acidity, and consistency, which lend themselves to mechanical or to chemical evaluation.

Consumers have indicated that freshness or ripeness are their primary criteria when selecting fresh fruits and vegetables and that appearance and condition are equally important. Sensory inspection of externally evident factors is the primary means by which consumers evaluate fresh produce quality. Grade factors have evolved to assist wholesale traders in the sorting and selecting of fresh fruits and vegetables.

Of increasing importance are nutritive content and other intrinsic dimensions of fruit and vegetable quality. But methods of incorporating this attribute into the grade standards available to consumers have not been and are unlikely to be developed.

Additional issues relevant to the communication of quality relate to the nomenclature used in describing grades and to the availability of consumer grades. Nomenclature is being simplified. Consumer grades, although available for processed products and some prepackaged fresh produce items, remain relatively undeveloped for most fresh fruits and vegetables. Thus, the current approach is to provide consistent consumer information about nutritive content and selection, purchase, and use of fresh fruits and vegetables.

Grades and standards also are being reconsidered in light of the emergence of viable market channels for organically produced fruits and vegetables. Some critics have charged that emphasis on external appearance factors in the USDA grade standards may have led to the excessive use of pesticides. Separate certification of organic production now is being developed as a means of identifying produce destined to serve the organic market segment.

Imports have become an increasingly important source of supply. And controversy has developed over the use of grade standards in conjunction with marketing orders to regulate quality of imported produce.

Such concerns are being evaluated in light of the newly created World Trade Organization that has replaced the GATT. Negotiations surrounding the newly-established NAFTA will keep quality issues in the foreground of the phytosanitary regulations debate.

Production patterns for fruits and vegetables are changing in response to changes in technology, the environment, and consumer demand. Marketing channels are increasingly dominated by large-scale distributing and food retailing firms. The effects of these changes will be substantial in terms of increased product availability and may improve average quality. The balance among important quality attributes, quality measurement methods, and U.S. grading systems, however, is unlikely to change greatly.

Fruits and vegetables are an increasingly important component of consumer diet, in which taste and health or dietary preferences reinforce each other. Consistently high quality, as always, will be difficult to achieve for such a diverse and perishable set of products. But consumer perceptions of important quality attributes are evolving. Challenges to the existing fixed system of grades and standards will continue to arise from both consumers and new suppliers seeking an increased share of the market.

## Glossary

**Condition.** Quality factors related to changes of the product in postharvest storage and handling and associated with texture, firmness, ripeness, and freshness. Also postharvest mechanical, disease, or decay damage.

**Quality factors.** Variety uniformity, cleanliness, shape, maturity, etc.

**Quality defects.** Injury or damage from diseases, insects, or machines, as well as cracks, sunburn, misshapenness, dirt, foreign material, etc.

**Size.** Objective measures of diameter, length, weight, and uniformity. Not always an integral part of grade standard; in some instances, used to describe permissible count and to pack arrangements in standard industry containers.

**Tolerances.** Stated in terms of percentage of defects that are, generally speaking, permissible.

**Vertical integration.** Process whereby production and processing are accomplished by the same firm.

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# 11 Cotton and Wool

Eluned C. Jones[35]

## Introduction

Accounting for approximately half of all fiber consumed, cotton is the most important fiber in the world and has been a major cash crop in the United States for nearly 200 yr. Although wool accounts for only 5% of world fiber consumption, it represents an important source of income for many farmers and provides unique fiber properties desired in the textile industry.

With the introduction of synthetic fibers in the 1920s, consumption of cotton and wool began a long-term decline. Properties such as ease of care, freedom from shrinkage, predictability of quality, and stability of price, which are easily incorporated into synthetics, were desirable to both mills and final consumers. Wool production, for example, declined steadily from 96 million lb in 1965 to 46.5 million lb in 1991. The apparel industry is being influenced increasingly by consumer preferences for the comfort, absorbency, resilience, and flame retardance obtainable from natural and synthetic fiber blends. Indeed, the decline in per capita cotton consumption was reversed in the late 1980s, and in 1991 U.S. mill consumption of cotton reached record levels at nearly 4.4 billion lb. Although domestic consumption of wool in apparel has increased, much of this increase has been from imported wool tops and end products.

This chapter will focus on quality issues in the U.S. cotton and wool industries and will describe influential aspects of production, marketing, and related technologies. Although wool accounts for a much smaller volume of fiber production than cotton does, factors directly related to measurement and to quality improvement of domestic and export wool markets also will be discussed.

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## Cotton

### Major Uses

World fiber consumption increased by 75% between 1970 and 1989. Concurrently, cotton's share of world fiber consumption remained stable, at nearly half. During the same 20 yr, U.S. cotton production increased by approximately half although number of acres planted remained the same. Thus, yield/a. increased by about half, from less than 1 bale/a. to about 1.5 bales.

From 1980 to 1990, total U.S. mill consumption of cotton increased by about 35% (Table 11.1). Simultaneously, consumption of both U.S. and imported cotton in finished products increased by more than half. One of the most noticeable changes was the declining market share of synthetic fibers (noncellulosic) and the increase in cotton's market share from 25 to 31% (Figure 11.1).

In 1987, the textile and apparel complex, one of the most important sectors of the U.S. economy, generated more than $42 billion in gross domestic product. The agriculture complex, which includes forestry and fishery, accounted for $95 billion; the auto complex, for $50 billion. The textile and apparel complex ac-

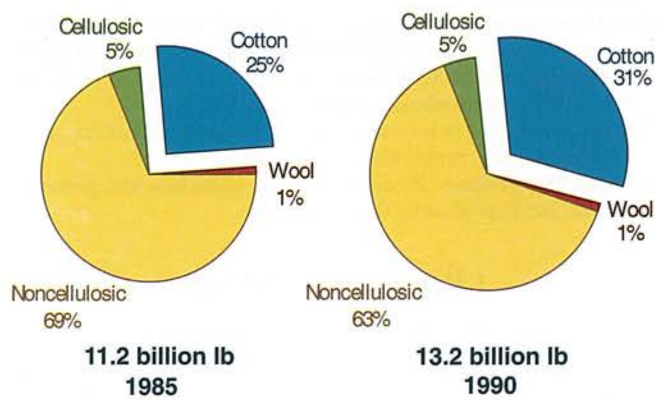


**Figure 11.1.** **U.S. mill consumption of primary fibers, 1986 and 1990 (U.S. Department of Agriculture, various issues, *Cotton and Wool Situation and Outlook*).**

counted for nearly 20% of U.S. manufacturing employment in 1987 (U.S. Department of Commerce, *Census of Manufacturers*, various issues).

Demand for cotton fiber at the mill level depends on demand for end-use textile products. Cotton can be found in apparel and in industrial products as diverse as towels, upholstery, medical supplies, and tire cord. Yarn for broadwoven fabric typically accounts for at least three-fourths of all yarn produced by the cotton industry and for more than two-thirds of all cotton fiber used in textile manufacturing (American Yarn Spinners Association, 1985; U.S. Department of Commerce, *Census of Manufacturers*, 1987).

Broadwoven fabric demand can be segmented into end uses typically woven from yarn within the same count range. Although numerous categories exist for specific apparel types and even for specific fabric weights, these categories, generally speaking, can be reduced to eight end-use categories representing yarn count ranges with distinct processing requirements (U.S. Department of Commerce, *Census of Manufacturers*, various issues; Jones-Russell, 1987):

1. denim,
2. duck,
3. toweling,
4. corduroy,
5. 100% cotton sheeting (muslin),
6. polyester/cotton sheeting (muslin and percale),
7. printcloth, and
8. fine broadcloth/apparel.

These end uses account for two-thirds of all domestic mill use and for all broadcloth end products (Table 11.2).

## General Production Description

The cultivated (linted) cotton species grown in the United States derives from the genus *Gossypium*. The predominant type is the American upland cotton *Gossypium hirsutem*, which constitutes 99% of the U.S. cotton crop. The remaining 1% generally is referred to as American Pima or as extra Long Staple

**Table 11.2. Share of mill consumption of cotton fiber accounted for by each end-use category (U.S. Department of Agriculture, *Census of Manufacturers*, 1987)**

| | End-use share of total mill consumption | | |
|---|---|---|---|
| End-use | Mean share for 1975–1984 | Minimum | Maximum |
| Denim | 18.2 | 11.4 | 24.6 |
| Duck | 2.7 | 1.6 | 3.9 |
| Toweling | 12.4 | 9.5 | 17.6 |
| Corduroy | 5.7 | 3.6 | 8.3 |
| 100% cotton sheeting | 9.6 | 6.3 | 15.2 |
| Polyester/cotton sheeting | 7.1 | 5.4 | 8.6 |
| 100% cotton printcloth | 6.5 | 4.9 | 8.9 |
| Polyester/cotton printcloth | 3.4 | 0.8 | 6.4 |
| Apparel | 1.7 | 1.0 | 2.3 |

**Table 11.1. U.S. cotton consumption, total and per capita, 1980–1990 (U.S. Department of Agriculture, various issues)**

| Year | U.S. mill use (million lb) | Percent of fibers | Textile trade[a] (million lb) Exports | Textile trade[a] (million lb) Imports | Total domestic consumption[b] | Percent of fibers | Per capita (lb) Mill use | Per capita (lb) Domestic consumption |
|---|---|---|---|---|---|---|---|---|
| 1980 | 3,036.4 | 27.0 | 528.2 | 810.9 | 3,319.1 | 29.2 | 13.3 | 14.6 |
| 1981 | 2,715.5 | 25.3 | 367.3 | 961.9 | 3,310.0 | 29.0 | 11.8 | 14.4 |
| 1982 | 2,487.9 | 26.5 | 253.3 | 897.2 | 3,138.4 | 29.9 | 10.7 | 13.5 |
| 1983 | 2,807.9 | 25.2 | 219.6 | 1,121.3 | 3,724.2 | 29.1 | 12.0 | 15.9 |
| 1984 | 2,716.1 | 25.1 | 206.1 | 1,465.5 | 3,975.5 | 30.2 | 11.5 | 16.8 |
| 1985 | 2,813.4 | 25.2 | 213.2 | 1,629.2 | 4,229.4 | 30.5 | 11.8 | 17.7 |
| 1986 | 3,259.0 | 27.0 | 274.8 | 1,910.5 | 4,894.7 | 31.0 | 13.5 | 20.3 |
| 1987 | 3,753.2 | 28.9 | 298.0 | 2,335.7 | 5,790.9 | 33.7 | 15.4 | 23.7 |
| 1988 | 3,508.0 | 27.3 | 330.3 | 2,118.8 | 5,304.4 | 32.0 | 14.2 | 21.5 |
| 1989 | 4,046.1 | 29.8 | 485.0 | 2,354.9 | 5,883.7 | 34.7 | 16.3 | 23.6 |
| 1990 | 4,103.4 | 30.5 | 632.3 | 2,391.0 | 5,848.7 | 35.4 | 16.3 | 23.3 |

[a]Textile trade = raw fiber equivalent of imports and exports of textile products.

[b]Total domestic consumption = U.S. mill consumption plus net textile product trade balance.

(ELS), i.e., *Gossypium barbadense*. Production of ELS cotton is confined to New Mexico, Arizona, California, Texas, and recently Mississippi. Production costs are significantly greater for ELS cotton, which is used primarily in high-value products such as fine apparel and sewing thread, than for upland cotton.

The Cotton Belt consists of 16 southern states, from California to Virginia. Production boundaries between western, eastern, and southern states follow national and coastal boundaries. The Belt's northern boundary is determined by average temperature and frost-free days for production. Commercial production usually requires 200 frost-free days between planting and harvesting and average temperatures of 77°F. As production approaches the Belt's northern boundary, average yield decreases, crop-loss risk increases, and relative revenues of the most competitive alternative crops, i.e., corn, soybean, and wheat, increase.

Environmental conditions affected the location of cotton acreage planted in the 1970s and the 1980s. Westward production shifts to California, Arizona, and the high plains of Texas and New Mexico were due to increased yields and to decreased costs and financial risks associated with irrigation. As the cost of irrigation increased in the 1980s and global market pressure depressed prices, the comparative advantage of the Southwest diminished. In the late 1980s and the early 1990s, acreage shifts were due primarily to political influences. Increased commodity program flexibility in the 1990 farm bill, as well as price incentives, encouraged resurgence of cotton plantings in the Southeast (Figure 11.2). By providing a production cost advantage in participating states, the boll weevil eradication program implemented in the 1980s also played a pivotal role in the geographic shift.

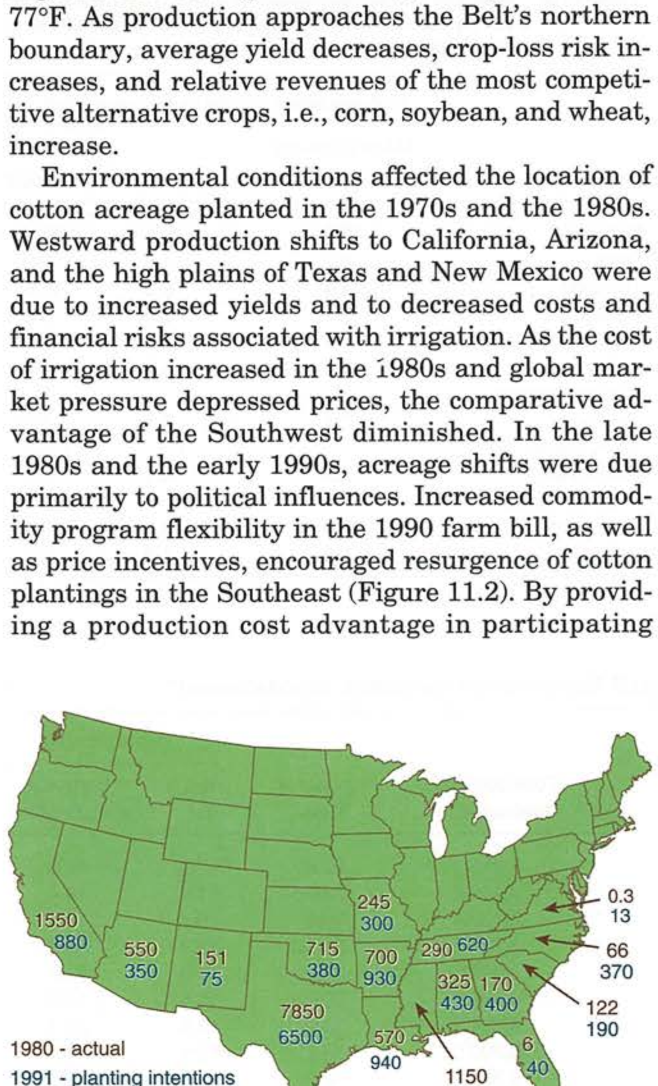


**Figure 11.2. Comparison of acreage in thousands planted in cotton, by state, 1980 and 1991 (U.S. Department of Agriculture, various issues, *Cotton and Wool Situation and Outlook*).**

Mechanization and cost constraints reduced the number of farms producing cotton from 200,000 in 1969 to 38,000 in 1982 (Starbird et al., 1987). At the same time, average farm size increased from 58 to more than 250 a. (Table 11.3).

Spindle-type pickers are used to harvest cotton except in the Texas and Oklahoma high plains, where machine stripping is practiced. Two-row, self-propelled pickers generally are used to harvest 10 to 14 d after a chemical defoliant has been applied to remove vegetation at 70% boll opening. Approximately two-thirds of the crop is picked in the first pass when spindle picking is practiced; the remainder is picked in the second pass. Strip-harvesting requires only one pass and is efficient when appropriate cotton cultivars are used along with management practices that ensure uniform boll-opening.

Inasmuch as they are determined by interactions among cultivar, weather, soil, harvest time and method, and ginning practice, the physical characteristics of cotton fiber depend on location. Yet production technologies have developed cultivars that, along with improved production practices, produce fibers running the gamut of desirable characteristics. Overall improvement in cotton fiber has blurred type distinctions among regions.

## Marketing System

### Market Channel Overview

Either loose or as a compressed module, seed cotton (lint and seed) is transferred by farm trailer or truck to the gin. The popularity of module technology, whereby seed cotton is compressed tightly on the ground or on a pallet at harvest time, is growing. After the seed cotton has been compressed, the mod-

**Table 11.3. Number of farms harvesting cotton and acres of cotton/farm, by region (U.S. Department of Commerce, *Census of Agriculture*, various issues)**

| | 1974 | | 1982 | |
|---|---|---|---|---|
| Region | Farms (No.) | Cotton acreage/ farm (a.) | Farms (No.) | Cotton acreage/ farm (a.) |
| Southeast | 16,020 | 82 | 3,265 | 181 |
| Delta | 34,228 | 123 | 10,921 | 214 |
| Southwest | 33,918 | 152 | 19,829 | 253 |
| West | 5,152 | 301 | 4,179 | 438 |
| United States | 89,536 | 137 | 38,266 | 256 |

ule is transported on a trailer or a specialized truck to the gin. This management system enables the producer to complete harvest before delivering the cotton and to limit the number of trailers required.

Cotton marketing involves separate transfer of product and of bale ownership (Figures 11.3 and 11.4). In the United States alone, annual physical transfer involves moving 15 million bales of cotton from more than 38,000 farms, through nearly 2,000 gins, to more than 5,000 domestic textile plants, and to more than 50 international destinations (Starbird et al., 1987).

Most cotton produced in the southcentral and the southeastern regions of the country end up in domestic mill use. Because the U.S. textile industry is concentrated along the Atlantic coast, the Southeast and the Southcentral, or Delta, have locational advantages in supplying the domestic industry (Figure 11.5). Although approximately half of the U.S. cotton fiber crop is exported each year, locationally the export supplies originate from the southern and western production states (Figure 11.6). Exports from the Gulf and California ports also leave the southeastern and southcentral producing states very dependent on the domestic textile industry.

In contrast, merchandizing, or ownership transfer, is concentrated in approximately 300 marketing and merchandising firms. Purchasing decisions are made at the firm level, after which the cotton is physically distributed to individual plants. Thus ownership transfer is concentrated. Cotton shippers constitute the primary link between producers and mill owners. Cotton bales are bought in mixed quality lots and resold in lots of similar quality, according to the mill's own blending requirements. Shippers account for 60% of all farm sales; ginners, for only 4% of cotton sales although they handle all production (Figure 11.7) (Glade and Johnson, 1988).

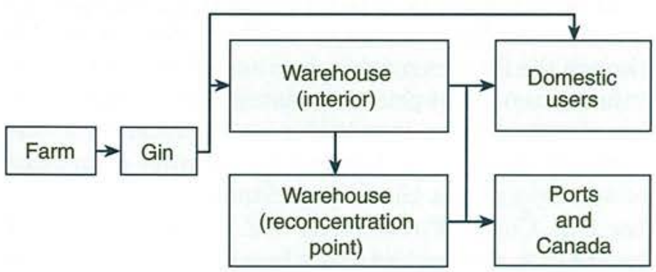


**Figure 11.3. Physical flow of U.S. cotton (Sporleder et al., 1978).**

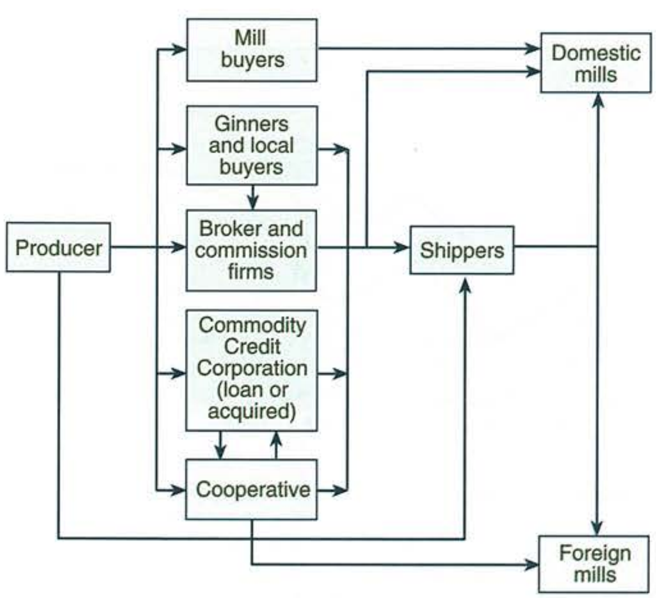


**Figure 11.4. Flow of ownership documents for U.S. cotton through market structure (Sporleder et al., 1978).**

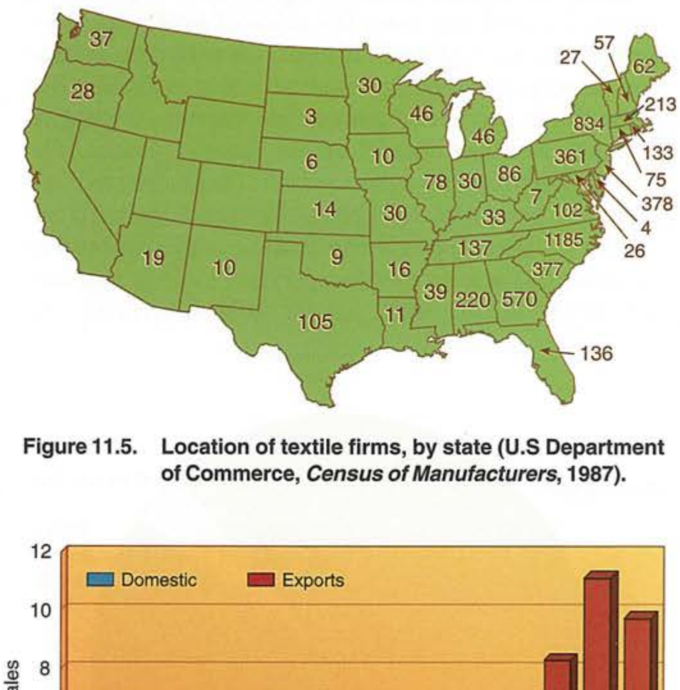

**Figure 11.5. Location of textile firms, by state (U.S Department of Commerce, *Census of Manufacturers*, 1987).**

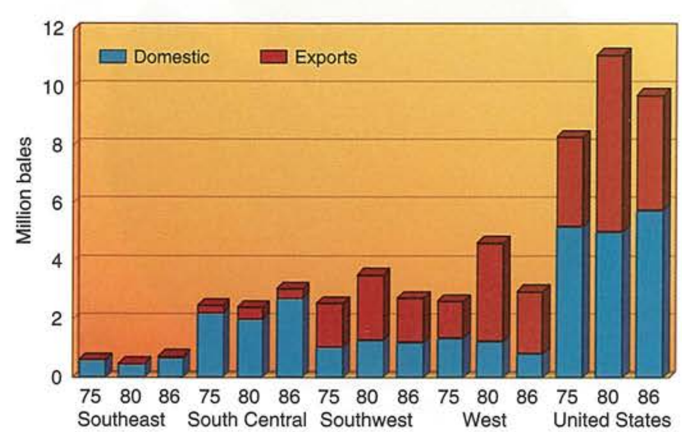


**Figure 11.6. Cotton shipments for domestic use and export, by region, 1975, 1980, and 1986 (Starbird et al., 1987).**

## Pricing Practices and Strategies

### Price Determination

The distinction between transfer of product and transfer of ownership of cotton contributes to the complexity of the market, and in particular to the difficulties attending price discovery and determination. Prices are quoted at many different levels in the market system. Average prices are published regularly for farm, cash, mill delivered or landed, and Northern Europe. Prices also are quoted by form, type, quality, and location (Figure 11.8).

The average annual price of cotton depends on domestic and export demand, and on the number of acres planted, the impact of weather, and the amount of reserve stock carried over from the previous year. Because cotton can be stored easily, supply historically has been influential in determining price. If price falls below or close to production cost, there is incentive for producers to store part of the crop until the next year.

Since the 1950s, one of the greatest influences on cotton demand has been the price of synthetic fiber. Such fibers are "tailored" to end uses with characteristics closely simulating those of natural fibers. But these fibers are not subject to the impacts of planted acreage, weather conditions, or reserve stocks. The mill is able to contract for a specific staple length, fineness, and strength of synthetic fiber, unlike with cotton fiber. "Branded" synthetic fiber is guaranteed by its manufacturer to meet a specified quality and consistency level at the mill. Fiber availability, price, and characteristic predictability contributed to substitution of synthetic fibers for cotton by textile mills in the 1960s and the 1970s (Donald et al., 1963). Developments in processing technology in the late 1980s, however, have reversed the trend and are helping increase cotton's share of the fiber market.

### Price Discovery

Since 1870, the New York Cotton Exchange (NYCE) has reflected the industry's price expectations. The exchange is a medium for price discovery, i.e., what 1 lb of 1 and 1/16 in. strict low middling cotton is worth in the market at a given time. If buyers and sellers in the futures market account for a significant portion of cotton production, then the price discovered through bidding will represent market value accurately. Although the futures market provides a means for offsetting a degree of price risk, it does not replace the spot market entirely in the price discovery process.

If price discovery is to be efficient, market participants must have access to market information. Although the futures market does assimilate and reflect information about price associated with a single quality of cotton fiber, it provides no information about regional supply and demand for quantity or quality of the crop across the United States. Thus, in 1916, the U.S. Cotton Futures Act (CFA) initiated a set of procedures and regulations whereby the USDA–AMS reports on cotton prices for different qualities in several designated markets across the country.

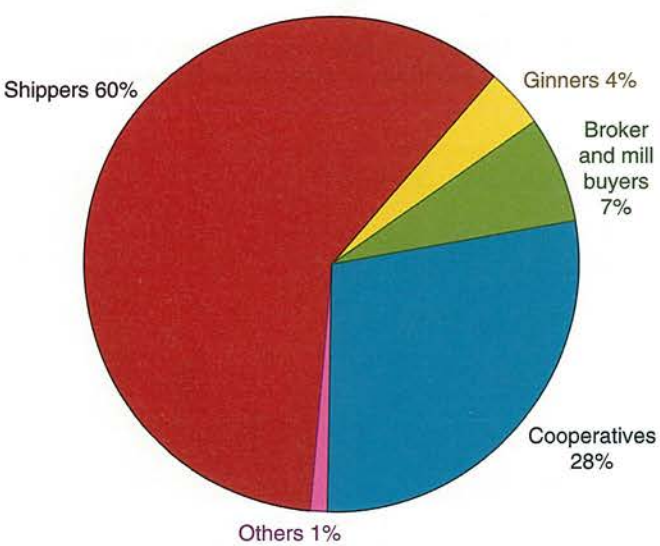


**Figure 11.7.** **Distribution of U.S. cotton farm sales by form of marketing (Glade and Johnson, 1988).**

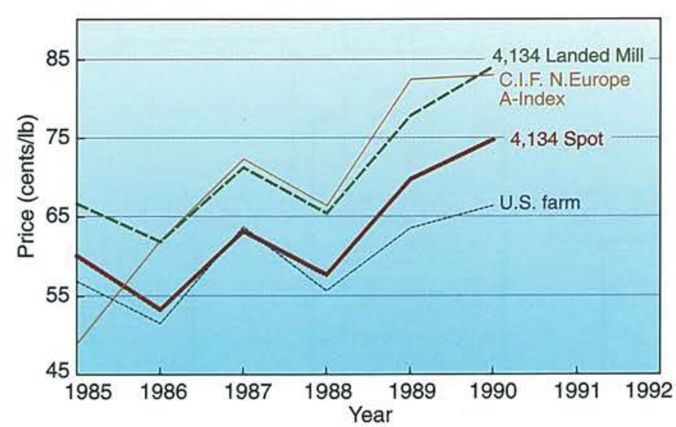


**Figure 11.8.** **United States average cotton price at the farm, spot market, landed (mill), and northern Europe. (Note that the 1985 farm bill provided a process for adjusting U.S. cotton price structure to World Average price.) (U.S. Department of Agriculture, *Cotton and Wool Situation and Outlook*, various issues).**

Daily spot cotton quotations are compiled from daily sample surveys of traders in Greenville, South Carolina; Montgomery, Alabama; Memphis, Tennessee; Greenwood, Mississippi; Dallas, Texas; Lubbock, Texas; Phoenix, Arizona; and Fresno, California. Although the original intent of the Act was to establish premiums and discounts specific to base grade and staple to settle futures contracts, these quotations are used as a basis for spot transactions and forward contracts.

Spot quotations are based on total volume handled but are undifferentiated by quantity of each quality, i.e., by micronaire, staple, or grade category. In short, neither supply nor demand for different qualities is reflected explicitly in spot quotations. Because approximately half of all production is used in domestic mills and because more than half is used in North and South Carolina mills, the highest spot prices generally are quoted in the Southeast. Prices tend to be lower in markets farther from major consumption centers. Prices in Fresno also are higher than those in interior markets because Los Angeles and San Francisco are key ports to Asian textile markets.

Surveys of mill bid prices are used to create the landed mill point price series, which provides prices similar to spot quotations but includes transportation costs to the delivery point. This series of prices from the Southeast, where the textile industry is concentrated, implicitly reflects supply and demand conditions as well as quality differentials. Moreover, the value of quality characteristics omitted from the export market quotations is implicit in the landed mill price, e.g., fiber strength before the 1991 crop.

## Quality Measurement in the Market Channel

### Technology's Relation to Quality

Raw cotton processing initially requires conversion of fiber containing 100 million separate fibers in a 1-lb sample into useable product. The first step in the process is opening and blending of bales at the mill. Bales are blended in the opening process to minimize variation in fiber properties within the laydown mix and to meet a predetermined set of input requirements for each end use.

The number of bales laid down in each mix depends on blender capacity and on end-use requirements. A coarse yarn generally has less stringent requirements in terms of input fiber properties. Fiber uniformity requirements can be influenced by spinning technology and by spinning cost criteria. The greater the emphasis on spinning performance and on end-product quality, the more critical the selection of laydown mix according to input requirement criteria (Rogers and Vaughn, 1985). A summary of a survey of mill use of cotton by broadcloth end uses indicates differences across both end-use and spinning technology in laydown blends (Table 11.4).

After the opening and blending processes, fibers pass over a series of tined rollers aligning them and simultaneously removing trash, dust, and crop debris. The resulting "picker lap" is a continuous sheet of fiber with relatively uniform fiber properties. This sheet of parallel fibers is fed across a machine, which reduces it to a loose rope of card sliver that in turn is coiled into large drums for processing or spinning. From opening to card sliver, the process is continuous.

Only 10 to 15% of sliver is processed further to provide cleaner fiber, which has greater uniformity of length because more short fiber has been removed. The resulting "combed" yarn generally is used for fine knits and apparel.

In 1966, Newton and Burley noted that the textile industry could improve overall quality if producers and ginners understood the relationship between fiber property and spinning. There was no incentive to provide rapid and economic measurement of fiber properties until the 1970s, with the first technical challenge to ring spinning—rotor spinning. After the introduction of rotor spinning technology, changes ceased to be limited to adjustments to the ring spinning system, which was based on the same principles as Arkwright's "spinning Jenny" was. The new technologies of rotor, friction, and air-jet do not engineer yarn by the same method. And these engineering differences have changed the requirements for fiber properties.

Initial cost reductions provided by the rotor spinning system were sufficient to offset quality and attribute differences (Deussen, 1984; 1986). However, increasing global market competition can provide the economic incentive to improve the quality range of yarns spun on open-end rotor systems. Since 1975, the fineness of yarns produced on rotor systems has increased, from coarse yarns intended for denims, twills, corduroy, and toweling to yarns intended for sheeting and printcloth.

By 1979, the second generation of open-end rotor spinning frames had reduced spinning cost to about half that incurred by ring spinning frames. By the late 1980s, rotor spinning had a productivity five to six times that of ring spinning, and the air-jet had increased productivity ten times (Deussen, 1984).

Increasing economic pressure on mill owners to become competitive in the international market gave

**Table 11.4. Actual composition of cotton fiber mix used in the production of various end-uses, crop 1984 (Jones–Russell, 1987)**

| End-use and spinning technology | Weighted averaging finest yarn number | Bales of cotton used | 100% cotton (%) | Polyester/ cotton blends (%) | Mix | | Grade | | Staple | | | Strength | | Micronaire | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | % | Regional[a] | | % | 1/32" | % | Ave.[b] | g/tex[c] | % | Low | High |
| Denim | | | | | | | | | | | | | | | |
| Open-end spun | 9 | 135,800 | 96 | 4 | 34 | P | SLM+[d] | 21 | 31 | 4 | 32.2 | 22 | 19 | 2.8 | 4.5 |
| | | | | | 34 | SJV | SLM | 47 | 32 | 62 | | 24 | 21 | | |
| | | | | | 32 | CB | SLM | 19 | 35 | 13 | | 25 | 39 | | |
| | | | | | | | LS | 13 | 36 | 21 | | 27 | 21 | | |
| | | | | | | | LM | | | | | | | | |
| Duck | | | | | | | | | | | | | | | |
| Ring-spun | 15 | 34,137 | 19 | 81 | 54 | CB | MLS | 20 | 32 | 20 | 34.2 | 21 | 26 | 2.8 | 4.9 |
| | | | | | 26 | SJV | SLM+ | 21 | 34 | 28 | | 24 | 20 | | |
| | | | | | 20 | P | SLM | 59 | 35 | 26 | | 26 | 26 | | |
| | | | | | | | | | 36 | 26 | (26)[e] | 28 | | | |
| Open-end spun | 15 | 377 | 100 | | 100 | CB | SLM | 100 | 34 | 100 | 34 | 26 | 100 | 3.5 | 4.9 |
| Toweling | | | | | | | | | | | | | | | |
| Ring-spun | 22 | 4,332 | 73 | 27 | 96 | CB | SLM+ | 14 | 34 | 73 | | | | | |
| | | | | | 4 | P | SLM | 86 | 35 | 27 | 34.3 | 26 | 100 | 3.5 | 5.0 |
| Open-end spun | 18 | 3,156 | 100 | | 100 | CB | SLM | 100 | 34 | 100 | 34 | 26 | 100 | 3.5 | 4.9 |
| Corduroy | | | | | | | | | | | | | | | |
| Ring-spun | 25 | 64,550 | 55 | 45 | 100 | CB | SLM+ | 50 | 35 | 100 | 35 | 26 | 100 | 4.0 | 4.4 |
| | | | | | | | SLM | 50 | | | | | | | |
| Open-end spun | 29 | 850 | 50 | 50 | 100 | CB | SLM+ | 50 | 35 | 100 | 35 | 26 | 100 | 4.2 | 4.4 |
| | | | | | | | SLM | 50 | | | | | | | |
| 100% cotton sheeting (muslin) | | | | | | | | | | | | | | | |
| Ring-spun | 26 | 12,500 | | 100 | 56 | SJV | M | 56 | 34 | 50 | 34.5 | 22 | 100 | 3.9 | 4.4 |
| | | | | | 44 | CB | MLS | 44 | 35 | 50 | | | | | |
| Polyester/cotton sheeting (muslin and percale) | | | | | | | | | | | | | | | |
| Ring-spun | 34 | 101,553 | | 100 | 58 | SJV | M | 6 | 34 | 6 | 35.4 | 21 | 45 | 3.5 | 4.9 |
| | | | | | 39 | CV | SLM+ | 32 | 35 | 43 | | 22 | 3 | | |
| | | | | | 3 | SE | SLM | 51 | 36 | 51 | | 24 | 6 | | |
| | | | | | | | LM+ | 11 | | | | | | | |
| | | | | | | | SLM LS | 1 | | | | (26)[e] | 46 | | |
| Airjet spun | 30 | 20,624 | | 100 | 64 | CB | M | 10 | 34 | 95 | 34.0 | (26)[e] | 100 | 3.9 | 4.4 |
| | | | | | 18 | SJV | SLM+ | 59 | 35 | 5 | | | | | |
| | | | | | 18 | SE | SLM | 31 | | | | | | | |

**Table 11.4. continued**

| End-use and spinning technology | Weighted averaging finest yarn number | Bales of cotton used | 100% cotton (%) | Polyester/cotton blends (%) | Mix | | Grade | | Staple | | | Strength | | Micronaire | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | % | Regional[a] | | % | 1/32" | % | Ave.[b] | g/tex[c] | % | Low | High |
| Polyester/cotton printcloth | | | | | | | | | | | | | | | |
| Ring-spun | 37 | 40,654 | | 100 | 54 | SVJ | SLM | 100 | 35 | 63 | 35.4 | 21 | 37 | 3.7 | 4.9 |
| | | | | | 46 | CB | | | 36 | 37 | | 27 | 63 | | |
| Apparel | | | | | | | | | | | | | | | |
| Ring-spun | 45 | 117,302 | 2 | 98 | 52 | CB | M | 16 | 32 | 5 | 34.8 | 21 | 5 | 3.5 | 4.9 |
| | | | | | 38 | SJV | SLM+ | 43 | 34 | 9 | | 22 | 2 | | |
| | | | | | 6 | SE | SLM | 38 | 35 | 80 | | 24 | 12 | | |
| | | | | | 4 | P | SLM LS | 3 | 36 | 6 | | 26 | 11 | | |
| Airjet spun | 35 | 11,500 | | 100 | 70 | CB | SLM+ | 58 | 35 | 100 | 100 | (26)[e] | 100 | | 4.4 |
| | | | | | 30 | SE | SLM | 42 | | | | | | | |

[a]P = Plains; SE = Southeast; SJV = San Joaquin Valley; CB = Central Belt.
[b]Laydown mix weighted crop average for this characteristic for each end-use.
[c]Fiber strength measured in g/tex.
[d]SLM = Strict Low Middling; LM = Low Middling; MLS = Middling Light Spot.
[e]Parentheses indicate crop average designated as required level of characteristic.

impetus to the commercial acceptance of the open-end rotor and of the new friction and air-jet spinning technologies. Structural differences in the new technologies place different requirements on raw material inputs, particularly on cotton fiber. Fiber fineness (*micronaire*) determines the technical upper limits of the yarn to be spun on both open-end rotor and air-jet systems. High micronaire levels (high density) indicate fiber that is large in diameter. Thus, there are fewer fibers in cross-section. The low threshold for spinning sliver is approximately 100 fibers in the yarn cross-section, below which spinning performance is impaired markedly. If micronaire is used as the measure of fineness, then low-micronaire cotton is desirable. But the U.S. market system discounts for low micronaire cotton that may be mature depending on production location and variety, and desirability for use on open-end rotor spinning systems.

The synthetic fiber industry recognizes the importance of fiber fineness in conjunction with the new spinning technologies and is providing mills with reduced denier polyester staple. This change reflects an ability to tailor synthetic fibers to mill requirements and to adjust rapidly to changes in requirements.

### Important Quality Attributes

The official USDA classification system has seen few revisions since its introduction in the 1920s. The Smith-Doxey (S-D) classification measures three factors: grade, staple, and micronaire (U.S. Department of Agriculture, 1980). Within this system are 45 grades, 31 staple lengths, and 7 micronaire groups resulting in more than 7,000 fiber-quality combinations. Potentially, each combination has an associated spot market price. In reality, because 70% of all production in any crop year is accounted for by less than 10% of these possible combinations, the amount of information about which market participants need remain current is considerably limited.

Staple and grade are determined subjectively by means of visual inspection and depend on consistent and accurate judgment of classers using the S-D classing system.

### Staple

This term, which usually refers to fiber length as determined by the classifier, is expressed in 1/32nds of an inch. In Upland cotton, fibers range in length from shorter than 1 in. to longer than 36/32 of an in. The base staple, or length used for the spot price system, is 34/32nds of an in., a measure designated "34." Cotton fiber shorter than 13/16ths of an in. is designated "Below 26." Extra Long Staple or American Pima fiber can be longer than 44/32 of an in. (U.S. Department of Agriculture, 1980).

### Length

Actual fiber length is measured in 1/100ths of an in. When length is reported in this unit of measure, it indicates that this is an instrument (objective) measurement. The S-D classification is based on staple rather than on length and is a classer (subjective) assessment.

### Micronaire

Micronaire indicates both fineness and maturity of the cotton fiber sample. Readings from the airflow instrument generally range from 2.4 to 7.5. A micronaire value between 3.5 and 4.9 is considered optimal for upland cotton. This range constitutes the basis of the discount system.

### Maturity

Cotton fiber maturity relates to average relative thickness of the secondary fiber wall and generally is reported as percentage of mature fibers present. Maturity depends on harvesting schedule, weather, disease incidence, and use—correct or incorrect—of boll openers and defoliants. Because bolls are formed at intervals on the plant and mature at different times, there can be considerable variation in fiber maturity from top to bottom of the plant.

Cotton lint containing immature fibers tends to tangle easily, forming clumps or neps. This condition often is indicated by uneven distribution of length or by lack of uniformity. Immature fiber takes up dye unevenly; does not give good reflectance (RD), which causes uneven fabric appearance; and weakens yarn, thus decreasing spinning and weaving efficiency.

### Fineness

*Fineness* refers to the average linear density of fiber and describes the number of fibers in the cross-section of a given yarn count. Finer fibers (low linear density in millitex) provide a greater number of fibers in the yarn cross-section and thus yield strong yarn. Because the coefficient of variation in yarn is a function of the number of fibers in the cross-section, increased fiber fineness results in increased yarn strength and uniformity, as well as in decreased variation.

Because fineness is a characteristic of cultivar, different micronaire values for the same cultivar indicate maturity differences. Yet mature fibers from a range of cultivars may give different micronaire readings as a result of genetic differences.

### Grade

*Grade* is a combined index describing both color and leaf, or trash, content in the sample. Cotton fiber should be a clean white, but age and weather exposure can cause spotting, yellowing, or greying. Color evaluators consider brilliance, RD, and hue.

Foreign materials such as leaf, stem, bark, grass, and even nonplant materials, e.g., rope, oil, or bagging, are considered *trash*. Dispersion of these particles into the sample influences color as well as appearance.

Grade is expressed as a two-digit index. The first digit is a trash code ranging from 1 to 8, with a base of 4. The second is a color code, also ranging from 1 to 8. A combined Grade Index of 41 is used as the basis for price determination.

Both color and trash are measured subjectively in the S-D classification.

### Authority for and History of Grades

In 1914, the U.S. CFA created official cotton standards for American Upland cotton. These were the first standards used in either domestic or export trade, for they could be enforced through cotton futures exchanges. The USDA's attempts to standardize cotton were given impetus by the U.S. Cotton Standards Act of 1923, an act requiring testing of all cotton in interstate and export markets.

In an attempt to motivate fiber-quality improvement, the S-D Amendment in 1937 provided, on request, classing services to cotton growers. These services were free until 1981 and had the desired effect of enabling documentation of cotton-fiber quality. More than 95% of the U.S. cotton crop has been USDA classed since the early 1980s.

### Measurement Technology

Instrument testing of cotton fiber was initiated in 1963 by the USDA, in response to the textile industry's demand for fiber property information. The fibronaire test for micronaire was introduced into official grading standards shortly thereafter. During the next 5 yr, Motion Control, a Dallas based instrumentation company, developed a series of instruments able to classify cotton systematically, objectively, and economically. The first high-volume instrument (HVI) system became operational in 1969 (Sheaffer, 1988).

Textile technologists, instrument manufacturers, and government officials determined the following properties as critical in efficient performance of new spinning technologies:

1. separating color into RD and yellowness (+b), measured by the colorimeter,
2. trash, percentage by weight,
3. mean length (ML) in in. and upper-half mean (UHM),
4. length uniformity = mean/UHM ratio,
5. strength, 1/8" gauge (g/tex), and
6. micronaire.

To meet economy and speed requirements, instruments had to equal or better the operating time of the fibronaire, i.e, a turn-around time of 10 seconds or less (Sheaffer, 1988; Smith, 1990).

Although being discounted extensively for short staple fibers, i.e., fibers ≤ 1 in., West Texas cotton farmers produced cotton that met the strength requirements for the new rotor spinning technology, which is relatively tolerant of short staple. So it seemed that, if they could work with mills using this technology, producers might receive higher market prices reflecting use value.

In the early 1970s, West Texas pioneered the use of HVI testing with the American Cotton Growers' denim plant in Littlefield, Texas, which since opening had been using HVI data to predict yarn quality. In 1979, a group of Lamesa, Texas producers bought ten systems complete with computers and set them up in a captive building, which subsequently was leased to the USDA to serve as an official classing office. The rapid initial acceptance of HVI in West Texas, despite a $0.45/bale surcharge for classing, can be attributed to the premium paid for strength by the Littlefield plant. By 1984, 75% of Texas cotton, or one-third of all U.S. cotton, was being tested and classed according to HVI.

Accurate descriptions of fiber that address processing requirements are critical to efficient allocation of qualities among uses. Interactions between fiber material and spinning technology greatly influence yarn quality and spinning cost, for the former is determined by fiber properties such as length, strength, fineness, uniformity, and maturity. The relative importances of these properties depend on the spinning system used and are reflected in both spinning performance and yarn quality. Thus, with raw materials accounting for 50 to 70% of total yarn cost, selection of fiber for specific spinning systems becomes economically necessary (Ethridge, 1981; Rademaker, 1985).

During the last 10 yr, varietal selection and production practice have been tied closely to market demand for specific characteristics. Moreover, incentives reflecting the changing processing technologies at the mill level have led to average fiber strength increasing from 10 to 15%, depending on production location (Figure 11.9). This change has occurred despite the lack of market value explicitly associated with the characteristic.

Average staple length also increased over the 10-yr period although less dramatically. All upland cotton fiber averaged greater than 1 in. in length by the late 1980s. Because there is a direct link between market price and staple length, direct incentives exist to select certain cultivars and to adjust production practices so as to yield long staple fiber.

By 1980, textile manufacturers were using additional measures of fiber properties to meet processing demands of the new spinning technologies. Three years later, rotor spinning accounted for 22% of total yarn output for broadwoven end-uses on nearly 400,000 rotor positions. Although the same fiber properties are used by all spinning technologies, the relative importances of these properties, and thus their economic values, differ.

In 1984, Deussen suggested that the signals sent from the mill to the producer on the relative importance of selected fiber characteristics in yarn production were changing. The traditional ranking considered yield most important. But changing technology and pricing were leading to revision and reranking of the list (Table 11.5).

By 1987, the textile industry was predicting that before the year 2000 half of all yarn would be produced on rotor spinning systems. Between rotor, friction, and air-jet spinning technologies, the mills faced

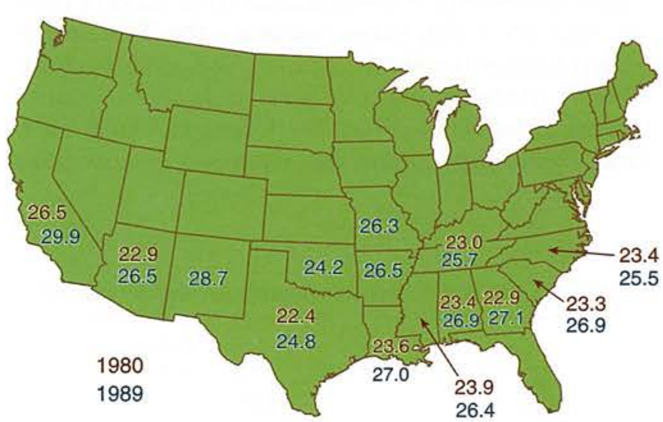


**Figure 11.9.** **United States average strength grams per tex (g/tex) for upland cotton, by state, 1980 and 1989 (U.S. Department of Agriculture, various issues, *U.S. Quality of Cotton Classed Under Smith Doxey Act*).**

a new generation of engineering yarns with structures different from those that were ring spun. All measures listed except friction and cleanliness were available at cost from private laboratories or from inhouse testing facilities.

Increasing global competition, rising labor cost favoring the increased productivity of rotor spinning, and rapid advancement in computer technology combined to propel joint acceptance of both rotor spinning and HVI testing in the late 1980s. The USDA had purchased 176 systems by 1989; 52 additional systems were operated in textile mills, and 14 in cotton marketing companies (Smith, 1990). Fifty-six more systems were operated in Europe, 53 in Asia and Australia, 19 in South America, and 28 in Africa and the Middle East.

Despite universal acceptance of the HVI system, the S-D classification system remained the official U.S. standard through the 1990 crop.

## Quality Related Issues and Problems

### Price-Quality Relations

According to the S-D classification system, Sample Grade can be no more than one grade higher than that assigned to color or leaf (trash) content. Thus, an incentive is provided to increase the amount of cleaning at the gin so as to remove leaves and to improve grade. Although this practice results in a high spot price or in a high price paid the producer, the practice has a negative effect on quality by increasing short-fiber volume and by diminishing fiber uniformity. More uniform fiber results in more uniform, stronger, and more valuable yarns.

Although acceptance of HVI testing in the early 1980s was slow, measurements of fiber strength and length uniformity were available from private laboratories. By 1980, three centers—the Textile Research Center (Lubbock, Texas), Cotton Incorporated (CI) (Raleigh, North Carolina), and Clemson University's School of Textiles (Clemson, South Carolina)—were developing equations to predict yarn break factor, yarn strength, and yarn evenness. Data for all seven HVI property measurements (micronaire, RD, +b, length, length uniformity, strength, and elongation) were being used in these equations (Rogers, 1986).

As costs increased and as rotor spinning potential became evident, textile mills began to indicate interest in the HVI data. In 1984, CI introduced an Engineered Fiber Selection system allowing mills to combine HVI data with end-use requirements. The system aided selection of the least costly combination meeting yarn and fabric specifications for bales in the laydown mix (Rozelle, 1984).

Development of contractual arrangements between producer cooperatives and mills, e.g., Plains Cotton Cooperative and the Littlefield denim plant, resulted from the introduction of these input management practices. To the extent that premiums were paid for increased fiber strength, there was a direct price incentive to producers. But even without such an incentive, increased availability of information about the importance of certain essential properties in yarn processing has brought about genetic developments and has enhanced cultural management and harvesting and ginning practices.

Comparing quality improvements across the Cotton Belt, Chen et al. (1991) looked at two 5-yr periods: 1980–1984 and 1985–1989. Although the S-D classification system provides no minimum standard for strength, 25 g/tex fiber strength was accepted as representative of the minimum requirements for a mill. Table 11.6 indicates noticeable improvement in fiber strength between the two time periods. Trash content declined in all regions, and staple increased in three of the four. Base values were those associated with the base price for the USDA–AMS spot quotations and with tenders on the NYCE. Consequently, base quality improvements indicated increased deliverability against futures contract requirements.

Improvements typically develop in response to incentives generated by price differentials. For exam-

**Table 11.5. Ranking of importance of cotton fiber properties by spinning technology (Deussen, 1984; 1987)**

| Ring | Rotor | Air-Jet | Friction |
|---|---|---|---|
| Length/uniformity | Strength | Length/uniformity | Strength |
| Strength | Fineness (> 100 fibers in x-section) | Fineness | Fineness |
| Fineness | Length/uniformity | Strength | Length/uniformity |
| | Cleanliness | Friction | Friction |
| | | Cleanliness | Cleanliness |

ple, reducing trash, increasing staple, and changing micronaire are responses to price signals. The price system signaled, however, that no change in micronaire was necessary. Although mills were documenting the need for decreased micronaire, particularly when rotor spinning was the processing method, the pricing structure discouraged producer response by imposing a discount on micronaire values smaller than 3.5.

Market information indicates clearly that strength has been gaining in importance as a desired fiber property. But, as with mill needs for decreased micronaire, the pricing system during the 1980s included no explicit price incentive for increased fiber strength. Unlike micronaire, however, strength was an attribute for which several mills were known to pay premiums. It is evident from Table 11.6 that producers and breeders did respond to market information as well as to price incentives in this regard (Figures 11.9 and 11.10).

The abrasive action of trash and dust on open-end rotors and on air-jet machinery can limit the life of these components greatly and can offset potential cost advantages. Like the abrasive action of dust, particles collecting in rotor grooves cause yarn quality deterioration in open-end rotor-spun yarns. In the early stages of the commercial application of such systems, a major shift occurred toward the use of West Texas/Plains short staple cotton. Because this fiber is short stapled and has low micronaire levels, it is discounted by the current U.S. market system. Yet the attributes for which this cotton is discounted make it seemingly ideal for open-end rotor spinning.

Notwithstanding, great amounts of dust particles take their toll on system components. The earlier shift to 100% use of West Texas cotton since has been modified to minimize the impact of dust content to economically acceptable levels.

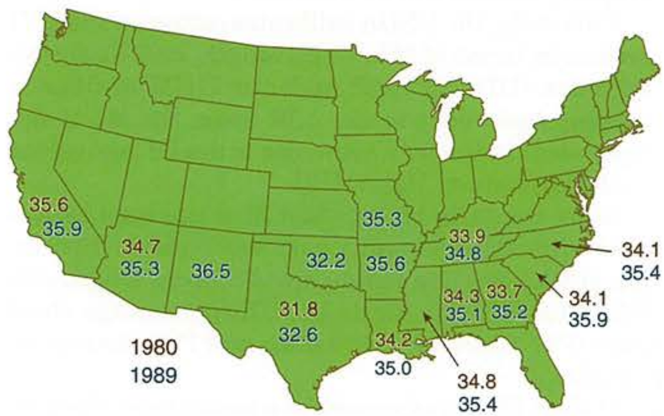


**Figure 11.10.** **United States average staple (1/32") for upland cotton, by state, 1980 and 1989 (U.S. Department of Agriculture, various issues, *U.S. Quality of Cotton Classed Under Smith Doxey Act*).**

**Table 11.6. Cotton quality changes, weighted averages and differences: crop years 1985–1989 vs. 1980–1984 (Chen et al., 1991)**

| | Trash index (1–8) | Color index (0–5) | Staple length 32d in. (26–37) | Low mike rdg. (26–35) | High mike rdg. (49–53) | Strength g/tex (20–31) |
|---|---|---|---|---|---|---|
| Southeast—Montgomery Market | | | | | | |
| 1980–1984 | 4.26 | 1.16 | 34.52 | 34.9 | 49.4 | 24.74 |
| 1985–1989 | 4.00 | 1.37 | 34.92 | 34.8 | 49.2 | 26.24 |
| Difference | −0.26 | 0.21 | 0.40 | −0.1 | −0.2 | 1.50 |
| Delta—Memphis Market | | | | | | |
| 1980–1984 | 4.38 | 1.38 | 34.54 | 34.8 | 49.2 | 24.48 |
| 1985–1989 | 4.00 | 1.40 | 34.94 | 34.9 | 49.3 | 25.26 |
| Difference | −0.38 | 0.02 | 0.40 | 0.1 | 0.1 | 0.78 |
| Southwest—Lubbock Market | | | | | | |
| 1980–1984 | 4.43 | 2.13 | 31.64 | 32.3 | 49.0 | 24.28 |
| 1985–1989 | 4.04 | 1.94 | 32.50 | 32.1 | 49.0 | 25.18 |
| Difference | −0.39 | −0.19 | 0.86 | −0.2 | 0.0 | 0.90 |
| West—Fresno Market | | | | | | |
| 1980–1984 | 3.59 | 0.94 | 35.92 | 34.8 | 49.0 | 28.46 |
| 1985–1989 | 3.29 | 1.05 | 35.92 | 34.9 | 49.0 | 29.70 |
| Difference | −0.30 | 0.11 | 0.00 | 0.1 | 0.0 | 1.24 |

### International Standards and Consistency Classification

As additional instrumentation companies develop technologies to measure different fiber properties, confusion may arise regarding comparability of measurements, especially in the global market. Instrument calibration and accepted testing methods therefore are critical to establishing a functional market. Until consensus has been reached regarding which measures to use in price determination, expansion of the seven-property HVI system to an eleven-property system will be difficult.

Currently, the USDA calibrates cotton on the HVI system in terms of ML, UHM length, and Uniformity Index (UI). But although the UHM of fiber is roughly equivalent to the 2.5% span, the ML is not equivalent to the 50% span, nor is the UI equivalent to the Uniformity Ratio (UR).

Since the early 1960s, short fiber has been associated with reduced quality yarn and reduced processing efficiency. As a result, five different length-distribution methods exist: UI, UR, percentage short fiber (PSF) content, PSF Index, and PSF content by weight.

If short fiber is expressed as a percentage of length, then a measurement highly correlated with fiber length results; that is, value increases with short fiber and decreases with long. Given the significant differences by region, e.g., Texas versus California, in terms of fiber length, use of this measure in price determination is unlikely to gain acceptance. Yet the less biased measurement based on percentage weight is considerably more complex and time consuming and consequently less economical with currently available measurement technology.

Because the question of consistency is critical to the use of HVI testing as a reference in the cotton market, the USDA has an extensive monitoring program operated by the Division of Quality Control in Memphis, Tennessee. The Cotton Division of the USDA collects samples at random from the classing offices, and these are retested by a USDA operator and by a third independent operator. In 1989, more than 95,000 samples, or 2%, of the 4.76 million bales classed by the USDA were retested under this system, with these results:

| Test | Tolerance | Repeatability |
|---|---|---|
| Micronaire | ± 1 unit | 73% |
| Length | ± 0.03" | 87% |
| Strength | ± 1.08 g/tex | 58% |

Increased variability in fiber strength can result from differing temperatures and humidities in laboratories. To limit the influence of these factors, the USDA classing offices were upgraded before the 1991 crop so as to maintain atmospheric conditions of 70° F (± 1°F) and 65% relative humidity (± 2%) in testing areas. Because fiber strength measurements have greater variability, debate is ongoing concerning whether strength should be averaged across each module because within-bale measurements of strength are inherently more variable than those of other properties.

Accuracy (observed = measured value) and repeatability of classed measurements depend on accuracy and reliability of calibration cotton samples. As HVI systems have gained international acceptance, demand for calibration cotton has increased. Although retesting of calibration samples improves accuracy and repeatability of measurements, cost is prohibitive.

Analysis of 981 calibration cotton samples during the 1989 classing season indicated that classification results from the USDA, the Quality Control Laboratories (QCLs), and CI (an independent cooperator) were well within one standard deviation. Included in this analysis were instrument readings from 19 classing offices, as well as from several different HVI systems from two instrument manufacturers (Moore, 1991).

Standard deviations of mean property measurements indicate the practical limits of measures used in the HVI system. Variation within these limits allows for instrument precision and sensitivity, as well as for natural cotton-bale variability (Table 11.7).

**Table 11.7. Precision and accepted standard deviations on high volume instrument systems (Sheaffer, 1990)**

| Measurement | Precision | Accepted standard deviation |
|---|---|---|
| Micronaire | x.xx (nearest 1/100) | 0.1 |
| Length | x.xx (nearest 1/100) | 0.016 |
| Length uniformity index (%) | xx.x (nearest 1/10) | 0.9% |
| Strength | xx.x (nearest 1/10) | 1.0 g/tex |
| Color | | |
| Rd | xx.x (nearest 1/10) | 0.9% |
| +b | xx.x (nearest 1/10) | 0.25 + b |
| Trash | | |
| leaf | x (nearest whole #) | |
| % area | x.x (nearest 1/10) | 0.10% |

## Anticipated Industry Change Influencing Quality

### Changes in Use

Consumer preference for easy-care, flame-retardant fabrics resulted in the substitution of synthetic for natural fibers. In the mid-1980s, however, yarn and fabric processing developments allowing incorporation of these features into 100% cotton or "mostly" cotton blends have enabled the cotton industry to recoup market share (Figure 11.1).

These developments also have been crucial in the middleweight fabric market, which is under competitive pressure from newly industrialized countries. For example, no-iron, easy-care 100% cotton percale has provided the U.S. textile industry with a competitive designer market.

### Changes in Marketing Structure

Increased producer awareness of the link between fiber quality and yarn and fabric quality has led to vertical linkage between producer groups, and cooperatives and textile mills. Although formal vertical arrangements are uncommon, informal links are developing whereby producers know not only the end use but also the intended textile mill and even the specific plant.

Increasing competition from textile and apparel imports led to major restructuring of the U.S. textile industry in the mid- and late 1980s. The result is a consumer oriented high-technology industry with approximately five times the productive capability of the previous decade. The challenge is for cotton producers to meet new industrial requirements.

The textile industry was as much a driving force in the acceptance of HVI testing as the producers were. The move to high-speed automated processing equipment necessitated availability of information about individual and collective properties of raw material inputs. Because multimillion dollar investments had been made in new forms of spinning and in refinements of traditional spinning, technology systems needed to be operated at high efficiencies, with minimal downtime.

Increasing demand for high-quality yarn and fabric is propelling the textile industry toward selection of raw materials with properties tailored to specific end-uses. Adoption of HVI testing has parallelled use of computer tracking of bales. Keypunched bale cards will be phased out as gins maintain computer-to-computer telecommunication transfer of classing data.

### Changes in Grades and Grading

In 1989, the secretary of agriculture established the National Advisory Committee (NAC) for Cotton Marketing. Subsequently, the USDA accepted these committee recommendations:

1. instrument testing be a prerequisite for loan eligibility beginning with the 1991 crop,
2. the base loan rate not be changed by addition of new quality factors,
3. bark and grass be a part of leaf grade, with values determined as separate components,
4. there be a premium range of 3.7–4.2 micronaire, excluding several low grades,
5. . . . instruments be developed as soon as possible to measure maturity and fineness,
6. . . . all committee recommendations be included in any new or amended farm bill affecting 1991 and subsequent crops. (Cotton Gin and Oil Mill Press, 1989)

Two early recommendations required additional review:

1. Twenty-four to twenty-five g/tex should be used as the base level for loan premium and discount schedules, beginning with the 1991 crop.
2. Cotton grades should be changed to reflect color and leaf content separately.

A further recommendation was to require approval of the International Cotton Standards Conferences, which would meet in 1992. The NAC set a target date for the 1993 crop for these changes to be implemented.

Classing cards were to reflect the recommended changes, affecting approximately 17 million bales of cotton in the 1991 crop season. Additionally, two samples/bale would be tested. Each bale has a unique gin code and number, which are maintained with the classing record in the USDA's permanent files (Figure 11.11). 1991 records no longer were to carry classers' staple, and length in both 1/32 and 1/100 in. were to be recorded in terms of fiber UHM. Length uniformity as a percentage of ML of all fibers divided by UHM also was to be recorded. Micronaire, from fibronaire instruments, and fiber strength in g/tex were to be given. Although classer grades were to be provided, the components also were to be reported as a percentage of sample surface covered with trash and color. Although trash content was to be measured by means of the HVI trashmeter, a trash grade in accordance with official standards was to be given.

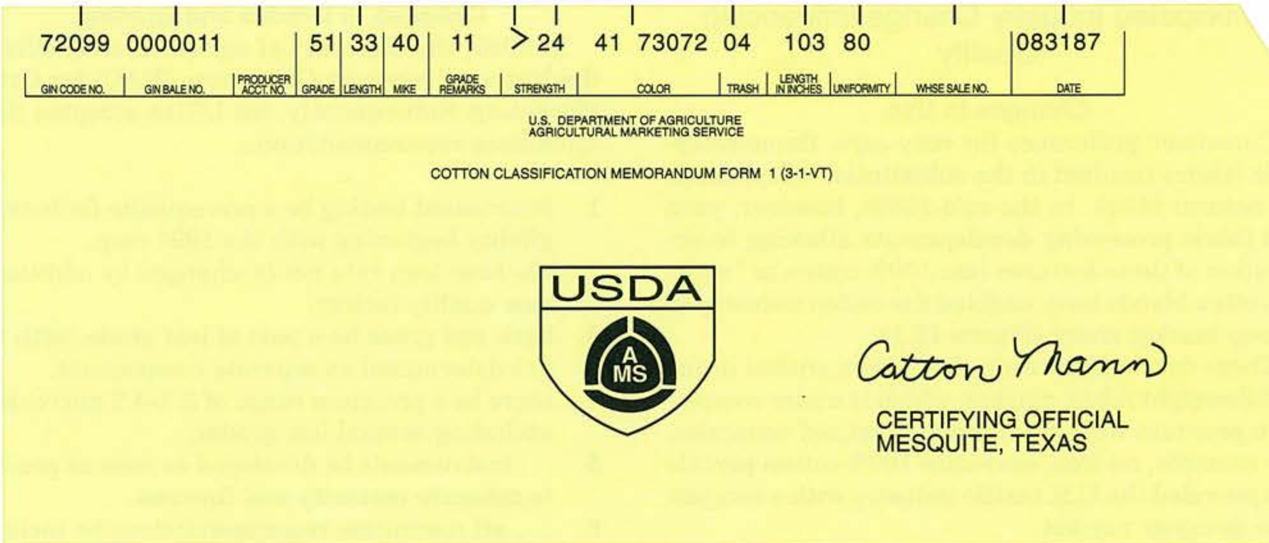


**Figure 11.11. High-volume instrument fiber measurements on the class card (U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Division).**

Beginning in 1991, actual coordinates for greyness (Rd) and +b were to be reported, in addition to overall color grade, which was to be split into quadrants to provide added detail. For example, when a color grade of 41 was reported it was to be divided into grades 41–1, 41–2, 41–3, and 41–4 (Figure 11.12).

The USDA accepted the recommendation to adopt HVI testing as a prerequisite for loan eligibility nearly 30 yr after the meeting that initiated development of the system. It is hoped that this change will permit increased flexibility for inclusion of measures of fiber properties, e.g., maturity and fineness, as these measures become feasible both economically and technically.

### Impact of Change on Price Determination

Adoption of HVI testing as a basis for loan entry occasions associated debate about the validity of the existing premium and discount schedule. Adoption also implies existence of a derived demand structure more complex than characterizable by the S-D classing system (Table 11.8).

Examination of certain known relationships between fiber properties and end-use demands indicate that this change is the first of many to occur during the next few years. For example, current standards throw all fiber finenesses from 3.5–4.9 micronaire into one class. No incentive exists for the producer to differentiate cultivars based on fineness except that of avoiding discounts for fiber with a micronaire score below 3.5 or above 4.9 (Deussen, 1990b).

Demand for fine, mature fiber already is creating inequities between mill demand and market signals (Table 11.9). Because the mill gains utility by increasing the efficiency of spinning fine fibers to produce medium count yarns on rotor systems, there should be incentives in the pricing structure (Table 11.10). As discussed, premiums paid for specific property requirements influence varietal choices and production practices. In time, the target fiber-property no longer will be constraining on the market.

### A New Marketing System/Pricing Structure

Debate has shifted over the last 10 yr from whether HVI should be accepted as a substitute for hand class-

**Table 11.8. Fiber properties assessed in the USDA classing system (Deussen, 1990a)**

| Past | 1991 | Future |
|---|---|---|
| Manual classing (4 properties) | HVI[a] (7 properties) | HVI (11 properties) |
| Length | Strength | Strength |
| Micronaire | Elongation | Elongation |
| Grade | Length | Length |
| (color and trash) | Uniformity | Uniformity or length distribution |
| | Micronaire | Fineness in m tex or d tex |
| | | Maturity |
| | Color | Color |
| | Trash | Trash |
| | | Dust content |
| | | Stickiness |

[a]HVI = high volume instrument.

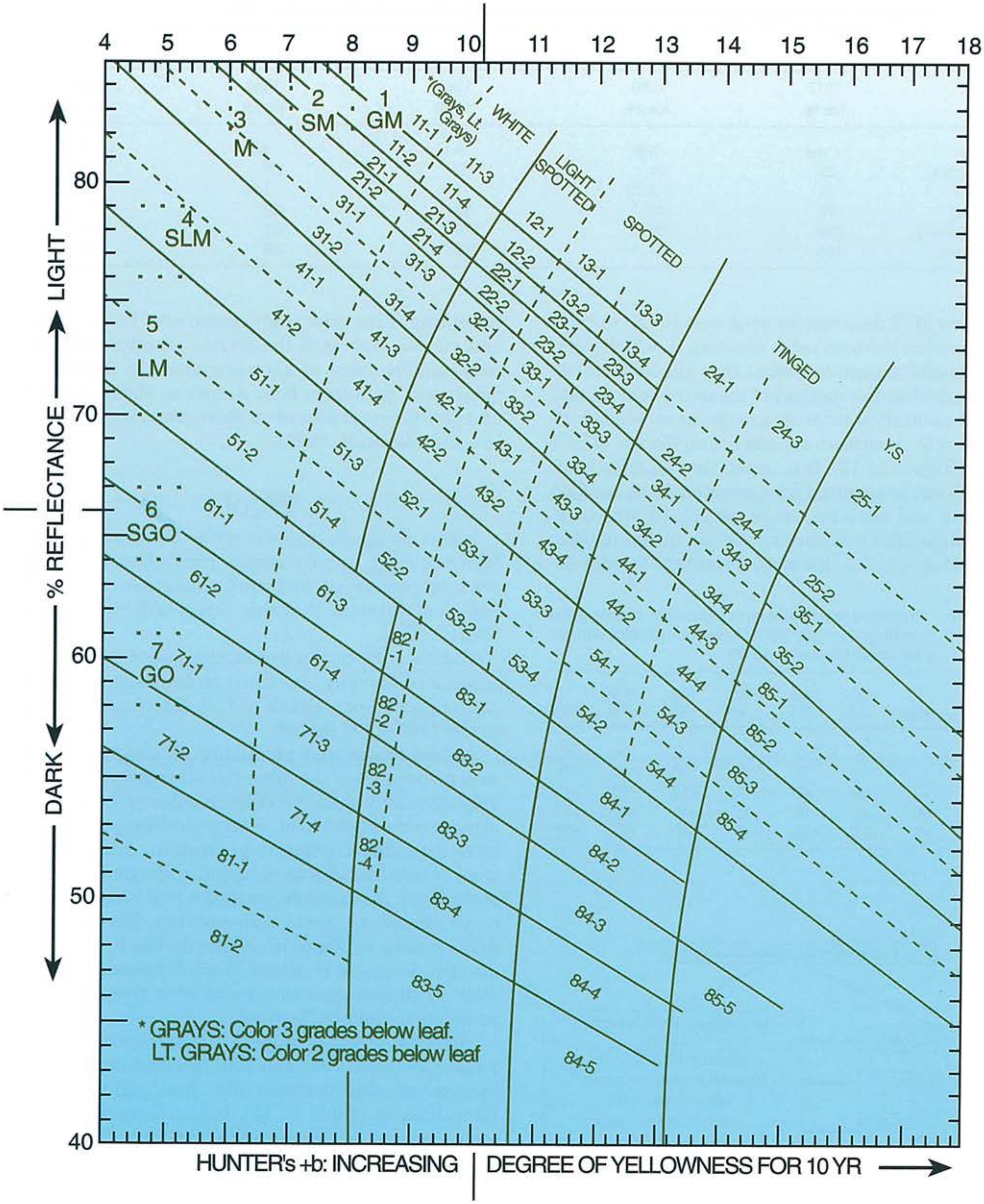


**Figure 11.12.** Color diagram for Nickerson-Hunter Cotton Colorimeter showing 1991 quadrant detail (U.S. Department of Agriculture, Agricultural Marketing Division).

**Table 11.9. Selection of cotton fiber properties in rotor spinning associated with spin limits (Deussen, 1989)**

| | Year of spin limit and yarn count | | | | |
|---|---|---|---|---|---|
| Property | 1977 Ne 16 | 1980 Ne 24 | 1983 Ne 30 | 1986 Ne 36 | 1989 Ne 45 |
| Micronaire | 4.4 | 4.2 | 4.1 | 3.9 | 3.6 |
| Strength (g/tex) | 22 | 24 | 26 | 28 | 30 |
| Length (in.) | 1 | 1.06 | 1.1 | 1.15 | 1.2 |
| Maturity (%) | 75 | 78 | 80 | 82 | 85 |
| Fineness (m tex) | 200 | 180 | 170 | 155 | 134 |
| Fibers (/x-sec) | 185 | 137 | 116 | 106 | 98 |

ing to how HVI data can be used best in the market to reflect what the true value of cotton is, which properties should be included, what they should be related to, and what the method of measurement should be. Representative interest groups have needed almost 30 yr to come to an agreement on the use of HVI testing (Figure 11.13). It is hoped that an additional 30 yr will not be required for agreement to be reached about how and when to change the pricing structure.

Although HVI measurements are in the market information set, the two most important factors determining farm price and income are classer grade and yield/a. Not until the pricing structure reflects true relative value of fiber properties in farm level prices will producers base decisions about cultivar and production practices on these two criteria (Deussen and Neuhaus, 1990).

**Table 11.10. Proposed list of premiums in percent of base price in contrast to current pricing system of discounts for micronaire (Deussen, 1987)**

| Maturity (%) | 4.0+ | 4.0–3.8 | 3.8–3.6 | 3.6–3.4 | 3.4–3.2 | 3.2–3.0 | <3.0 |
|---|---|---|---|---|---|---|---|
| ≤75 | – | – | – | – | – | – | – |
| 75–80 | – | – | +2 | +5 | +8 | +11 | +14 |
| 80–85 | – | +3 | +6 | +9 | +12 | +15 | +18 |
| 85–90 | +4 | +7 | +10 | +13 | +16 | +19 | +22 |
| >90 | +8 | +11 | +14 | +17 | +20 | +23 | +26 |

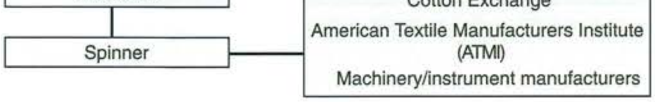


**Figure 11.13. Cotton interest groups in the United States (Deussen, 1990c).**

# Wool

Although wool competes with cotton in the U.S. fiber industry, quality issues, production practices, price determination, and market practices of wool are sufficiently unique that this report will treat it as a distinct fiber.

Unlike U.S. cotton production, wool production accounted for only one-third of domestic mill consumption and one-eighth of U.S. final consumption in the 1985–1990 period.

United States wool production typically is viewed as a by-product of the lamb (meat) industry. In that only 20 to 30% of the production value of a sheep operation comes from wool, even great changes in price have little direct effect on production. And because wool is considered a by-product, management decisions favor, for example, nutrition and breeding concerns relative to meat characteristics. These factors provide some explanation for the decline in wool production despite a National Wool Act established in 1954 to support and to provide incentives for wool production and quality wool.

The United States produces 1% of the world's wool supply. Between 1975 and 1991, production of grease (unscoured) wool declined 30%, from 125 million to 88 million lb (Table 11.11). Over the same period, global production increased by 25% from 5.9 billion to 7.3 billion lb.

The introduction of synthetic fibers has had a long-term negative effect on demand for wool fiber, especially in the carpet sector. Between 1960 and 1973, production of synthetic fiber increased fourfold, from

1.71 billion to 7.18 billion lb, with an associated decline in real price. During the same time, U.S. mill consumption of raw wool declined by two-thirds.

Table 11.11. U. S. wool production and disappearance, 1975–1991 (million lb) (U. S. Department of Commerce, Census of Agriculture, various years)

| Year | Total production (greasy) | Production (clean) | Imports | Mill | Use exports | Total |
|---|---|---|---|---|---|---|
| 1975 | 125.54 | 67.49 | 33.6 | 110.0 | 7.7 | 117.7 |
| 1976 | 115.95 | 62.20 | 57.5 | 121.7 | 1.1 | 122.8 |
| 1977 | 109.78 | 58.46 | 53.0 | 108.0 | 0.4 | 108.4 |
| 1978 | 103.94 | 55.08 | 50.4 | 115.3 | 0.4 | 115.7 |
| 1979 | 105.77 | 56.03 | 42.3 | 117.0 | 0.3 | 117.3 |
| 1980 | 106.47 | 56.43 | 56.5 | 123.4 | 0.3 | 123.7 |
| 1981 | 110.94 | 58.81 | 74.3 | 138.6 | 0.3 | 138.9 |
| 1982 | 107.13 | 56.77 | 61.4 | 115.7 | 1.4 | 117.1 |
| 1983 | 103.89 | 55.05 | 78.1 | 140.6 | 1.0 | 141.6 |
| 1984 | 96.47 | 51.14 | 94.2 | 142.2 | 0.5 | 142.6 |
| 1985 | 88.94 | 47.16 | 79.5 | 116.6 | 1.4 | 118.0 |
| 1986 | 85.40 | 45.30 | 97.0 | 136.7 | 0.8 | 137.5 |
| 1987 | 85.40 | 45.30 | 105.1 | 142.8 | 1.0 | 143.8 |
| 1988 | 90.50 | 48.00 | 96.7 | 134.7 | 1.2 | 133.9 |
| 1989 | 90.20 | 47.80 | 106.9 | 134.7 | 1.2 | 135.9 |
| 1990 | 89.00 | 47.20 | 71.7 | 132.7 | 2.7 | 135.4 |
| 1991 | 88.00 | 46.70 | 86.5 | 151.5 | 3.9 | 155.4 |

## Major Uses

United States mill consumption of wool, for all end uses, increased by almost 25% during the 1980s (Table 11.12). Total wool disappearance in the United States, however, including raw wool content in textile imports, doubled between 1975 and 1986 but lost half this gain by 1990 (Figure 11.14). A great propor-

Table 11.13. Estimated marketing channels for domestic wool production, 1981 (Hogeland and Sronce, 1984)

| Marketing channel | Volume (million lb) | % of total |
|---|---|---|
| TX-NM noncoop warehouses | 26 | 24 |
| Coop warehouses[a] | 30 | 27 |
| Western pools[b] | 11 | 10 |
| Eastern pools and midwestern pools[c] | 2.5 | 3 |
| Marketing direct to mill, non-coop warehouses and dealers | 40.5 | 37 |
| Total domestic production[d] | 110 | 100 |

[a]National (midstates, Utah wool, Wyoming wool, and Cal-wool), N. Central (South Dakota, Iowa, Minnesota, Nebraska, and Great Lakes Wool Growers Associations), and farmers and ranchers.

[b]Montana, Idaho, Oregon, Wyoming, Washington, North Dakota, Utah, and Colorado.

[c]Virginia, Pennsylvania, and Iowa.

[d]Values for warehouses represent slight double counting because they sometimes purchase pure wool.

Table 11.12. Wool consumption of U.S. mills, imported wool, and wool content of textile imports, 1975–1991 (million lb, clean basis) (U.S. Department of Commerce, Census of Manufacturers, various issues)

| Year | Apparel: Worsted system | Apparel: Woolen system | Carpet | Total mill consumption | Raw wool content of imported wool | Total U.S. textile imports | Imported wool, % of domestic consumption | U.S. mill consumption | Textile exports |
|---|---|---|---|---|---|---|---|---|---|
| 1975 | 53.1 | 41.0 | 15.9 | 110.0 | 33.6 | 68.4 | 178.4 | 30.5 | 0 |
| 1976 | 56.8 | 49.8 | 15.1 | 121.7 | 57.5 | 98.6 | 220.3 | 47.2 | 0 |
| 1977 | 46.9 | 48.6 | 12.5 | 108.0 | 53.0 | 116.6 | 224.6 | 49.1 | 0 |
| 1978 | 49.2 | 53.0 | 13.0 | 115.2 | 50.4 | 129.4 | 244.6 | 43.7 | 0 |
| 1979 | 49.1 | 57.4 | 10.5 | 117.0 | 42.3 | 109.5 | 226.5 | 36.2 | 0 |
| 1980 | 56.4 | 57.0 | 10.0 | 123.4 | 56.5 | 103.3 | 226.7 | 45.8 | 0 |
| 1981 | 63.2 | 64.5 | 10.9 | 138.6 | 74.2 | 113.6 | 252.6 | 53.6 | 0 |
| 1982 | 57.5 | 48.3 | 9.8 | 115.6 | 61.4 | 112.2 | 227.8 | 53.1 | 0 |
| 1983 | 66.1 | 60.7 | 13.9 | 140.7 | 78.1 | 149.8 | 290.5 | 55.5 | 0 |
| 1984 | 63.8 | 65.2 | 13.1 | 142.1 | 94.2 | 210.2 | 352.3 | 66.3 | 0 |
| 1985 | 50.3 | 55.7 | 10.6 | 116.6 | 79.5 | 264.8 | 381.4 | 68.2 | 0 |
| 1986 | 60.5 | 66.3 | 10.0 | 136.7 | 97.0 | 275.6 | 396.3 | 71.0 | 16.0 |
| 1987 | 68.7 | 61.0 | 13.1 | 142.8 | 105.1 | 276.1 | 395.4 | 73.6 | 23.5 |
| 1988 | 72.4 | 44.6 | 15.6 | 132.7 | 96.7 | 242.4 | 350.7 | 72.9 | 30.7 |
| 1989 | 74.6 | 45.9 | 14.1 | 134.7 | 106.9 | 222.4 | 290.7 | 79.4 | 66.3 |
| 1990 | 69.5 | 51.1 | 12.1 | 132.7 | 71.7 | 205.8 | 278.9 | 54.0 | 57.6 |
| 1991 | 78.6 | 58.6 | 14.4 | 151.5 | 86.5 | 210.9 | 299.1 | 57.1 | 63.3 |

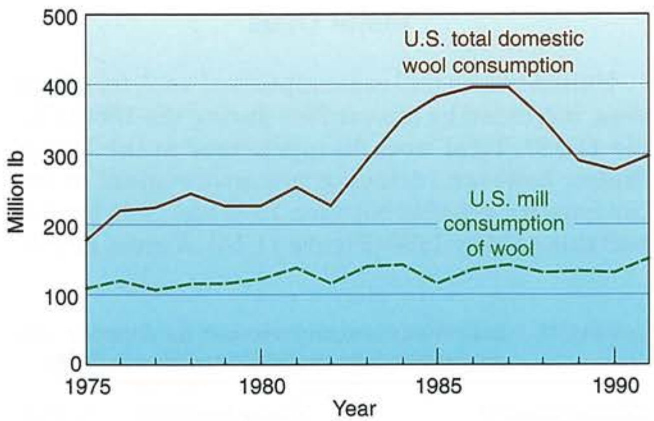


**Figure 11.14.** **United States mill wool consumption and total domestic wool consumption (including wool in textile imports) (U.S. Department of Agriculture, various issues, *Cotton and Wool Situation and Outlook*).**

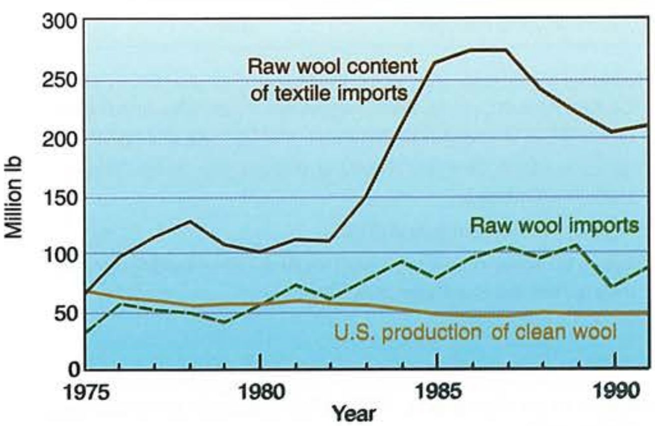


**Figure 11.15.** **Source of wool in total U.S. consumption (U.S. Department of Agriculture, various issues, *Cotton and Wool Situation and Outlook*).**

tion of increased consumption has been met through imported manufactured or semimanufactured woolen articles (Figure 11.15).

Two-thirds of global wool production is consumed in apparel; the remainder is used in carpet, felt, upholstery, and blankets. In contrast, 90% of raw wool domestic production is consumed by U.S. mills in apparel end uses, a fact reflecting the overall fine type/breed of wool produced in the United States. But domestic wool accounts for only half the wool used in apparel end-uses; the rest is imported. In contrast, only 20% of the wool used in U.S. produced carpeting is domestic.

## General Production Description

Since the late 1970s, global consumption of wool has increased by 10%. World production trended upward through the 1970s and the 1980s, reaching a record level of 7.43 billion lb in 1990. Leading producers are Australia, the former USSR, China, New Zealand, Argentina, South Africa, and Uruguay. Annual U.S. production, however, has declined from 450 million lb of *grease wool*, i.e., raw or unscoured wool, accounting for 11.5% of world production in the 1930s, to less than 100 million lb (1.3% of total) recently.

United States production is concentrated in the territory states, which account for 75% of production. *Territory wool* refers to production from 14 western states, including Montana, Wyoming, Colorado, and Texas. Production typically occurs on large sheep ranches raising a single breed. The 34 states east of the territory states are known as the Fleece Area, in which production occurs on small farms raising diversified breeds. Typical flock size in the territory states is greater than four times that in the Fleece Area (Figure 11.16).

Three primary types of wool are distinguished in the United States. Texas-Rambouillet and Delaine-Merino breeds produce the finest wools and typically command a premium in comparison with medium breeds and crossbreeds. Texas produces almost half of U.S. fine wool. Territory wools are considered fine; coarser fleece wools generally are raised east of the Kansas-Colorado border.

## Marketing System

### Market Channel Overview

Producers may sell directly to the mill if they produce a substantial clip, but a great proportion of U.S. clip is handled at some stage in the channel by either a pool or a warehouse (Table 11.13). Both function to concentrate and to grade wools (Figure 11.17).

Warehouses grade, core test, store, insure, and package, and provide marketing services at a few cents more per pound for Fleece than for Territory wools. Unlike most warehouses, which work on a daily business schedule, wool pools generally operate as needed, which in fact may be only a few days each year. Marketing charges usually are much lower for pools because they use volunteers from among their memberships. Dealers and warehouses handle wool all year long and thus also perform an inventory function for mills. The importance of this function is increasing as additional mills buy wool in response to specific order requirements and simultaneously carry smaller inventories.

Typical methods for selling wool include sealed bid sales and private treaties. If the market supports neither option, the producer may consign the clip to a warehouse for subsequent sale.

## Pricing Practices and Strategies

### Price Determination

Wool is priced on both a grease and a clean basis. But because the United States produces only one-third of its domestic mill demand, the major price determining factor is foreign supply. In contrast to

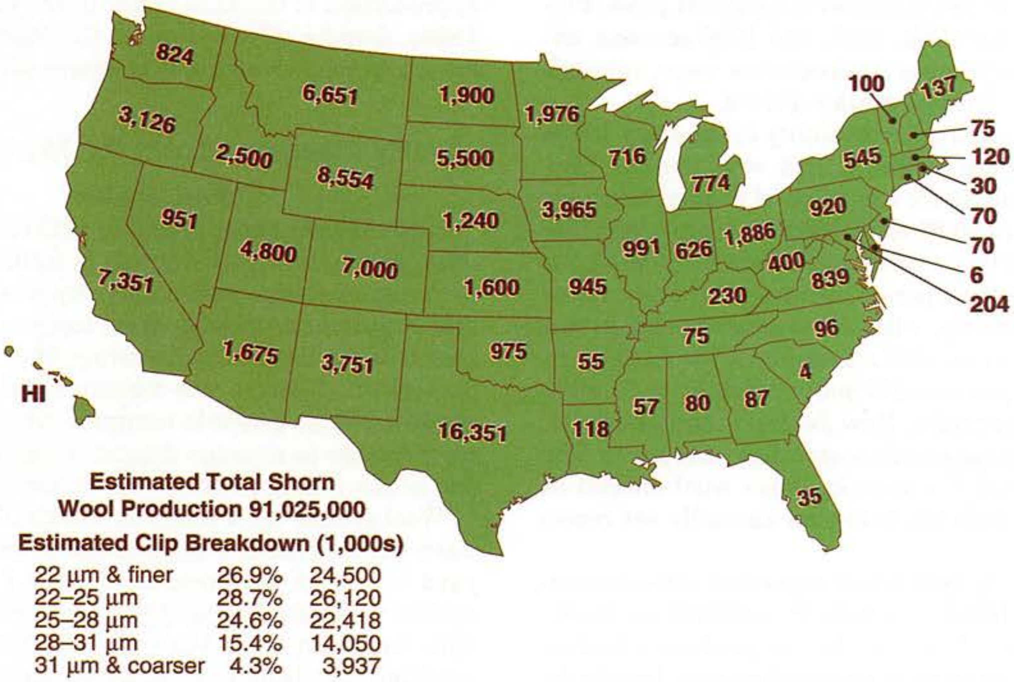


**Figure 11.16. Estimated U.S. wool clip for 1991 (1000s) (American Sheep Producers Council, various issues).**

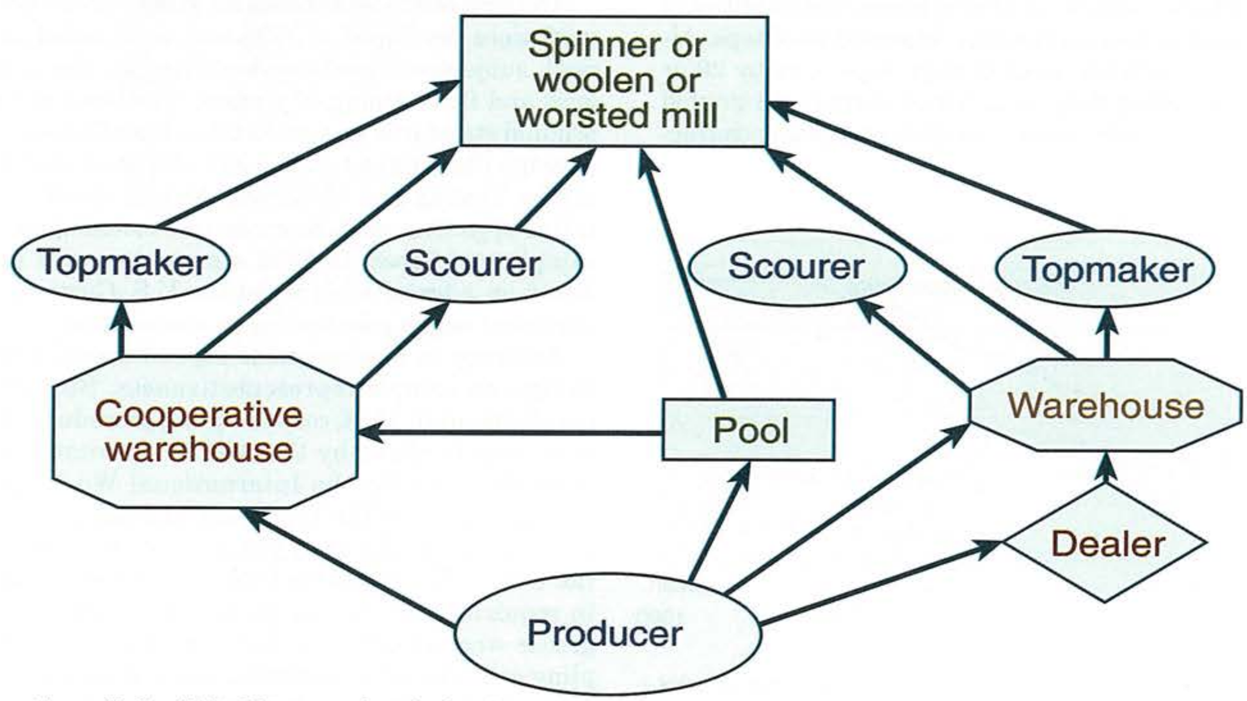


**Figure 11.17. United States wool marketing channels.**

most major agricultural commodity markets, the wool market evidences little relation between ending stocks and average U.S. farm level prices. Price level is influenced by variability in imports, which accounts for the volatility in U.S. wool prices. Furthermore, since 1973, U.S. average market price received by producers has yet to exceed the support price (Figure 11.18). In the 1983, 1985, and 1986 seasons, average direct payments to producers were approximately double average market prices.

Price fluctuation and variability in the early 1970s contributed to the decline in U.S. wool demand. Between 1970 and 1975, the price of graded territory 64s ranged from \$0.60 to \$2.70/lb. In comparison, the price of graded fleece 54s ranged from \$0.55 to \$1.74/lb. During this same period, futures contracts on wool tops ceased trading, with the consequence that uncertainty and price risk associated with quite variable domestic prices could not be offset by U.S. mills. In contrast, Australia, New Zealand, and South Africa use marketing boards to stabilize wool prices. The Australian Wool Corporation buys wool offered at auction when bids fall below an annually set reservation price.

Although U.S. wool is less expensive than Australian wool, the latter generally is preferred for several reasons. First, U.S. crossbreeds produce a coarser wool but have more meat cutout than pure breeds do. More important to U.S. textile mills, Australian wool is graded and sorted to remove short, belly, and off-color fibers. Variability among prices and qualities of U.S. wool drives demand for imported wool tops. Although Australian wool is more expensive by 20 or 30%, including duty, it is better sorted and graded and thus provides more desirable processing characteristics.

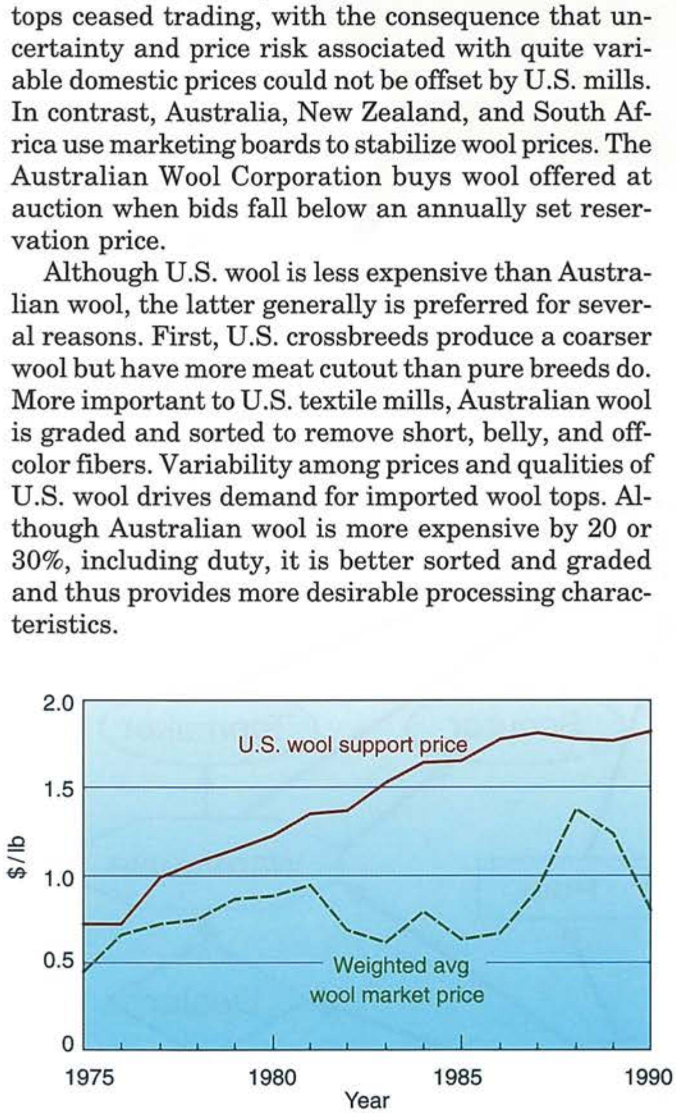


**Figure 11.18. Actual farm level relative to incentive price for wool in the United States.**

The United States has imposed an import duty applicable to fine wools competing directly with U.S. wool. By the mid-1980s, Australia and New Zealand, which accounted for 85 to 90% of U.S. raw wool imports, provided two-thirds of total U.S. wool consumption. Textile wool imports also surged in response to appreciation of the U.S. dollar in the early and mid-1980s, despite efforts through the Multifiber Agreement to provide restraints by means of import duties.

## Quality Measurement in the Market Channel

### Wool Grades

Although the range of grades within a single breed often can be wide, wool grade is influenced greatly by breed of sheep, particularly by whether the animal is pure or crossbred. Wool top grades are determined on the basis of both average fiber diameter and dispersion. If these two measures fall in different grades, a dual grade is assigned whereby the first corresponds to average diameter and the second is one grade coarser, to indicate disparity.

Wool grades were based on the Bradford Worsted Yarn Count system, which reflects the number of 560-yard lengths of yarn needed to make 1 lb. When the system was established, it was technically feasible to spin 64s yarn from 64s wool. But with increased machine speeds and productivity requirements, this no longer is possible. Thus, confusion can result from the use of *count* as a grade description (Lupton, 1989).

The first official standards for grades of raw grease wool were developed in 1923 and were based on visual, subjective assessments relying on the experience and the training of graders. The basis of these original standards was, and still is, fiber fineness and average fiber diameter. In 1935, the American Society for Testing and Materials (ASTM) issued a tentative objective wool- fineness test focusing on core sampling of fleece. In 1938, core testing was introduced on a broad scale when the U.S. Customs Department began core testing to assess tariffs.

Accuracy in measurement depends, among other things, on sample representativeness. Since their development in 1938, core sampling procedures have been standardized by the ASTM. Currently, they form the basis for the International Wool Textile Organization (IWTO) Core Test Regulations (Pohle et al., 1958). In the early years of this method's use, the United States led the international wool market in requiring core testing to determine the value of grease wool according to standard methods of sampling core and of determining yield, fiber diameter, crimp, and staple length. Notwithstanding, a great proportion of U.S. wool still is sold such that most parameters considered of importance by textile mills are determined subjectively by the wool buyer.

The ASTM core testing procedure does not specify coring-tube diameter either in the U.S. procedure description or in the IWTO standards. This fact has caused concern that tube diameter size may affect consistency of sample measurement for yield and fineness. Both 2 and 0.5 in. diameter tubes are used for sampling although it is commercial practice to subsample a 0.5 in. sample for actual testing (Lupton, 1987; Pfeiffer et al., 1990a).

In 1989, the Objective Measurement Task Force of the American Sheep Producers' Council of America identified core testing of small lots (< 5,000 lb) as an issue requiring consideration. The Council considers removal of 40 fiber samples of 60 lb or greater from the clip an excessive percentage of total and recommends that clip sampling be decreased without biasing sample measurements.

### Important Quality Attributes

The quality attributes important in the wool industry are similar to those important in the cotton industry. They include fiber diameter, yield, staple length, fiber strength, crimp, and fiber color.

All major and secondary characteristics except *cots*, i.e., felted fibers, can be measured objectively. A 1978 survey by an Australian wool industry group ranked characteristics for the worsted industry (Table 11.14) (Lupton, 1987). Yield (including foreign material), staple length, fiber diameter, staple strength, and color were identified as the most important attributes.

**Table 11.14. Ranking of wool fiber characteristics for the worsted industry (Lupton, 1987)**

| Rank | Characteristics |
|---|---|
| Primary | Yield, including quantity and type of vegetable matter |
| | Average fiber diameter |
| | Average staple length |
| | Staple strength and position of break |
| | Color/colored fibers |
| Secondary | Variability of fiber diameter |
| | Variability of staple length |
| | Cots (felted fibers) |
| | Crimp (resistance to compression) |
| Minor | Weathered tips |
| | Age/breed/type |
| | Style/character/handle |

### Yield

Yield assessment necessitates scouring wool core samples in hot, soapy water and subsequently determining levels of residual grease, inorganic ash, and vegetable content of the dried, scoured wool. Pure oven-dried wool, or *wool base*, next is converted to *clean wool* by dividing by 0.86, which adjusts to a moisture content of 12%, an alcohol extractive content of 1.5%, and a mineral content of 0.5%.

This assessment method has remained unchanged since the introduction of standards even though it technically is possible to measure fiber yield objectively by means of NIR reflectance spectroscopy. Although commercially available, this method at present is too time consuming and uneconomic for widespread use.

### Diameter

The international industry's measurement standard is a microprojection technique by which short longitudinal sections are projected onto a screen at a standard magnification of 500∞. Widths of the projected images are measured by means of a standard wedge card, which allows for calculation of both an average and a measure of diameter variability.

The most likely successor to this method is the Fiber Diameter Analyzer, a technology developed in Australia in the 1970s. First known as the Laser Fibre Fineness Distribution Analyzer, it became available commercially in the United States in 1983. Since its introduction, the fiber diameter analyzer has been used widely in research and industry for rapid and accurate measurement of fiber diameter distribution in wool and in mohair (Lupton et al., 1990a).

In 1966, the USDA revised wool grade standards to include an objective measure of fiber diameter. A range of average diameter for 16 grades and a maximum allowable deviation from the average were specified (Table 11.15). Although visual classification standards have been retained as official, in the case of dispute the objective measure prevails. Diameter influences end use of wool (Figure 11.19).

### Length

Staple length is used primarily to determine on which system the wool will be spun into yarn, i.e., on the worsted, woolen, or short-staple (cotton) system. Numerous studies have documented the highly significant linear relation between staple length of sound wools and mean fiber length in top. Fiber length in top significantly influences spinning speed, yarn count, and yarn quality.

The standard requires simple measurement of fi-

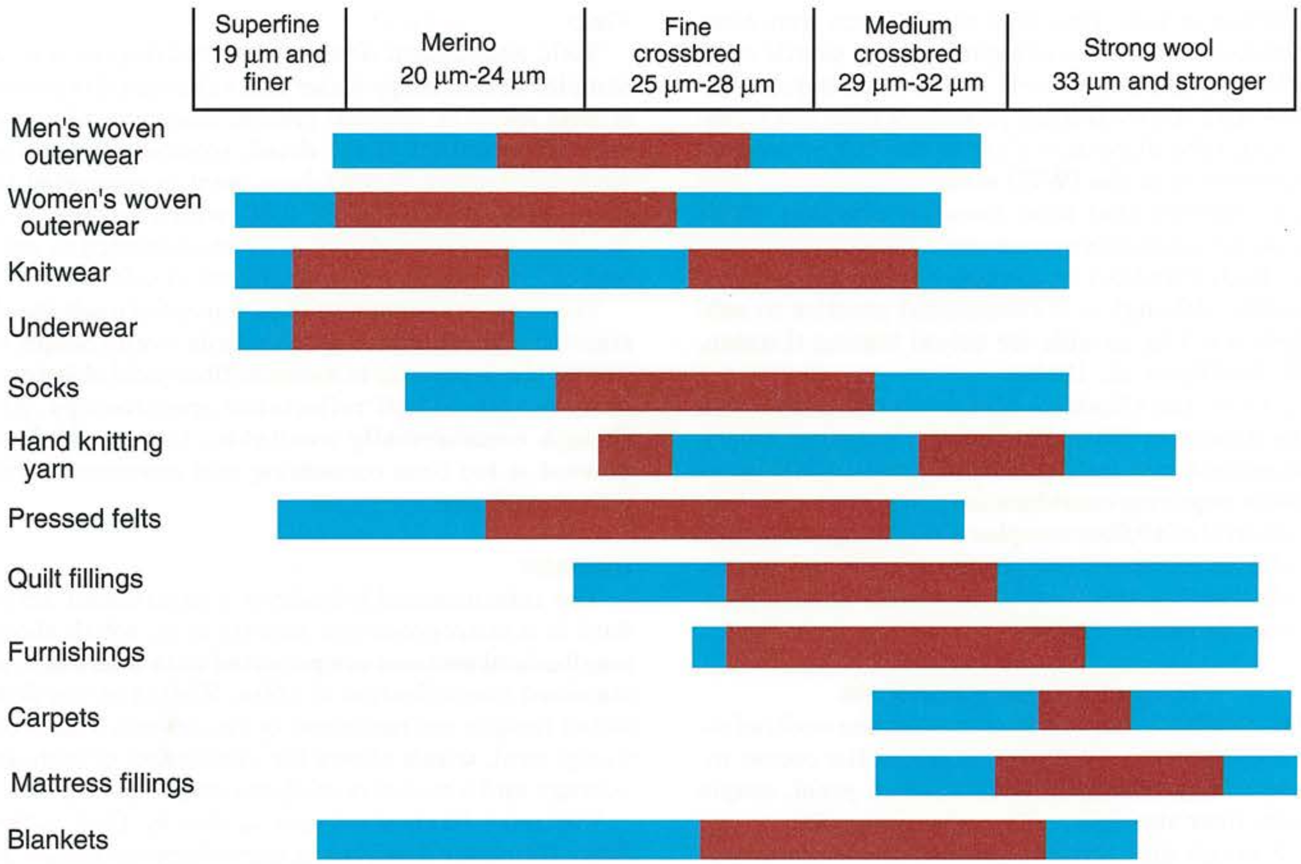


**Figure 11.19. Wool diameter ranges for apparel and nonapparel products (International Wool Secretariat) (Lupton et al., 1990a).**

**Table 11.15. Specifications for grades of wool**

| Grade | Range for average fiber diameter, µ | Standard deviation max, µ |
|---|---|---|
| Finer than 80s | under 17.70 | 3.59 |
| 80s | 17.70 to 19.14 | 4.09 |
| 70s | 19.15 to 20.59 | 4.59 |
| 64s | 20.60 to 22.04 | 5.19 |
| 62s | 22.05 to 23.49 | 5.89 |
| 60s | 23.50 to 24.94 | 6.49 |
| 58s | 24.95 to 26.39 | 7.09 |
| 56s | 26.40 to 27.84 | 7.59 |
| 54s | 27.85 to 29.29 | 8.19 |
| 50s | 29.30 to 30.99 | 8.69 |
| 48s | 31.00 to 32.69 | 9.09 |
| 46s | 32.70 to 34.39 | 9.59 |
| 44s | 34.40 to 36.19 | 10.09 |
| 40s | 36.20 to 38.09 | 10.69 |
| 36s | 38.10 to 40.20 | 11.19 |
| Coarser than 36s | over 40.20 | |

ber with a ruler. A semiautomatic system using a *light-beam break*, which measures fiber within 0.1 in. of staple length, has been developed but has yet to qualify as an ASTM standard.

### Strength

Wool fiber strength is a major factor determining yarn strength. Staple strength can be affected by sheep health, nutrition, pregnancy, lactation, stress, disease, and age. The importance of staple strength relates to yarn processing performance, e.g., machine speed and efficiency. Poor fiber strength generally will cause increased processing breakage, increased noil percentage, increased card waste and decreased mean fiber length of top. Measuring strength thus is of practical importance if producers are to be provided with information about the extent to which their production output meets mill requirements, i.e., economic performance of wool tops on the spinning system.

Position of weaknesses along the staple also is important although this factor is omitted from the ASTM method for testing the tensile strength of staple. The Australian Wool Testing Authority Laboratories have developed an instrument to measure staple length, strength, and break position—the CSIRO Automatic Tester for Length and Strength (ATLAS). Researchers in South Africa have developed a length and strength tester providing a strength profile in addition to information at maximum practical gauge level and at short gauge. Both instruments are being used in research but are not yet standard in the wool market.

Wool fiber strength typically is measured as the maximum load (or in *newton*, N) or as the energy needed to break a staple. To correct for differences in size of staple tested, these measures are standardized by the amount (mass, in g) or the *linear density*, i.e., g/m = ktex, of clean wool. Subjective assessment of strength is constrained by the ability to apply sufficient manual force and to detect differences in manual force required. Consequently, 25 N/ktex is considered the upper limit detectable by even a trained grader.

#### Compression Resistance and Crimp

No actual ASTM standard exists by which to determine crimp. Subjective, visual appraisal of crimp frequency and type constitutes the basis for most purchasing decisions. Objective measurement of crimp can be obtained by measuring fiber compressibility. Resistance to compression (R-to-C), as measured in kiloPascals (kPa), is the force/unit needed to compress a known mass of wool to a fixed volume. As this measurement decreases, wool generally becomes relatively soft and lustrous. High R-to-C values indicate greater fiber diameter and greater crimp frequency. With each 2 kPa increase in R-to-C, significant differences in processing may occur (Blakeman et al., 1990, 1991).

Studies characterizing the 1988 U.S. wool clip indicated that 73% of fleeces were sound, with staple strengths exceeding 30 N/ktex. Sixty percent of total clip was classified as having high R-to- C, and 39% as having medium R-to-C. Fine wools tended to fall into the lower end of the high category, however, with a mean of 11.88 kPa. Less than 8 kPa was designated as low R-to-C; 8 to 10.9 kPa, as medium; and 11–18 kPa as high. medium wools were less bulky than the others and had a mean R-to-C of 11.88 kPa. Coarse wools had a mean value of 12.38 kPa.

Although this information was based on a 1-yr study, the R-to-C characteristic is not expected to change from year to year inasmuch as it is influenced primarily by breed (Blakeman et al., 1990, 1991).

#### Color/Colored Fiber

No ASTM standard exists for this factor although it is a measurable characteristic under consideration for inclusion in the standards of both Australia and the United States. New Zealand already includes the factor in its standards.

## Quality Related Issues and Problems

### Price-Quality Relations

Although presale instrument testing of fiber has become increasingly available, testing in the late 1980s and the early 1990s probably was less frequent than in the 1950s and the 1960s. This change is as much due to resistance from wool buyers and to lack of financial incentive from textile mills as to producer awareness of the potential of objective measures in long-range planning and marketing.

Although Australia, South Africa, and New Zealand have increased the practice of objective testing before sale, the United States has made no significant move toward it. By 1986, approximately 90% of all Australian auction wools were being tested presale and sold by sample. Measurements were being provided of fiber diameter, yield, and vegetable matter from core samples. This was a major change in market process in that sale by description implies that buyers have no recourse on the basis of physical or visual examination. Furthermore, the value of the wool (its price) is based on the objective description.

Although ASTM standards were the basis of the original IWTO internationally accepted standards, the ASTM standards are now out of step and considered inadequate in international markets. For this reason, U.S. producers must use and meet IWTO standards when selling overseas. But adoption of new standards based on objective measurements will require that a consensus be reached among participants in the market, including producers, warehousers, wool cooperative managers, commercial fiber testing companies, wool buyers, and wool processors.

Standing to gain the most from the availability of rapid, accurate, and objective measurements is the textile miller followed by the producer, wool buyer, and warehouser. The textile mill would gain from improved quality control, processing efficiency, and predictability of top and yarn properties and end fabric quality.

Information about objectively measured characteristics may provide a common language in global market transactions. Between market participants there would be a common language for determining processors' requirements for characteristics, as well as the potential for uniform definition of these characteristics. At each level in the market, handling costs could be reduced through more efficient blending with known characteristics on both the supply and the demand side. Producers would be able to use the information to develop breeding, management, and marketing practices targeted to meet their needs and those of the wool processing industry.

Objective measurements are being used in programs for the study of breeding and performance, and of clip preparation effects on quantity, quality, and value of wool (Pfeiffer et al., 1990b).

### Common Issues in Fiber Quality Measurement

The similarities between technologies for spinning yarn from cotton and wool fibers result in demand for similar attributes. Fiber length, strength, diameter, and color are considered important given the current technologies. Innovations in measurement technologies have enabled inclusion of fiber strength as an economic measure for cotton, but this factor has yet to be introduced at the market level for wool.

Use of HVI testing for wool has been under serious consideration in Australia but is still in the development stage. Length of wool fibers further complicates automation of measurement systems. Given the relative importance of these two fibers, both the impetus for adopting new technologies and the leadership in market remuneration for quality characteristics are more likely to occur in the cotton industry. The similarities of attributes desired indicate, however, that there will be an equivalent, albeit lagged, response in the wool market.

## Glossary

**Cots.** Felted fibers.
**Fiber fineness.** Factor determining the technical upper limits of the yarn to be spun on both open-end rotor and air jet systems. High fiber fineness levels (high density) indicate large diameter fiber.
**Fineness.** Average linear density of fiber; the number of fibers in the cross-section of a given yarn count.
**Grade.** Combined index describing both color and leaf, or trash, content in a sample.
**Grease wool.** Raw or unscoured wool.
**Light-beam break.** Semiautomatic system for measuring fiber within 0.1 in. of staple length.
**Linear density.** g/mass = ktex
**Micronaire.** Fiber fineness.
**Newton.** Maximum load or energy needed to break a staple.
**Territory wool.** Wool produced in 14 western states.
**Trash.** Foreign material such as leaf, stem, bark, grass, and even nonplant materials, e.g., rope, oil, or bagging.
**Wool base.** Pure oven-dried wool.

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# 12 Forages

Neal P. Martin[37]

## Introduction

*Forages* are plants harvested primarily by grazing animals. Also included in this category are crops cut and fed directly to grazing animals or preserved as hay or as silage for later feeding. Forages supply an estimated 83% of nutrients consumed by beef and 61% of those consumed by dairy cattle.

The economic value of forages may be estimated in terms of the value that they create. For 1979, total value of production on U.S. farms and ranches was estimated at $132.2 billion; the value added or created (value of production minus value of inputs) was estimated at $83.2 billion (Kunz and Purcell, 1982.

The value added by forages to U.S. agriculture in 1979 was both direct and indirect. Harvested hay was vlued at $7.4 billion in terms of production value and at $5.2 billion in terms of value added. The major contribution of forages to the value of agricultural production, however, was indirect, through the production of meat and milk: forage consumption often converts land resources unsuitable for grain production (human food) into these two products. Thus, much forage production is consumed indirectly by grazing livestock.

The indirect value from feed to meat and milk resulted in adjusted values of $21.8 billion and $12.0 billion, respectively. The sum of forage contributions attributed directly to hay production, and values added indirectly through beef and milk production constitute 27% of total value created in all U.S. agriculture (Kunz and Purcell, 1982).

This limited assessment of the economic value of forages has emphasized the two major food production enterprises heavily dependent on such crops. The nonfood aspects of these enterprises have not been discussed; nor has the value of forages to horses, sheep, goats, and wildlife production.

The primary forage marketed in the United States is hay, specifically alfalfa hay, although most is consumed on the farm producing it. Other by-products also marketed are hay cubes, suncured pellets, dehydrated alfalfa pellets and cubes, and compressed bales.

## Major Uses

Hay is consumed primarily by ruminant livestock (dairy cattle, beef cattle, sheep, goats, and horses). Few statistics are available, but the USDA–NASS reports that forages are harvested on 21% of U.S. crop production acreage (Table 12.1). In 1990, hay on a hay-equivalent basis represented 79%, or 146,985 t, of total harvested forage (corn and sorghum silage and all hay production). Fifty-six percent of hay was alfalfa.

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**Table 12.1. Harvested forage crop production in the United States in 1988–1990 (U.S. Department of Agriculture, 1991)**

| | Acres (thousands) | | | Production (thousand t) | | |
|---|---|---|---|---|---|---|
| Crop | 1988 | 1989 | 1990 | 1988 | 1989 | 1990 |
| Corn for silage | 8,294 | 6,606 | 6,124 | 78,791 | 86,109 | 86,844 |
| Sorghum for silage | 518 | 541 | 537 | 5,252 | 5,647 | 5,480 |
| All hay | 65,055 | 63,300 | 61,557 | 126,010 | 145,512 | 146,985 |
| Alfalfa | 26,750 | 25,944 | 25,401 | 69,304 | 77,370 | 83,555 |
| All other | 38,305 | 37,356 | 37,156 | 56,706 | 68,142 | 63,430 |

## All Hay

*All hay*, including alfalfa and alfalfa-grass mixtures, can be either a perennial or an annual crop harvested, suncured, and baled for storage. The majority of this hay, consumed primarily by beef cattle, consists of perennial grasses with or without legumes. All hay usually is baled to be fed to ruminants on the farm raising it. Low-quality, rain damaged hay can be used as mulch in highway and landscape seedings. Some specialty hay crops—timothy, sudangrass, and grass/straw—are exported to Japan. Hay shipped overseas often is squeezed into high-density bales and fumigated beforehand.

## Alfalfa Hay

Although alfalfa and alfalfa-grass mixtures are grown on 41% of U.S. hay acreage, they represent 57% of hay products exported. Alfalfa hay often is higher in quality than other perennial hay crops are. High-quality alfalfa is consumed primarily by dairy cattle. Specialty markets also have been developed domestically for thoroughbred racehorses located on the East Coast and in Kentucky and Florida. To reduce transportation costs, two or three of the very bulky bales are compressed together to create 150-lb bales to allow for pelleting and for loading into shipping containers (semitruck trailers).

Marble (1990) states that between 48 and 52 stationary bale compressors operate on the West Coast. These products shipped overseas also are treated with fumigants and preservatives to prevent molding during transit. United States hay exporters have experienced fierce Canadian competition over freight rates, especially for products shipped to Portland, Oregon and to Seattle, Washington via the Canadian railway, which have been subsidized heavily by the Canadian government.

In 1985, Japan received the majority of U.S. hay exports (Table 12.2), which tend to originate in Pacific Coast and California ports (Table 12.3). Although these two areas dominate, some hay is shipped from the Great Lakes region to Europe, and some pellets made from hay produced in Nebraska and the Great Lakes region are shipped from New Orleans, Louisiana (Marble, 1990).

**Table 12.2. Exports of alfalfa cubes and bales of hay and straw from U.S. ports, 1985 (Anderson, 1985 as modified by V. L. Marble)**

| Alfalfa cubes | | | Bales of hay and straw | | |
|---|---|---|---|---|---|
| Rank/Country[a] | t | % | Rank/Country[a] | t | % |
| 1 Japan | 400,171 | 91 | 1 Japan | 159,097 | 79 |
| 2 Canada | 34,753 | 8 | 2 Canada | 33,647 | 17 |
| 3 China (Taiwan) | 1,414 | 3 | 3 Mexico | 8,035 | 4 |
| 4 Mexico | 1,258 | 3 | 4 Hong Kong | 639 | |
| 5 Hong Kong | 352 | | 5 United Kingdom | 325 | |
| 6 Malaysia | 285 | | 6 Bermuda | 284 | |
| 7 Venezuela | 184 | | 7 West Germany | 249 | |
| 8 Thailand | 158 | | 8 China (Taiwan) | 105 | |
| 9 Netherlands Antilles | 106 | | 9 Netherlands Antilles | 64 | |
| 10 Panama | 86 | | 10 Panama | 52 | |
| 11 Greece | 49 | | 11 Bahamas | 15 | |
| 12 Saudi Arabia | 36 | | 12 Leeward–Windward Is. | 13 | |
| 13 Phillipines | 25 | | 13 Netherlands | 12 | |
| 14 United Kingdom | 12 | | 14 Malaysia | 8 | |
| 15 Spain | 10 | | | | |
| 16 Singapore | 9 | | | | |
| 17 West Germany | 5 | | | | |
| Total | 439,171 | | | 202,545 | |
| Combined total | 641,716 | | | | |

[a]Other countries sometimes importing hay cubes and bales include: El Salvador, Costa Rica, Jamaica, Haiti, Barbados, Dominican Republic, Trinidad–Tobago, French West Indies, Brazil, Sweden, Norway, Ireland, Kuwait, India, China (Mainland), France, United Arab Emirates, and Macao.

## Alfalfa Cubes and Pellets

Alfalfa is sold as suncured cubes, pellets, and dehydrated pellets and cubes. A *cube* is a dry product coarsely ground and compressed into a bulk density of at least 25 lb/ft$^3$. Reduced storage space, handling labor, and waste during feeding, as well as increased consumption by animals, are among the advantages of cubed alfalfa for livestock feeders.

Moreover, cubes can be used as substitutes for forage fiber sources in a dairy ration. Pellets, however, cannot substitute for forage because they have been ground finely before compression. As a result of this process, the unique advantage of alfalfa—high levels of energy with an effective ruminal fiber—is lost for dairy cattle.

Suncured and dehydrated pellets are produced for protein and vitamin supplements. Dehydrated alfalfa cubes and pellets are processed by harvesting alfalfa green from the field and by drying it artificially before processing. Since the deregulation of natural gas prices, the alfalfa dehydration industry has been depressed.

Alfalfa cubes are the leading U.S. alfalfa export product (Tables 12.2 and 12.4), and in 1988 Japan received 91% of these exports. Alfalfa cubes and baled products constitute 90 to 95% of all alfalfa product exports, with only 60,000 t of all pellets imported in 1988–1989 (Marble, 1990). Cube exports are increasing. They comprised 52% of total forage products shipped from the Pacific Coast ports in 1988 (Table 12.3); the other 48% was exported as compressed bales. California ports handled 63% of the 1988–1989 exports, compared with Portland, Oregon and Seattle, Washington ports, which handled 37%.

**Table 12.4. Types of hay products imported by Japan from all sources, 1988 (Emanual, 1989 as modified by V. L. Marble)**

| Product | Imports (%) | Exports from U.S. t | Exports from U.S. % |
|---|---|---|---|
| Alfalfa hay cubes | 40 | 523,398 | 42 |
| Alfalfa bales | 15 | 181,864 | 15 |
| Sudan bales | 20 | 251,864 | 20 |
| Timothy bales | 8 | 63,267 | 5 |
| Grass/straw bales | 17 | 225,174 | 18 |
| Total | | 1,245,437 | |

**Table 12.3. Exports of alfalfa, hay, and straw products from California and Pacific Northwest ports, 1986–1988 (U.S. Department of Commerce, various years as modified by V. L. Marble, 1990)**

| Product | 1986 t | 1987 t | 1987 % | 1988 t | 1988 % |
|---|---|---|---|---|---|
| Cubes–California | 444,447 | 392,536 | 38.9 | 472,218 | 33.3 |
| Japan | 441,868 | 390,812 | 38.7 | 469,552 | 33.1 |
| Others | 2,579 | 1,724 | 0.2 | 2,666 | 0.2 |
| Cubes–Portland and Seattle | 191,818 | 198,166 | 19.6 | 264,839 | 18.6 |
| Japan | 155,952 | 171,807 | 17.0 | 226,092 | 15.9 |
| Others | 35,866 | 26,359 | 2.6 | 37,743 | 2.7 |
| Cubes–total West Coast | 635,986 | 591,642 | 58.6 | 737,057 | 51.9 |
| Compressed hay and straw–California | | 216,202 | 21.4 | 416,733 | 29.3 |
| Japan | | 211,834 | 21.0 | 396,138 | 27.9 |
| Others | | 4,368 | 0.4 | 20,595 | 1.5 |
| Compressed hay and straw–Portland and Seattle | | 157,950 | 15.6 | 266,538 | 18.8 |
| Japan | | 143,004 | 14.2 | 259,058 | 18.2 |
| Others | | 14,946 | 1.5 | 7,480 | 0.6 |
| Compressed hay and straw–total West Coast | | 374,152 | 37.0 | 683,271 | 48.1 |
| Total California | | 660,649 | 65.4 | 888,951 | 62.6 |
| Total Portland and Seattle | | 349,768 | 34.6 | 531,377 | 37.4 |
| Total West Coast | | 1,010,417 | | 1,420,328 | |

Alfalfa pellets, of which Nebraska is the largest producer, are exported in insignificant quantities from West Coast ports. Canada dominates the world market for alfalfa pellets. In 1985, only 2,000 t were exported to Japan from the United States, compared with 243,000 from Canada and 16,000 from Chile.

# General Description of Production

## All Hay

Forty-eight (48) states report production. In 1990, total hay production was 147 Mt from 61.6 million a. (Table 12.5). In terms of total U.S. hay production, the ten leading states, which accounted for 48.4% of all production, were Wisconsin, Texas, California, Nebraska, Iowa, Missouri, Minnesota, South Dakota, Kansas, and Michigan. The north central region of the United States is the dominant hay producing location, followed by the West and by Texas.

The *Census of Agriculture* provides farm size statistics for hay production and grass silage combined. These data indicate that the leading alfalfa producing states of the north central region are dominated by small acreages. In 1987 in Iowa, 91% of farms producing hay reported 100 harvested acres or fewer (Table 12.6). But South Dakota and Nebraska have a great number of larger operations. The highest percentage of farms using irrigation in hay production are in the western states, i.e., Idaho, California, Montana, Nebraska, and Kansas.

## Alfalfa and Alfalfa-Grass Mixtures

Accounting for 56.9% of total U.S. hay production in 1990, alfalfa and alfalfa-grass mixtures are the nation's dominant perennial forage crops. In 1990, alfalfa hay production was reported in 43 states (Table 12.7) and totaled 83.6 million t from 25.4 million a. The ten leading production states, i.e., Wisconsin, California, Iowa Minnesota, Michigan, Nebraska, South Dakota, Idaho, Montana, and Kansas, produced 60.4% of the U.S. alfalfa hay crop in 1990. The 12 north central states contained 62% of the nation's alfalfa acreage; the West, 25%; the Northeast, 8%; and the Southeast, 5%. Only Wisconsin (68%) and South Dakota harvested alfalfa on more than 50% of their farms.

Alfalfa production occurs on U.S. farms ranging widely in size (Table 12.8). The crop is produced on many a./farm in Nebraska, South Dakota, Montana, Kansas, and Minnesota. Acres/farm are fewer in the other leading alfalfa production states. Recently, large farms have been expanding alfalfa hay production, and high prices have supported improvements

**Table 12.5. All U.S. hay acreage and production by state, 1988–1990 (U.S. Department of Agriculture, 1991)**

| | Harvested (1,000 a.) | | | Production (1,000 t) | | |
|---|---|---|---|---|---|---|
| State | 1988 | 1989 | 1990 | 1988 | 1989 | 1990 |
| Alabama | 750 | 700 | 750 | 1,500 | 1,540 | 1,125 |
| Arizona | 180 | 185 | 195 | 1,325 | 1,280 | 1,421 |
| Arkansas | 970 | 1,000 | 975 | 1,671 | 2,228 | 1,738 |
| California | 1,680 | 1,670 | 1,630 | 8,652 | 8,524 | 8,307 |
| Colorado | 1,650 | 1,500 | 1,550 | 3,957 | 3,450 | 3,805 |
| Conn. | 79 | 83 | 86 | 188 | 171 | 198 |
| Delaware | 26 | 25 | 23 | 188 | 171 | 198 |
| Florida | 270 | 260 | 240 | 648 | 598 | 552 |
| Georgia | 570 | 600 | 570 | 1,254 | 1,620 | 1,140 |
| Idaho | 1,140 | 1,120 | 1,130 | 3,881 | 4,043 | 4,084 |
| Illinois | 1,500 | 1,100 | 900 | 3,310 | 3,526 | 3,348 |
| Indiana | 940 | 770 | 700 | 1,868 | 2,365 | 2,220 |
| Iowa | 3,200 | 2,400 | 2,000 | 6,760 | 6,650 | 7,095 |
| Kansas | 2,550 | 2,450 | 2,500 | 5,175 | 5,620 | 6,100 |
| Kentucky | 2,220 | 2,330 | 2,200 | 3,811 | 5,501 | 4,848 |
| Louisiana | 355 | 300 | 300 | 891 | 791 | 660 |
| Maryland | 245 | 240 | 225 | 663 | 629 | 678 |
| Mass. | 109 | 103 | 103 | 257 | 237 | 233 |
| Michigan | 1,900 | 1,550 | 1,450 | 4,220 | 5,205 | 5,335 |
| Minnesota | 4,000 | 2,600 | 2,400 | 6,960 | 6,400 | 6,560 |
| Mississippi | 650 | 650 | 575 | 1,300 | 1,560 | 1,035 |
| Missouri | 3,880 | 3,730 | 3,580 | 5,088 | 6,764 | 6,865 |
| Montana | 1,800 | 2,350 | 2,150 | 2,790 | 4,470 | 4,495 |
| Nebraska | 3,400 | 3,200 | 3,800 | 6,510 | 5,705 | 7,370 |
| Nevada | 510 | 520 | 490 | 1,336 | 1,463 | 1,359 |
| N. Hamp. | 82 | 76 | 76 | 179 | 167 | 159 |
| N. Jersey | 110 | 111 | 110 | 256 | 241 | 246 |
| N. Mexico | 295 | 300 | 320 | 1,275 | 1,332 | 1,376 |
| New York | 2,070 | 2,080 | 1,980 | 4,697 | 4,538 | 4,377 |
| N. Carolina | 450 | 515 | 470 | 797 | 3,020 | 3,745 |
| N. Dakota | 2,700 | 3,400 | 3,500 | 1,940 | 3,020 | 3,745 |
| Ohio | 1,625 | 1,625 | 1,400 | 3,543 | 4,553 | 4,620 |
| Oklahoma | 2,310 | 2,400 | 2,130 | 3,931 | 5,115 | 3,926 |
| Oregon | 1,035 | 1,050 | 1,020 | 2,652 | 2,890 | 2,826 |
| Penn. | 1,960 | 1,930 | 1,900 | 4,564 | 4,709 | 4,719 |
| Rh. Island | 8 | 7 | 7 | 20 | 17 | 18 |
| S. Carolina | 240 | 235 | 240 | 504 | 564 | 456 |
| S.Dakota | 4,100 | 4,100 | 4,200 | 3,910 | 4,290 | 6,300 |
| Tennessee | 1,610 | 1,700 | 1,500 | 2,331 | 3,499 | 3,255 |
| Texas | 3,200 | 3,910 | 3,900 | 5,350 | 9,582 | 8,000 |
| Utah | 630 | 600 | 625 | 2,177 | 1,986 | 2,123 |
| Vermont | 375 | 365 | 365 | 715 | 654 | 772 |
| Virginia | 1,210 | 1,200 | 1,160 | 2,252 | 2,565 | 2,600 |
| Wash. | 800 | 780 | 790 | 2,833 | 2,814 | 3,056 |
| W. Virginia | 550 | 560 | 560 | 785 | 1,036 | 1,142 |
| Wisconsin | 3,780 | 3,600 | 3,400 | 4,952 | 8,080 | 9,120 |
| Wyoming | 1,140 | 1,100 | 1,160 | 1,878 | 1,776 | 2,076 |
| U.S. | 65,055 | 63,300 | 61,557 | 126,010 | 145,512 | 146,985 |

in mechanization of handling, storing, and transporting.

# Description of the Marketing System and Organization of the Industry

## Overview of the Marketing Channel

Hay and its products most often are sold quite close to the production site. No hay products are sold through commodity markets. Professional hay dealers are members of the National Hay Association (NHA) and provide assurance of professional expertise to hay buyers and sellers. Through its international marketing committee, the NHA also identifies export markets. Export trades often are handled through professional brokers. Most hay moves directly from producer to consumer and is interrupted only by auction markets and/or hay brokers. Data are available, however, to illustrate the portion of hay production moving through each market channel.

Local hay sales are accomplished without movement (sold as standing crop in the field) and with minimal transport requirements (wagon, pick-up, or small farm-trucks). Commercial hay dealers use semitruck trailers for interstate deliveries. Railroads often are used to provide hay movement when great quantities are delivered to drought-stricken regions from distant surplus production areas. Costs for long-distance transportation (over 300 miles or farther) often exceed production value unless specialized high-density balers are used or bales are compressed mechanically before shipment. Back hauling often is used to reduce transportation costs. In some regions, interstate weight and trailer length restrictions can pose additional problems.

Export shipments of compressed hay bales or cubes

**Table 12.6. The number of U.S. farms by size of harvested acres of hay and silage from ten leading alfalfa production states (U.S. Department of Commerce, various years)**

| State | Total farms | Farm acres harvested | | | | |
|---|---|---|---|---|---|---|
| | | 1–24 | 25–99 | 100–249 | 250–499 | 500 |
| Wisconsin | 60,404 | 13,375 | 29,496 | 15,330 | 2,002 | 201 |
| California | 10,638 | 3,578 | 3,459 | 2,042 | 903 | 656 |
| Iowa | 48,271 | 22,645 | 21,233 | 4,085 | 278 | 30 |
| Minnesota | 46,531 | 17,523 | 22,379 | 5,924 | 622 | 83 |
| Michigan | 25,983 | 12,059 | 9,703 | 3,358 | 740 | 123 |
| Nebraska | 30,224 | 11,152 | 12,671 | 4,238 | 1,214 | 949 |
| S. Dakota | 23,131 | 3,998 | 8,871 | 6,343 | 2,753 | 1,166 |
| Idaho | 13,717 | 4,981 | 5,460 | 2,322 | 641 | 313 |
| Montana | 13,701 | 2,986 | 4,718 | 3,596 | 1,603 | 798 |
| Kansas | 33,964 | 11,391 | 16,111 | 5,267 | 913 | 252 |

**Table 12.7. U.S. alfalfa and alfalfa–grass mixture acreage and production, 1988–1990 (U.S. Department of Agriculture, 1991)**

| State | Harvested (1,000 a.) | | | Production (1,000 t) | | |
|---|---|---|---|---|---|---|
| | 1988 | 1989 | 1990 | 1988 | 1989 | 1990 |
| Arizona | 155 | 150 | 165 | 1,225 | 1,140 | 1,304 |
| Arkansas | 35 | 35 | 25 | 81 | 105 | 75 |
| California | 1,100 | 1,020 | 1,060 | 7,260 | 6,834 | 6,996 |
| Colorado | 780 | 750 | 740 | 2,652 | 2,400 | 2,590 |
| Conn. | 19 | 17 | 19 | 53 | 46 | 51 |
| Delaware | 9 | 9 | 8 | 34 | 37 | 33 |
| Idaho | 920 | 930 | 960 | 3,496 | 3,720 | 3,744 |
| Illinois | 950 | 780 | 660 | 2,375 | 2,886 | 2,772 |
| Indiana | 460 | 400 | 400 | 1,196 | 1,440 | 1,560 |
| Iowa | 2,400 | 1,900 | 1,700 | 5,640 | 5,700 | 6,375 |
| Kansas | 750 | 850 | 800 | 2,475 | 3,060 | 3,040 |
| Kentucky | 370 | 380 | 320 | 1,036 | 1,406 | 1,088 |
| Louisiana | 10 | 5 | —[a] | 28 | 14 | —[a] |
| Maine | 21 | 20 | 22 | 53 | 40 | 53 |
| Maryland | 80 | 85 | 80 | 300 | 319 | 308 |
| Mass. | 33 | 31 | 29 | 86 | 82 | 81 |
| Michigan | 1,300 | 1,300 | 1,250 | 3,380 | 4,680 | 4,875 |
| Minnesota | 2,400 | 1,700 | 1,600 | 4,560 | 4,420 | 5,120 |
| Missouri | 480 | 530 | 480 | 1,008 | 1,484 | 1,440 |
| Montana | 1,100 | 1,350 | 1,350 | 2,090 | 2,970 | 3,375 |
| Nebraska | 1,350 | 1,300 | 1,450 | 4,050 | 3,900 | 4,785 |
| Nevada | 250 | 245 | 240 | 1,050 | 1,078 | 984 |
| N. Hamp. | 17 | 16 | 15 | 42 | 41 | 37 |
| N. Jersey | 39 | 34 | 26 | 121 | 95 | 78 |
| N. Mexico | 240 | 240 | 250 | 1,176 | 1,224 | 1,250 |
| New York | 880 | 840 | 860 | 2,376 | 2,058 | 2,193 |
| N. Carolina | 30 | 35 | 30 | 83 | 105 | 87 |
| N. Dakota | 1,000 | 1,500 | 1,400 | 750 | 1,500 | 1,540 |
| Ohio | 725 | 725 | 700 | 2,103 | 2,393 | 2,800 |
| Oklahoma | 410 | 450 | 430 | 1,271 | 1,800 | 1,376 |
| Oregon | 385 | 400 | 420 | 1,579 | 1,720 | 1,806 |
| Penn. | 840 | 820 | 810 | 2,436 | 2,378 | 2,430 |
| Rh. Island | 2 | 2 | 2 | 6 | 5 | 6 |
| S. Dakota | 2,100 | 2,000 | 2,100 | 2,310 | 2,400 | 3,780 |
| Tennessee | 110 | 90 | 70 | 231 | 279 | 252 |
| Texas | 100 | 110 | 100 | 390 | 462 | 400 |
| Utah | 490 | 470 | 485 | 1,911 | 1,739 | 1,843 |
| Vermont | 100 | 105 | 105 | 220 | 247 | 252 |
| Virginia | 130 | 150 | 140 | 416 | 570 | 560 |
| Wash. | 490 | 480 | 470 | 2,058 | 2,064 | 2,256 |
| W. Virginia | 70 | 70 | 60 | 161 | 203 | 192 |
| Wisconsin | 3,100 | 3,100 | 3,000 | 4,340 | 7,130 | 8,400 |
| Wyoming | 520 | 520 | 570 | 1,196 | 1,196 | 1,368 |
| U.S. | 26,750 | 25,944 | 25,401 | 69,304 | 77,370 | 83,555 |

[a]Included in other hay.

typically are loaded into semitrailer containers for ease of delivery from receiving ports.

## Pricing Practices and Strategies

It is difficult to describe prices, practices, and strategies in the forages market because no central source of market information exists. Midmonth price estimates of all hay and alfalfa hay, tabulated monthly by state Agricultural Statistics Services, are available the next month; but estimates for the full month are available annually—usually in the early spring.

Hay prices in northern states peak during the winter months closest to the next spring growing season. Prices follow supply and demand patterns. Many commercial hay producers have the capabilities to move hay rapidly over long distances for livestock producers in drought-stricken regions.

Hay as an aggregate in the United States generally is sold by type, e.g., alfalfa, alfalfa-grass, grass, or grass-legume; cutting number; weight/bale; and storage and harvest characteristics. For the last 6 yr, Wisconsin and Minnesota have been conducting quality-tested hay auctions to establish a price based on expected feeding value (Figure 12.1). At these auctions, hay load lots are tested for nutritional composition (primarily protein content) before buying commences. Thus, buyers can consider the results of feeding value tests in conjunction with physical characteristics before agreeing on a purchase price. Forage and Grassland Councils in Minnesota and Wisconsin, as well as in other states, have supported the auctions inasmuch as they stabilize the hay marketing system.

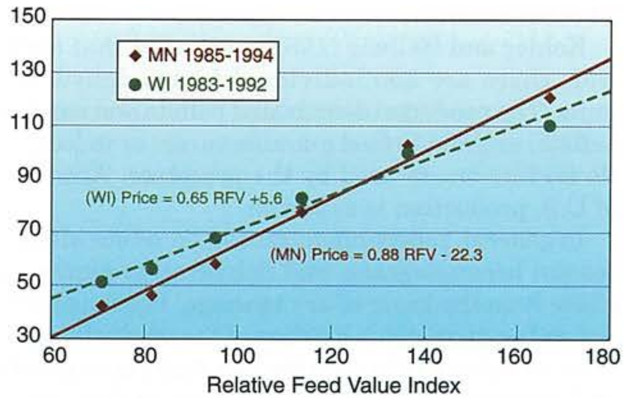


**Figure 12. 1. Average price and Relative Feed Value Index by quality test standards of hays sold at auctions in Minnesota (9 yr, 1985–1994) and Wisconsin (9 yr, 1983-1992).**

## Dehydration and Processing of Forage Crops

Although alfalfa is the primary subject of the story of forage dehydration in the United States (Kohler and Hellwig, 1985), since 1960 great amounts of dehydrated bermudagrass have been produced (40,000 to 60,000 t/yr) in the Southeast. The leading dehydrated-alfalfa production state is Nebraska, followed by Kansas. These two represent 70% of total U.S. production, the balance of which is distributed among

**Table 12.8. Summary by size of U.S. farm of the ten leading alfalfa producing states, 1987 (U.S. Department of Commerce, various years)**

| Rank/state[a] | Total farms: Land | Total farms: Alfalfa | Acres of alfalfa hay harvested per farm: 1–9 | 10–49 | 50–69 | 70–99 | 100–139 | 140–179 | 180–219 | 220–259 | 260–499 | 500–999 | 1,000–1,999 | ⊕2,000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Wisconsin | 75,131 | 51,051 | 308 | 4,018 | 1,826 | 4,739 | 5,991 | 6,500 | 5,700 | 4,785 | 12,679 | 3,804 | 630 | 71 |
| 2 California | 82,217 | 10,638[b] | 435 | 2,413 | 526 | 683 | 616 | 578 | 455 | 357 | 1,332 | 1,283 | 966 | 994 |
| 3 Iowa | 105,108 | 48,271 | 490 | 3,631 | 1,184 | 2,802 | 3,534 | 5,091 | 3,606 | 3,803 | 13,619 | 8,519 | 1,791 | 181 |
| 4 Minnesota | 85,079 | 37,906 | 287 | 3,407 | 1,186 | 2,761 | 3,161 | 4,624 | 3,221 | 3,213 | 10,121 | 4,649 | 1,112 | 164 |
| 5 Michigan | 51,172 | 22,439 | 187 | 4,014 | 1,527 | 2,914 | 2,613 | 2,153 | 1,576 | 1,247 | 3,577 | 2,014 | 525 | 92 |
| 6 Nebraska | 60,502 | 24,217 | 148 | 906 | 310 | 744 | 626 | 1,760 | 800 | 1,170 | 6,096 | 6,234 | 3,365 | 2,056 |
| 7 S. Dakota | 36,376 | 19,754 | 47 | 599 | 188 | 363 | 345 | 945 | 400 | 611 | 3,717 | 5,067 | 4,063 | 3,409 |
| 8 Idaho | 24,142 | 11,780 | 329 | 2,209 | 560 | 982 | 819 | 842 | 533 | 599 | 1,782 | 1,411 | 929 | 735 |
| 9 Montana | 24,568 | 9,988 | 71 | 959 | 233 | 371 | 298 | 374 | 255 | 258 | 1,054 | 1,180 | 1,359 | 3,576 |
| 10 Kansas | 68,579 | 15,484 | 60 | 564 | 184 | 542 | 380 | 805 | 455 | 628 | 2,847 | 3,353 | 2,340 | 1,826 |
| Average | 61,387 | 25,153 | 236 | 2,272 | 772 | 1,690 | 1,838 | 2,367 | 1,700 | 1,667 | 5,682 | 3,751 | 1,808 | 1,310 |

[a]Ten leading alfalfa producing states based on 1990 production (see Table 12.7).

[b]Farm estimates in California are reported on hay and grass silage production. Alfalfa hay data were not available.

22 other states.

Kohler and Hellwig (1985) estimated that nationwide there are 250 individual forage dehydrating units. The products (dehydrated pellets and suncured pellets) are sold to feed manufacturers or to local cattle feeders or are used by the processor. About 10% of U.S. production is exported.

In general, independent growers produce alfalfa or coastal bermudagrass, and dehydration plants purchase it on the basis of dry tonnage. Purchase prices depend on geographic location of the production, competitive value of the crop for hay making or grazing, and environmental factors affecting production.

Dehydrated forages are consumed by both monogastric (single-stomached) and ruminant (multiple-stomached) animals. The nutritional needs of these two classes differ markedly. Through the action of symbiotic rumen organisms, ruminants such as cattle, sheep, and goats can utilize much higher levels of fiber than monogastric animals such as horses and swine can. These rumen organisms also supply their hosts with water-soluble vitamins, which monogastric animals must receive from feed sources.

Although xanthophyll is unnecessary in the ruminant ration, it usually is programmed into poultry rations because of the demands for yellow-skinned, fatty broilers and for dark-yellow egg yolks. Products of fractionated, dehydrated alfalfa are better suited to each of the two classes of animals than whole alfalfa is. A product high in protein, vitamins, and xanthophyll and low in fiber is needed for the feeding of poultry and swine.

Three approaches to the fractionation problem have been developed: (1) dry separation milling; (2) separation in the field by leaf harvesting or by separate harvesting of tops and lower plant portions; and (3) wet processing by pressing. Thus far, the industry has adopted these processes to a limited extent. A wet fractionation process termed the *ProXam* process has received some commercial attention.

## Quality Measurement in the Market Channel

Quality of hay and of other harvested forage crops is defined in terms of nutritional attributes required by livestock consuming the products, antiquality traits, and physical features desired by buyers. The National Alfalfa Hay Quality Committee (NAHQC) (Marble, 1984) identified percentage moisture, percentage dry matter (DM), percentage crude protein (CP), percentage acid detergent fiber (ADF), and predictions of digestible dry matter (DDM) and digestible energy as minimum quality tests recommended to market alfalfa hay. These recommendations have been endorsed by the NHA and by the American Forage and Grassland Council (AFGC).

Additionally, the committee suggested that if a region of the United States required other quality traits to predict animal performance more precisely, further tests could be recommended provided that the region document its need and explain the proper use of such attributes. Wisconsin and Minnesota identified the need to use percentage neutral detergent fiber (NDF) to predict DM intake potential of all perennial cool season legumes, grasses, and mixtures (Jorgensen et al., 1985). Grasses as digestible as legumes often have less DM intake potential than legumes do. Many hays are a mixture of grasses and legumes. Rohweder et al. (pers. comm., 1994) have improved the definition of quality test standards proposed by Jorgensen et al. (1985) (Table 12.9). Ultimately, Wisconsin and Minnesota developed the Relative Feed Value (RFV) Index as the final parameter according to which hays are ranked by potential intake of DDM, the most limited forage nutritional factor for highly productive dairy cattle.

### Definitions of Quality Terms

*Dry matter* is the nonwater percentage of feed. Hay and other feeds must be expressed on a DM basis to indicate whether a daily ration meets animal nutrient requirements. One-hundred minus DM equals moisture percentage, which is used to determine hay storage condition. Less than 18% moisture is required

**Table 12.9. Legume, grass, and legume-grass mixture quality test standards (Linn and Martin, 1989)**

| | | Analysis | | | |
|---|---|---|---|---|---|
| Standard[a] | RFV[b] (% of DM) | ADF (% of DM) | NDF (% of DM) | DDM (%) | DMI (% of BW) |
| Prime | >151 | <31 | <40 | >65 | >3.0 |
| 1 | 151–125 | 31–35 | 40–46 | 62–65 | 3.0–2.6 |
| 2 | 124–103 | 36–40 | 47–53 | 58–61 | 2.5–2.3 |
| 3 | 102–87 | 41–42 | 54–60 | 56–57 | 2.2–2.0 |
| 4 | 86–75 | 43–45 | 61–65 | 53–55 | 1.9–1.8 |
| 5 | <75 | >45 | >65 | <53 | <1.8 |

[a]Standard assigned by Hay Market Task Force on American Forage and Grassland Council.

[b]RFV = relative feed value; ADF = acid detergent fiber; NDF = neutral detergent fiber; DDM = digestible dry matter; DMI = dry matter intake; DM = dry matter; BW = body weight.

for safe storage.

*Crude protein*, determined by measuring total nitrogen and multiplying by 6.25, is a mixture of true protein and nonprotein nitrogen.

*Acid detergent fiber* is the percentage of fiber in forage samples that is soluble in weak acid. This characteristic represents complex carbohydrates (cellulose and lignin) as well as silica and aids in determining the amount of forage digested by animals.

*Neutral detergent fiber*, the percentage of fiber in forage samples that is undigestible in neutral detergent solution, includes ADF (except pectin) and hemicellulose. Digestible only partly by animals, NDF represents the cell wall. An NDF value of 100 indicates that cells are highly digestible. Because NDF is related inversely to voluntary intake, as NDF increases, intake declines.

*Digestible dry matter*, an estimate of the relative amount of digestible forage, is determined from percentage ADF (Rohweder, 1984), by means of the equation

$$\%\ \mathrm{DDM} = 88.9 - (\%\ \mathrm{ADF} \times 0.779).$$

Digestible dry matter is an in vivo animal determination; it therefore equals percentage of total digestible nutrients (TDN):

$$\%\ \mathrm{DDM} = \%\ \mathrm{TDN} \text{ for cool-season legume and grass.}$$

*Dry matter intake (DMI)*, an estimate of the relative amount of forage an animal will eat when only forage is fed, is determined from NDF (Mertens, 1985) by means of the equation

$$\mathrm{DMI} \text{ as a } \% \text{ of body weight} = 120/\text{forage NDF (of DM)}.$$

*Relative feed value* is an index used to rank cool-season perennial forage crops according to their potential intakes of DDM. The RFV Index does not incorporate CP, as proposed originally by Rohweder and Baylor (1980), because protein in grasses does not correlate with fiber. The RFV index is used to allocate the correct forage to specific animal performance; to price hay (highest test value correlated with price at quality-tested hay auctions); and to assess forage management, harvest, and storage skills.

$$\text{RFV index} = \mathrm{DDM} \times \mathrm{DMI}/1.29.$$

## Antiquality Parameter

Forages at times can contain compounds that are toxic or result in diminished animal performance. Although especially prevalent in weeds or in other plants that invade forages, these compounds can occur in forage crops under adverse growing and improper storage conditions. Routine analysis of all antiquality traits is impractical, but analysis should be conducted when conditions warrant. Drought, frost, and any condition causing plant stress often can lead to development of antiquality compounds such as nitrate, prussic acid, and mycotoxins.

## Physical Attributes

Knowledge of the physical attributes of hay is essential to buyers. The NAHQC recommends using a hay product description sheet that identifies the lot by harvest date, cutting number, and maturity stage; describes the lot quantity, bale size, and storage type; and describes the hay in terms of color, foreign material, leaf attachment, injurious foreign material, stem-to-leaf relation, odor, visible mold, stem texture, drying agent, and preservative.

## Importance of Quality Attributes

Forage crops supply nutrients to ruminant livestock, and forage quality influences quality performance (Marten and Martin, 1986). Animal performance and supplemental feed needs in turn influence livestock profitability and hay price. Thus, identification of quality tests and physical description tests of hay are needed if hay markets are to develop into commodity trading. Hay is too diverse a material in description and in feeding value to warrant less than testing before purchase. Buyers, processors, and users alike need quality-test information.

## Quality Measurement and Control at Each Point in the Market Channel

Although voluntary in hay marketing, quality testing is increasing in frequency. Data on the amount of hay tested are not available, but testing is done increasingly at the request of buyers (especially dairy farmers). Commercial forage testing laboratories and university service laboratories test hay. A voluntary laboratory certification program is operated by the National Forage Testing Association (NFTA) to certify the accuracy of tests for DM, CP, and ADF in alfalfa hay.[38]

The laboratory certification program was initiated in 1985 from subcommittee action of the National Hay Quality Committee (NHQC). In that year, 46 forage testing laboratories were certified; the 1992 list contained 116 labs. Information about laboratory certification and test variation between laboratories is beginning to be disseminated to producers. The use of quality test information is between buyers and sellers, with no other control than laboratory certification and implementation of standards recommended by the NHQC.

# Grades and Standards

## Description

No official grades or standards for hay and straw are published in the *Federal Register* by the USDA–FGIS. But uniform alfalfa-hay testing standards provided by the NAHQC have been implemented privately by the National Alfalfa Hay Testing Association (NAHTA) (Hannaway, 1986) in cooperation with the NHA and the AFGC. The NAHTA has been renamed and incorporated as the NFTA. Quality test standards for cool-season legumes, grasses, and mixtures featuring the RFV concept are being used in Minnesota and in Wisconsin (Table 12.9) (Linn and Martin, 1989). Extension and industry programs in Illinois, Indiana, Kentucky, Missouri, Oregon, South Dakota, Utah, and Wyoming feature these or their own standards. The latter usually contain measures of CP, some form of available energy, and mineral and DM concentrations.

For example, the University of Florida program relies on a quality index (QI) to express intake of digestible energy as a multiple of TDN maintenance requirements (Moore, 1987). Speakers at the Forage Crop Workshop of the 1988 conference *Agricultural Products Quality and Competitiveness: Now and in the Future* recommended that the United States develop a voluntary uniform indexing system to be incorporated into the current uniform hay test.

## Authority for Quality Certification

State governments are authorized to bond hay and straw dealers. Additionally, some states have established criteria with which to inspect hay for noxious weeds. The AMA of 1946, as amended (7 U.S.C. 1621 et seq) pursuant to section 203(c) of the Act (7 U.S.C. 1622[c]), outlined U.S. standards for the marketing of hay and straw.

Originally, there were 300 standards for hay and straw, but these gradually became outdated, were available only from a few qualified inspectors, and omitted factors measuring composition or nutritional attributes. As such, the grades failed to meet the informational needs of the hay industry. When the Hay Marketing Task Force of the AFCG and other groups failed to persuade the USDA to change the standards and to include the factors related to nutritional value, the U.S. hay and straw standards were dropped by the USDA–FGIS effective March 13, 1988 (*Federal Register*, 1987).

The hay industry, as represented by the NHA and the AFGC, has implemented the uniform hay test on alfalfa and, through the efforts of the NFTA, will expand test standards to include more tests on alfalfa and tests on other hays and other forages. The industry resisted efforts to introduce tests to measure chemical composition because the testing method depended on time consuming, expensive procedures. Until rapid and reliable methods for measuring components became available, constant delays in obtaining chemical analyses prevented rapid adoption of such tests.

To market hay according to quality test standards, forage and grassland councils in Wisconsin, Minnesota, Illinois, and Michigan and departments of agriculture in Illinois and Utah established educational programs in conjunction with mobile NIR spectroscopy units. Quality-tested hay auctions were established in Wisconsin (1983) and in Minnesota (1985) to evaluate the influence of testing on price.

These and similar programs developed in the 1980s provide the foundation for a marketing system based on a combination of personal inspection and nutritional analysis. The opportunity to identify physical attributes visually in conjunction with NIR spectroscopy results and to use an index (RFV) ranking hay in terms of potential animal performance has led to the successful establishment of hay markets based on voluntary quality testing.

## Measurement Technology for Quality

Norris et al. (1976) proposed NIR spectroscopy as a rapid, accurate, precise, and nonconsumptive method of evaluating the quality of forages and of other feed stuffs. The NAHQC (Marten, 1984) recommend-

[38]Officers of the association can be reached at National Forage Testing Association, PO Box 371115, Omaha, Nebraska 68137.

ed that alfalfa hay be tested by either this method or conventional chemical methods. Routine analyses of hay by means of NIR spectroscopy involve DM, CP, ADF, ADF-CP, NDF, calcium, phosphate, potassium, and magnesium. On-site analysis and rapid return make such tests results accessible to the marketplace. The National NIR Spectroscopy Forage Research Network (Templeton et al., 1981) has provided recommendations for successful use of this method.

Analyses of dehydrated alfalfa or of alfalfa protein processing by-products are conducted using conventional chemistry. Limited use of these products and tests may have constrained the use of NIR spectroscopy in quality analyses.

## Quality-Related Issues

1. No uniform grades and standards are being used to access hay quality. Excellent methods are available but voluntary. Voluntary grades and standards developed within the industry may limit the amount of information available from which to estimate value and price of hay in commercial sales.
2. Export demand likely will increase. And increased demand of foreign buyers for accurate quality descriptions may necessitate an objective third-party measurement of quality and a uniform reporting system. Hay buyers in the international market are not likely to inspect or to test each shipment of hay personally. Instead, they will require uniform grades and standards to facilitate efficient marketing.
3. Uncertainty in farm programs, especially in the Conservation Reserve Program, creates uncertainty regarding the supply of hay with specific qualities. The export market is expanding rapidly, and Japan now buys nearly 1 million t of various types of forage from the United States annually. This market has been growing at a rate of 10 to 20%/yr.
4. Educational and promotional efforts are needed not only to assist foreign buyers in selecting the qualities best suiting their needs, but also to assist domestic buyers having special use and nutritional requirements. There is a gradual shift from low-quality forages to high-quality feedstuffs such as alfalfa. The nutritional properties of the latter will place increasing demands on industry or government agencies to provide more detailed information with assurances built into a system of accurate value and price reporting.
5. The industry now has a uniform test for quality in place. This test is controlled by the AFGC and the NHA. Laboratories have been certified for a uniform test developed for all the systems with input from the USDA. The development of past and future technologies could be accelerated with support from government agencies and from private trade associations.
6. New measurement technology is required to provide rapid, repeatable, and accurate information about nutritional characteristics of forages. Although NIR spectroscopy is available, a major effort is needed on the part of extension and the USDA to support and to train users. Research to improve calibration also is essential. It has been recommended that the USDA establish a national NIR spectroscopy technology transfer center to be funded by a public/private consortium (Agricultural Products Quality and Competitiveness: Now and for the Future, 1988).

## Glossary

**Acid detergent fiber (ADF).** Fiber percentage in forage samples that is soluble in weak acid. Representing complex carbohydrates (cellulose and lignin), as well as silica, and aiding in determining the amount of forage digested by animals.

**All hay.** Forages, including alfalfa and alfalfa-grass mixtures, that can be either a perennial or an annual crop harvested, suncured, and baled for storage. Primarily perennial grasses with or without legumes.

**Crude protein.** Mixture of true protein and nonprotein nitrogen; determined by measuring total nitrogen and multiplying by 6.25.

**Cube.** Dry product coarsely ground and compressed into a bulk density of at least 25 lb/ft$^3$.

**Digestible dry matter (DDM).** Estimate of the relative amount of digestible forage; determined from percentage ADF, by means of the equation: % DDM = 88.9 – (% ADF × 0.779).

**Dry matter.** Nonwater percentage of feed.

**Dry matter intake (DMI).** Estimate of the relative amount of forage that an animal will eat when only forage is fed; determined from neutral detergent fiber (NDF) by means of the equation: DMI as a % of body weight = 120/forage NDF (of DM).

**Forages.** Plants harvested primarily by grazing animals.

**Monogastric.** Animals having one stomach.

**Neutral detergent fiber (NDF).** Percentage of fiber in forage samples that is undigestible in neutral detergent solution and includes acid detergent fiber (except pectin) and hemicellulose. Digestible only partly by animals, NDF represents the cell wall. An NDF value of 100 indicates that cells are highly digestible. Related inversely to voluntary intake.

**ProXam.** A wet fractionation process for forage crops.

**Relative feed value (RFV).** An index used to rank cool-season perennial forage crops according to their potential intakes of digestible dry matter. Used to allocate the correct forage to specific animal performance; to price hay (highest test value correlated with price at quality-tested hay auctions); and to assess forage management, harvest, and storage skills.
RFV index = DDM × DMI/1.29.

**Ruminant.** Animals having a stomach with four cavities.

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# 13 Poultry

Paul Aho[39]

## Introduction

From its beginning in backyard flocks kept primarily for egg production, the U.S. poultry industry has become a highly concentrated and industrialized agribusiness giant dedicated primarily to the production of broiler and turkey meats. The industry employs 150,000 workers and generates $30 billion in retail sales—6% of total U.S. food expenditure. The multibillion dollar components of the industry are broilers, turkeys, and eggs. Although several million dollars worth of duck, geese, quail, pheasant, guinea, and pigeon also are sold each year, this report on quality related issues will be confined to broilers, turkeys, and eggs.

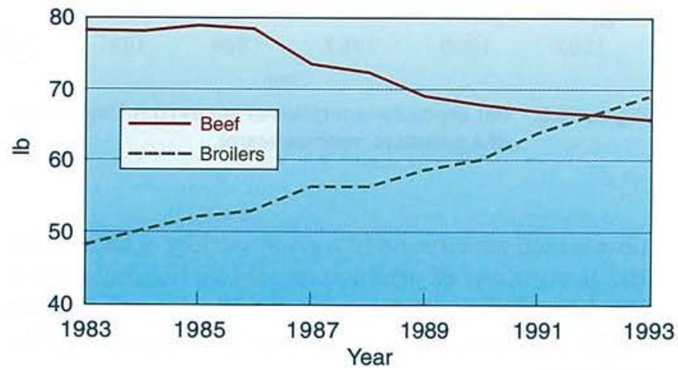


**Figure 13.1. Per capita consumption of beef and broilers (U.S. Department of Agriculture, various years).**

## Production and Use

### Major Uses: Broiler Industry

In 1976, Americans ate an average of 94 lb of beef and 42 lb of broilers. But a remarkable shift in the eating habits of the nation has occurred. Brand name marketing of whole broilers and parts began to accelerate in the early 1970s, when sales of cut-up tray packs became popular. Subsequently, beef consumption has skidded while broiler consumption has grown. By 1992, retail weight annual per capita consumption of broilers surpassed that of beef (Figure 13.1).

The fundamental reason for the popularity of chicken is that its average retail price is one-third beef's. Moreover, the poultry industry has been quick to provide the convenience foods that Americans demand. Poultry meat is being deboned, marinated, spiced, breaded, smoked, and sold to fast-food chains, five-star restaurants, schools, the military, deli counters, supermarkets, and convenience stores. Finally, chicken and turkey have been a natural choice for those limiting the amount of saturated fat in their diets. Being both healthy and economical, poultry is irresistible to consumers.

The new-found popularity of broiler meat produced in the United States is not limited to the domestic market. Between 1984 and 1993, exports increased from $220 million to nearly $1 billion. In 1993, broiler exports are expected to account for 5% of domestic broiler production.

### Major Uses: Turkey Industry

Until just a few decades ago, turkey was a relatively rare holiday food in this country. In 1960, the average American ate only 6 lb of turkey annually compared with 63 lb of beef, 60 lb of pork, and 24 lb of chicken. During the next 20 yr, the turkey industry achieved a 4-lb increase in yearly per capita consumption, reaching 10 lb in 1980. Turkey consumption rose 80% during the 1980s and reached 18 lb per capita in 1990 (Figure 13.2). Since 1990, for reasons that are not yet clear, consumption has not moved from 18 lb.

Low cost and nutritional value are the reasons cited most frequently for the success of turkey; marketing of new products, however, also has played an important role. During the 1980s, the turkey industry accelerated development of a variety of new further-processed products. As a result of the development and popularization of such products, turkey

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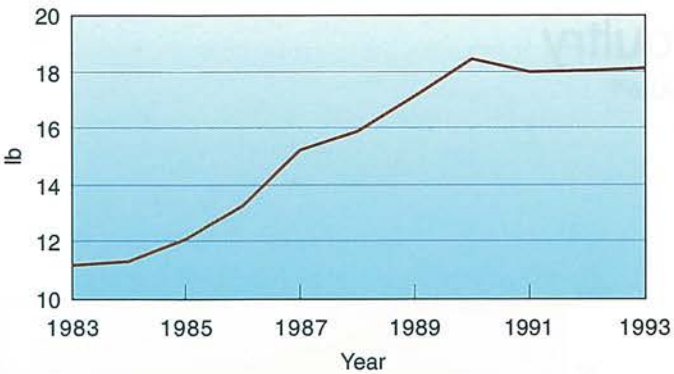


Figure 13.2. Per capita consumption of turkey (U.S. Department of Agriculture, various years).

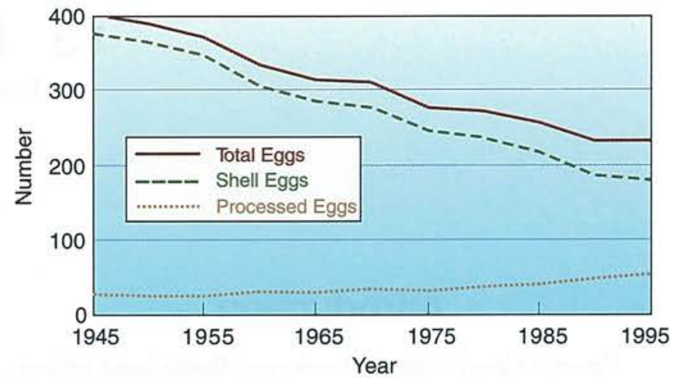


Figure 13.4. Per capita egg consumption (U.S. Department of Agriculture, various years).

now is sold year-round in a great variety of forms, and the percentage of production sold as holiday food in the last quarter of the year has decreased (Figure 13.3). Exports play a minor but growing role in the industry.

## Major Uses: Egg Industry

Shell eggs, at one time the mainstay of the traditional American-style breakfast, have faded in popularity. Per capita annual egg consumption peaked at an unusually high level during World War II, at more than 400 eggs, and has been declining at a constant rate since. Annual shell egg consumption now is fewer than 180 eggs per capita.

The decline in consumption since 1950 is illustrated in Figure 13.4. Processed egg consumption is rising, and a trend favoring new further-processed convenience foods is in place. Included in this category are products such as liquid pasteurized egg. Egg exports represent only 2% of domestic production.

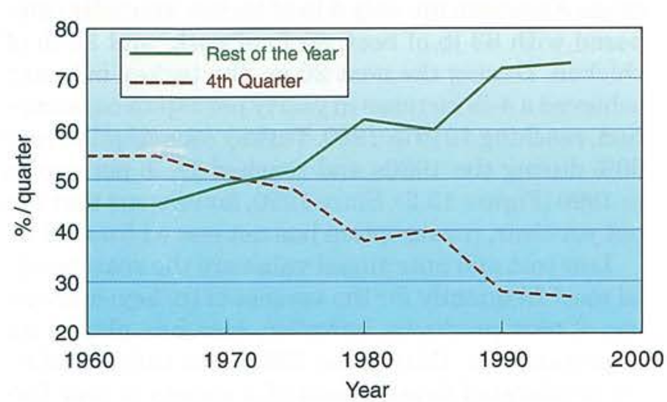


Figure 13.3. Turkey consumption—percentage by quarter (U.S. Department of Agriculture, various years).

The reasons for the dramatic decline in shell-egg consumption are many, but perhaps the most important are health concerns over cholesterol and disappearance of the American breakfast. Once the nation woke every morning to a large breakfast that usually included eggs. Now, for a great number of Americans, the day begins with another type of breakfast, or with none at all.

The only bright spot has been the consumption of processed eggs, which is increasing gradually. The latest data indicate that the increase in per capita consumption of processed eggs now has matched the decline in per capita consumption of shell eggs. Total per capita egg consumption may have reached its lowest point in the century at 233.

In summary, the U.S. poultry industry is an agribusiness giant garnering 6% of total domestic expenditure of food. The most dynamic elements of the industry are further-processed broiler and turkey meats and processed egg products.

## General Description of Production: Broilers

For approximately half the life of the broiler industry, or 33 yr, broiler production was scattered across the country. The broiler industry thrived in the Delmarva (Delaware, Maryland, and Virginia) region of the East, in the South, in New England, in the Midwest, and in the Far West. The industry then consisted of thousands of independent producers, processors, hatcheries, and feed mills that sold products to each other.

As the structure of the industry changed dramatically in the 1940s and 1950s, its location also changed. The Midwest and most of New England were abandoned for the Southeast as the industry became integrated vertically. The Southeast rose to broiler production prominence by capitalizing not only on the new structure but also on the unmatched comparative advantages of land, labor, climate and transportation.

Vertical integration in the 1950s decreased the number of firms involved in broiler production from thousands to hundreds. Later, horizontal integration decreased that number even further. In 1993, eight firms produced more than 60% of U.S. broilers.

## General Description of Production: Turkey Industry

Like the broiler industry, the turkey industry has consolidated into a handful of large firms. In contrast, however, the turkey industry has found no regional home. The four largest turkey-producing states are California, Arkansas, Minnesota, and North Carolina. At one point, Minnesota was the leading turkey-producing state; now North Carolina is. Nevertheless, the Midwest has retained a significant part of the turkey industry.

## General Description of Production: Shell Egg Industry

Over the last 40 yr, the shell egg industry has evidenced shifting production patterns (Figure 13.5). In the 1950s and the 1960s, the West and the South had a competitive edge over other regions, and the Midwest lost its leading role. By the 1980s, however, the Midwest again had become the leading egg production area. The Northeast has played a small role throughout the industry's history.

The advantage gained by the West and the South

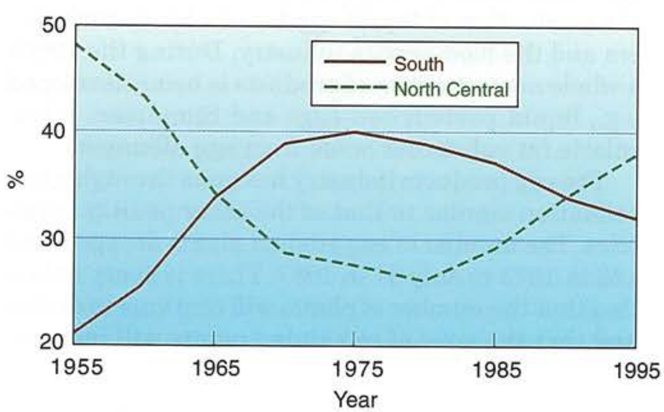


**Figure 13.5. Percentage of national egg production (U.S. Department of Agriculture, various years).**

in the 1950s and the 1960s came from low-cost housing, rapid technological adaptation, and low-cost labor. Even with high feed-costs, these two regions were able to provide for their own growing markets and to send eggs to other regions. By the 1980s, however, the technological leadership of the West and the South had diminished, as had their housing advantage, and grain transportation and labor costs had grown prohibitively expensive.

The Midwest dominated egg production just after World War II, but with aging facilities and outmoded production systems. Farmers with small facilities bought retail feed from independent feed mills and sold their product wholesale to processors—a modern recipe for disaster. But the Midwest began to regain a technological and organizational lead in the 1980s by means of in-line production and processing complexes in units with on-site feed preparation for 300,000 to 1.6 million layers. These midwestern in-line complexes now produce eggs less expensively than do any other plants in the country—and perhaps in the world. The advantage is notable, especially in the production of eggs for egg products.

Consolidation of the egg industry has been even more dramatic than that of the broiler and the turkey industries. In 1930, there were 5 million egg producers in the United States. By 1960, only 2 million. In 1980, 6,000 commercial producers remained, and in the next 8 yr, 71% of those producers left the business. By 1990, only 1,400 producers remained, and the 50 producers with 1 million or more hens owned 60% of the national laying flock.

## General Description of Production: Egg Products Industry

The egg products industry has been located wherever there are chickens producing eggs for the shell egg market. Thus, production has shifted to the Midwest as egg production has increased there.

# Organization of the Marketing System

## Overview

Poultry products are sold to two broad domestic markets—food service and retail. In the former, products are sold to commercial and institutional customers including fast-food chains, food-service distributors serving independent restaurants, supermarket delicatessens, convenience stores, schools, colleges, hospitals, cafeterias, and large-volume feeders, as well as to industrial food-processing companies. In retail markets, distributors sell food products for home consumption. These distributors include national and regional grocery chains, regional distributors, club and warehouse stores, and military installations.

Commodity producers primarily sell whole and cut-up chicken and shell eggs, whereas producers of further-processed products sell value-added products. In the latter instance, grain costs as a percentage of total product costs are reduced because of the value added to the product by cutting, deboning, cooking, packaging, or freezing. As a result, the company's profitability is less vulnerable to fluctuations in grain and market prices. Most firms therefore are increasing their production of further-processed items at the expense of bulk commodities.

Price discovery in the poultry industry is difficult to describe because of the thousands of products and the many different methods used to negotiate price. Nevertheless, market price information is available readily from state and federal sources such as the Georgia Dock price of broilers and the USDA 12-city price of broilers. Additionally, private sources of benchmark prices, e.g., the Urner-Barry large egg price, are important in contract negotiations.

## Broiler and Turkey Industries

The poultry industry grew by combining production states into large vertically integrated firms able to exploit rapidly changing biological and engineering technologies. The resulting system has fostered low real prices for poultry products. Indeed, the broiler industry often is cited as a model of the organization that may come to characterize U.S. agriculture.

In the early days of the broiler business only 50 yr ago, the major production stages of producing meat all engendered separate businesses. Independent feedmills, hatcheries, farms, and processors each sold products in a separate market.

But in the 1940s, Jesse Jewell, a feed store owner in Gainesville, Georgia, began to sell chicks to growers and to purchase their live birds, becoming the first to coordinate certain broiler production stages. After Jewell, the independent businesses once involved in the different production stages were combined by "integrators," who reduced costs by coordinating the production capacity of each stage. As a result, an industry once characterized by tens of thousands of small businesses became characterized by hundreds of vertically integrated businesses. Later through horizontal integration, that number was reduced to about 50 by the 1990s.

## Shell Egg Industry

The shell egg industry also has experienced rapid integration and consolidation although production and processing remain spread out over hundreds of firms. The combination of declining per capita consumption, increasing production/hen, and increasing farm size has reduced the number of egg producers dramatically. As mentioned, the number of egg farms in the United States has fallen from millions to somewhat more than 1,000. This dramatic decline perhaps is unmatched historically by that of any other U.S. commodity group.

Of course, such a decline in producer numbers meant that layer enterprises grew. In 1980, producers with more than 1 million hens owned 37% of the laying flock. Today, the 56 firms with more than 1 million birds own 36% of the flock. The largest egg firm, Cal-Maine Foods, Inc., owns 14 million laying hens.

## Egg Product Industry

The egg production industry originated from the need to use and thereby to salvage value from the Undergrade and checked eggs that are part of egg production. The industry began in the late 1800s, after the development of freezing and drying technologies, but was limited in size until fairly recently. The introduction in the 1950s of egg breaking and separating equipment and of pasteurization was a breakthrough that reduced labor costs and made possible the development of a variety of disease-free products.

Increase in egg breaking volumes in the 1970s and the 1980s could be attributed to a steady increase in the production of liquid egg for use by manufacturers and the food-service industry. During the 1990s, a whole new spectrum of products is being developed, e.g., liquid pasteurized eggs and Simplesse, a low-calorie fat substitute made from egg albumen.

The egg products industry has gone through a consolidation similar to that of the other poultry industries. The number of egg product plants dropped from 153 in 1973 to only 91 in 1987. There is every indication that the number of plants will continue to decline and that the sizes of remaining plants will increase.

# Quality Measurement in the Market Channel

## Important Quality Attributes

The U.S. consumer has the luxury of going to any supermarket in the country and knowing that the eggs and the poultry meat for sale have been inspected for wholesomeness by federal and state inspectors. With that assurance, the consumer can compare prices and choose the product offering the greatest value for the money.

As long as the public has confidence that the food supply is wholesome, grades and standards will be a nonissue. Eggs and poultry meat sold in the country are all Grade A. Consumers pay no attention to grade because there usually is only one offered for sale. Such transparent grades and standards maintained by federal and state inspectors can be considered successful.

## General Description: Eggs, Broilers, and Turkeys

Demand for eggs in the supermarket is extremely inelastic, and consumers buy approximately the same amount each month, regardless of price. Additionally, the brand name of the eggs is for the most part irrelevant despite repeated attempts to sell branded eggs. Consumers tend to treat all eggs equally, with the exception of brown eggs, for which they are willing to pay a premium in New England.

The demand for poultry meat is much more elastic than that for eggs, and consumers pay a great deal of attention to brand names. Additionally, value-added items have moved the poultry meat industry ever farther from a commodity base.

The popularity of poultry meat products in the U.S. is due not only to the wholesomeness of the product but to the fact that processing and marketing procedures are designed to preserve wholesomeness. Inspection regulations require that the temperature of ready-to-cook poultry be reduced to 40° F or below within 4 hr of slaughter. This temperature reduction usually is accomplished within 1 hr in continuous chilling units.

Most broilers are delivered promptly to retail stores, where they are held in refrigerated showcases until sold. Off-condition fresh poultry is rarely, if ever, found in retail outlets.

Frozen poultry, primarily turkeys, are packaged tightly in plastic and kept in freezer compartments in retail stores until sold. Frozen poultry to be stored in refrigerated warehouses not only are encased in plastic but also are packed in fiberboard master containers. Essentially no deterioration occurs in frozen products.

Most further-processed items and cut-up poultry parts are prepackaged at processing plants. Such items are packaged on fiber or plastic trays and overwrapped with plastic film. The many packaging materials available today offer excellent means of preserving poultry product quality.

Although an issue not addressed specifically by this CAST report, food safety as it relates to quality is an important issue to the poultry industry. Needless to say, the purpose of inspection of poultry for wholesomeness is to ensure safety.

Poultry inspection is required by law in the United States, and the government finances such inspection. The grading program, however, is voluntary and paid for by poultry companies. Only federally inspected poultry labeled *wholesome* may be graded by the USDA for quality. Because the poultry grading program is voluntary, its acceptance was slow at first. But during World War II, the federal government required all produce purchased for the armed services to be graded according to U.S. standards. This requirement stimulated the nearly universal use of grading.

With standards set up and enforced by the USDA, poultry products are either Grade A or Undergrade. Undergrade poultry products are salvaged in a number of ways, including, for example, the pasteurization of Undergrade eggs. The consumer normally is given no choice but to purchase Grade A products.

During World War II, there also was great interest in legislation to improve marketing practices. In 1946, the AMA was passed unanimously by Congress. Poultry grading programs now operate under the authority of this act. Through the years, rather significant adjustments in grading standards for poultry have been made although the criteria for determining quality, e.g., fleshing, fat covering, conformation, and defects, have remained essentially the same.

## Grading

The development of USDA poultry standards and grading programs can be traced to 1918, when Congress enacted legislation to authorize grading services and to establish standards and grades for farm products. One of the provisions of the legislation was that the programs be as self-supporting as possible.

Standards and grades for poultry were proposed first in 1927. Qualities were designated Prime, Choice, and Commercial. In 1943, these designations were changed to U.S. Grades A, B, and C, respectively. The original factors determining quality were based on conformation; fleshing; fat covering; and absence or presence of bruises or discolorations in skin and flesh, torn skin, and broken bones. These basic factors are evaluated today.

In 1925, the USDA issued the first U.S. quality standards for eggs and provided four quality divisions for shell eggs of edible quality: U.S. Specials, U.S. Extras, U.S. Standards, and U.S. Trades. These later were changed to AA, A, B, and C, respectively. *Dirty, stained,* and *checked eggs* also were defined. The primary quality factors considered in the specifications were conditions of shell, air cell, yolk, and white. Size and shape of yolk since have been added.

# Issues and Problems Related to Quality

## Product Research and Development

Research is needed to identify and to refine control measures to ensure product quality. Product grade and standards and their respective monitoring systems must meet specific consumer demands efficiently.

## Nutritional Quality

Processing techniques have the most influence on the nutritional quality of products. Process practices include chilling, storing, freezing, deboning, and cooking. Cooking type also has a significant effect on nutritional profile. Package type, preservation method, and storage length and condition affect the vitamin content of poultry products.

## Quality Assurance and Inspection

Quality assurance and inspection programs exist to ensure quality and wholesomeness of food products. But additional study in inspection operations is needed to keep pace with advances in science and modern technology. Processing operations should involve the Hazard Analysis and Critical Control Point (HACCP) system; state-of-the-art residue monitoring; and microbiological control of the environment during production, processing and distribution. New packaging and preservation systems extending shelf life and protecting wholesomeness will enhance the quality of poultry and egg products.

## Egg Industry

Table eggs are nutritious, cheaper than ever, and wholesome. Yet per capita egg consumption has fallen by half in the last 50 yr. The industry has put all the right things into the table egg except what the consumer rightly or wrongly wants.

The issue of food safety aside, increasing desirability (and therefore quality) among consumers depends on developing and marketing new egg products. But grades and standards will have little or no effect. The table egg itself in this country is both nearly perfect and increasingly difficult to sell. Part of this difficulty is, of course, the issue of cholesterol. Whether cholesterol continues to hurt the egg industry depends on future findings of the medical establishment.

## Uniform Standards

Besides that of ensuring wholesomeness, the most important role of the federal government is perhaps to ensure as level a playing field as possible for the trade of poultry products across the country. For example, in California, there is a minimum egg weight but no minimum dozen weight for a dozen large eggs. Federal regulations require a minimum dozen weight. Therefore, a dozen large eggs produced and sold legally in California could be underweight according to federal regulations for interstate commerce if produced in another state and sold in California.

## Food Safety

Although food safety is an issue not addressed specifically by this CAST report, it remains the focal quality issue. The purpose of poultry inspection for wholesomeness is to ensure safety. Most controversy about poultry products in the future will revolve around the issue of whether the industry and the inspection system are ensuring safety adequately.

## Price-Quality Issues

Because nearly all poultry products sold are Grade A, price differences do not occur based on grade. Differences occur based on which part of the chicken or turkey is being sold. These differences reflect current supply and demand. Most of the remaining price variation for poultry products is due to the effectiveness of marketing for branded products. Individual marketing campaigns assert that the product promoted is of the highest quality. To the extent that consumers are willing to pay more for branded products, they pay for quality.

### Information Dissemination

New market services are provided by both federal government agencies and state departments of agriculture. As mentioned, market price information is available readily from sources such as the Georgia Dock and the USDA 12-city. In addition, private sources of benchmark prices such as the Urner-Barry large egg price are important in contract negotiations.

To communicate with consumers, the poultry industry uses numerous avenues, including food product labels, marketing programs, point-of-purchase information, classroom instruction, and consumer hotlines. Consumers benefit from this information by developing an improved understanding of nutrition, product formulation, market research, and the media.

Given the structure of the industry, private brands have become a substitute for official grades. In the future, private brand labeling and promotion will become the dominant strategies for consumer determination of poultry quality inasmuch as official grading remains limited to separating the acceptable from the unacceptable.

## Anticipated Changes Influencing Quality

### Further-Processed Poultry

The popularity of further-processed poultry has increased as consumers eat more poultry meat away from home and purchase more fast preparation poultry meat for consumption at home. Growth in two-income families and decline in the amount of time that consumers wish to spend cooking or eating have influenced this trend.

The increasing popularity of further-processed meat has had a profound effect on the poultry industry because turkeys and broilers both are ideal for the fabrication of such foods. The egg, another inexpensive raw material that should be well suited for a variety of products, has been slower to appear in new markets. Nevertheless, new further-processed egg products likely will become much more popular.

### Production, Geographic

The broiler industry probably will continue to reside primarily in the southeastern and the south central regions. Nevertheless, there has been movement recently toward the construction of integrated broiler complexes located in the South but closer to the Midwest than existing plants are. Turkey production will continue to spread over the map, without a regional home.

As the promising processed-egg business locates itself there, the north central region is likely to attract most of the growth in the egg industry. Nevertheless, the other regions will continue to provide most of their own shell eggs. In all regions, surviving producers will be those who expend as much effort in marketing as in production and who deal successfully with the problems of waste disposal, flies, and odors.

### Research and Development

Research and development have improved the quality of poultry products, in both production and processing. Research and development for the promotion of poultry and egg quality is a joint responsibility of public and private sectors. Work in genetics, biotechnology, and new process technologies, to mention only three areas, has the potential to enhance product nutrition, functionality, and yield.

### Marketing Structure

Over the last several decades, the poultry industry has undergone wrenching structural change that has eliminated millions of participants. The vertical integration now characterizing this industry likely will change very little over the next few decades. The only anticipated change is increasing concentration. Although the government has a role in ensuring wholesomeness, the poultry industry increasingly will establish quality/price relations by means of new product development and marketing.

### Public Policy

Government should play at least four roles in the poultry industry. It should ensure product wholesomeness, encourage free trade, provide research support, and disseminate information to both producers and consumers.

## Inspection Procedures and Funding

Government always will play an important role in inspecting poultry products for wholesomeness. Clear written interpretations of policy thus are necessary. Examples of areas without clear written interpretation are those of body checks and egg downgrading. Another important inspection issue is uncertain funding: poultry meat production is threatened yearly at budget time. A welcome development in the poultry industry has been the joint private-public cooperative activities associated with HACCP programs, which are dealt with in detail in the CAST report *Foodborne Pathogens: Risks and Consequences*. (Council for Agricultural Science and Technology, 1994).

As the United States instructs eastern Europe and the Soviet Union on the functioning of free markets, it should not take its own market for granted. The example of nonstandard standards as a barrier to egg trade in California has been mentioned. A potential barrier to trade was the proposed New York requirement of *Salmonella enteritidis* testing for eggs. For free interstate trade, one standard of egg and flock safety is ideal.

## Research Activities and Funds

Another important role for government is investing in research and development. The real cost in current dollars of broilers, turkeys, and eggs has been declining for decades because there has been an ongoing and significant investment in poultry research and development by state agricultural experiment stations, land grant universities, the USDA, and suppliers of poultry inputs. An example of the fruits of that research can be seen on a graph representing the decline in both prices and costs of ready-to-cook broiler meat over the last 14 yr (Figure 13.6). An important activity for the public sector is to continue funding such productive research.

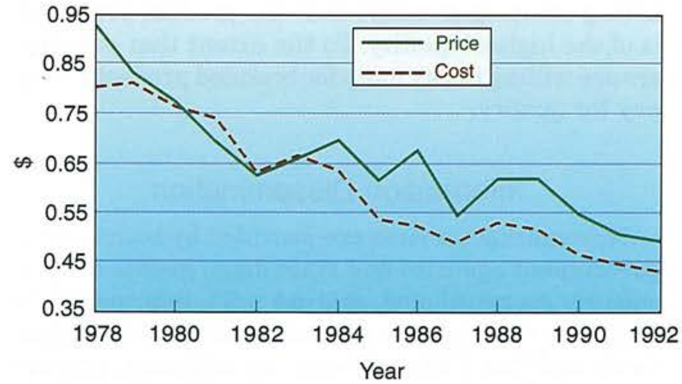


**Figure 13.6. Wholesale broiler price and cost in 1990 cents/ resistance to compression pound (U.S. Department of Agriculture, various years).**

## Information

Finally, the federal government has a responsibility to provide quality information to consumers. This activity will be especially important in the future, when issues of quality/price relations will be complicated by intensive nationwide marketing efforts for most foods, including poultry. Need will increase for independent and objective voices in the healthy debate concerning the relative values of foods.

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# 14 Beef, Pork, and Lamb

Keith E. Belk, H. Russell Cross, Lawrence A. Duewer, Randal P. Garrett, Kenneth E. Nelson[40]

## Introduction

Beef, pork, veal, and lamb constitute a major part of the American diet. In 1994, 96.5 lb of beef, 68.4 lb of pork, 1.1 lb of veal, and 1.3 lb of lamb and mutton were consumed per capita, on a carcass weight basis.

These figures compare with 79.4 lb of chicken and 18 lb of turkey per capita, on a ready-to-cook basis. Over the past two decades, production and consumption of poultry have been increasing at the expense of red meat, in response to changing tastes, health concerns, and price differentials. In 1981, per capita consumption of red meat in the United States was 178 lb; in 1994, 167 lb.

But measured as per capita disappearance or as production value, red meat long has been recognized as an important American agricultural product. In 1993, farm cash receipts from the sale of cattle, swine, and sheep were estimated at $51 billion and $47 billion in 1994.

Any analysis of the U.S. meat supply must take into account meat appearance, nutrition, health, and consumer preference. The structures of production, processing, and marketing sectors influence industry ability to respond to questions about such quality factors.

This analysis of quality issues will both discuss fresh and processed beef, pork, and lamb (including mutton) and extend the market chain to retail. In this manner, measurement of quality and assessment of government grade and private label brand values can be provided to consumers.

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## Consumption and Use

### Beef

Most beef is purchased as fresh meat in stores or as ready-to-eat meals in food-service establishments. A much smaller amount is sold as prepared processed products.

Most U.S. beef is produced and consumed domestically, but increased access to foreign markets is causing increased returns from export trade (a record $2.2 billion in 1994). Most U.S. exports (57% in 1993) are feedlot finished steer and heifer beef to Japan. Used for hamburger and manufactured products, grass-fed beef from Australia and New Zealand is the most frequently imported type of beef (65% in 1993). Exports on a carcass weight equivalent basis were 6.5% of domestic production in 1994; imports, 9.8% (Table 14.1). Per capita consumption of beef has declined from its peak of 127.5 lb carcass weight in 1976 to 96.5 lb in 1994.

### Pork

Fresh pork comprises approximately one-third of U.S. pork sales; processed products, the remainder. Thirty-five to forty percent of all pork is sold through food-service establishments, but most is sold through retail outlets.

Processed pork products include frankfurters, luncheon loaves, and smoked and fermented sausages. Cured and smoked hams are sold in forms ranging from whole, bone-in, country-style hams to boneless, sectioned, and formed ham slices.

In 1994, 17.7 billion lb of pork was produced in the United States. Only 540 million lb was exported, whereas 744 million lb was imported.

Per capita annual pork consumption (boneless equivalent) has risen since 1970, ranging from 45 to 50 lb (Table 14.2).

**Table 14.1. Red meat supply and utilization, carcass and retail weight (U.S. Department of Agriculture, 1995)[a]**

| Total | Production: Commercial (million lb) | Production: Total (million lb) | Beginning stocks (million lb) | Imports (million lb) | Total supply (million lb) | Exports (million lb) | Ending stocks (million lb) | Total disappearance (million lb) | Per capita: Carcass weight (lb) | Per capita: Retail weight (lb) |
|---|---|---|---|---|---|---|---|---|---|---|
| Beef | | | | | | | | | | |
| 1993 | | | | | | | | | | |
| I | 5,357 | 5,394 | 360 | 741 | 6,495 | 267 | 390 | 5,838 | 22.7 | 15.9 |
| II | 5,690 | 5,706 | 390 | 580 | 6,676 | 346 | 362 | 5,968 | 23.1 | 16.2 |
| III | 6,076 | 6,092 | 362 | 607 | 7,061 | 334 | 433 | 6,294 | 24.3 | 17.0 |
| IV | 5,819 | 5,867 | 433 | 473 | 6,763 | 328 | 529 | 5,906 | 22.8 | 15.9 |
| Year | 22,942 | 23,049 | 360 | 2,401 | 25,810 | 1,275 | 529 | 24,006 | 93.0 | 65.1 |
| 1994 | | | | | | | | | | |
| I | 5,744 | 5,781 | 529 | 682 | 6,992 | 359 | 560 | 6,073 | 23.4 | 16.4 |
| II | 6,044 | 6,060 | 560 | 603 | 7,223 | 391 | 506 | 6,326 | 24.3 | 17.0 |
| III | 6,378 | 6,394 | 506 | 587 | 7,487 | 416 | 536 | 6,535 | 25.0 | 17.5 |
| IV | 6,116 | 6,154 | 536 | 520 | 7,210 | 415 | 557 | 6,238 | 23.8 | 16.7 |
| Year | 24,282 | 24,389 | 529 | 2,392 | 27,310 | 1,581 | 557 | 25,172 | 96.5 | 67.5 |
| 1995 | | | | | | | | | | |
| I[b] | 5,975 | 6,012 | 557 | 705 | 7,274 | 405 | 500 | 6,369 | 24.3 | 17.0 |
| II[b] | 6,100 | 6,116 | 500 | 695 | 7,311 | 435 | 450 | 6,426 | 24.4 | 17.1 |
| III[b] | 6,400 | 6,416 | 450 | 640 | 7,506 | 450 | 425 | 6,631 | 25.1 | 17.6 |
| IV[b] | 6,150 | 6,188 | 425 | 595 | 7,208 | 445 | 450 | 6,313 | 23.9 | 16.7 |
| Year[b] | 24,625 | 24,732 | 557 | 2,635 | 27,924 | 1,735 | 450 | 25,739 | 97.7 | 68.4 |
| Pork | | | | | | | | | | |
| 1993 | | | | | | | | | | |
| I | 4,204 | 4,224 | 385 | 177 | 4,786 | 87 | 385 | 4,314 | 16.8 | 13.0 |
| II | 4,151 | 4,160 | 385 | 163 | 4,708 | 100 | 414 | 4,194 | 16.3 | 12.6 |
| III | 4,140 | 4,149 | 414 | 184 | 4,747 | 95 | 372 | 4,280 | 16.5 | 12.8 |
| IV | 4,535 | 4,555 | 372 | 216 | 5,143 | 153 | 359 | 4,631 | 17.9 | 13.9 |
| Year | 17,030 | 17,088 | 385 | 740 | 18,213 | 435 | 359 | 17,419 | 67.5 | 52.3 |
| 1994 | | | | | | | | | | |
| I | 4,182 | 4,202 | 359 | 205 | 4,766 | 104 | 468 | 4,194 | 16.1 | 12.5 |
| II | 4,240 | 4,249 | 468 | 206 | 4,923 | 115 | 482 | 4,326 | 16.6 | 12.9 |
| III | 4,326 | 4,335 | 482 | 168 | 4,985 | 131 | 419 | 4,435 | 17.0 | 13.2 |
| IV | 4,913 | 4,933 | 419 | 165 | 5,517 | 190 | 430 | 4,897 | 18.7 | 14.5 |
| Year | 17,661 | 17,719 | 359 | 744 | 18,822 | 540 | 430 | 17,852 | 68.4 | 53.1 |
| 1995 | | | | | | | | | | |
| I[b] | 4,475 | 4,495 | 430 | 180 | 5,105 | 130 | 435 | 4,540 | 17.3 | 13.4 |
| II[b] | 4,325 | 4,334 | 435 | 190 | 4,959 | 125 | 400 | 4,434 | 16.9 | 13.1 |
| III[b] | 4,425 | 4,434 | 400 | 180 | 5,014 | 110 | 380 | 4,524 | 17.2 | 13.3 |
| IV[b] | 4,700 | 4,720 | 380 | 180 | 5,280 | 130 | 375 | 4,775 | 18.1 | 14.0 |
| Year[b] | 17,925 | 17,983 | 430 | 730 | 19,143 | 495 | 375 | 18,273 | 69.4 | 53.8 |
| Veal | | | | | | | | | | |
| 1993 | | | | | | | | | | |
| I | 69 | 75 | 5 | | 80 | | 5 | 75 | 0.3 | 0.2 |
| II | 63 | 66 | 5 | | 71 | | 4 | 67 | 0.3 | 0.2 |
| III | 66 | 69 | 4 | | 73 | | 5 | 68 | 0.3 | 0.2 |
| IV | 69 | 75 | 5 | | 80 | | 4 | 76 | 0.3 | 0.2 |
| Year | 267 | 285 | 5 | | 290 | | 4 | 286 | 1.1 | 0.9 |
| 1994 | | | | | | | | | | |
| I | 71 | 77 | 4 | | 81 | | 4 | 77 | 0.3 | 0.2 |
| II | 68 | 71 | 4 | | 75 | | 5 | 70 | 0.3 | 0.2 |
| III | 68 | 71 | 5 | | 76 | | 6 | 70 | 0.3 | 0.2 |
| IV | 70 | 76 | 6 | | 82 | | 5 | 77 | 0.3 | 0.2 |
| Year | 277 | 295 | 4 | | 299 | | 5 | 294 | 1.1 | 0.9 |
| 1995 | | | | | | | | | | |
| I[b] | 74 | 80 | 6 | | 86 | | 6 | 80 | 0.3 | 0.3 |
| II[b] | 68 | 71 | 6 | | 77 | | 5 | 72 | 0.3 | 0.2 |
| III[b] | 68 | 71 | 5 | | 76 | | 5 | 71 | 0.3 | 0.2 |
| IV[b] | 74 | 80 | 5 | | 85 | | 5 | 80 | 0.3 | 0.3 |
| Year[b] | 284 | 302 | 6 | | 308 | | 5 | 303 | 1.2 | 1.0 |

**Table 14.1. continued**

| Total | Production: Commercial (million lb) | Production: Total (million lb) | Beginning stocks (million lb) | Imports (million lb) | Total supply (million lb) | Exports (million lb) | Ending stocks (million lb) | Total disappearance (million lb) | Per capita: Carcass weight (lb) | Per capita: Retail weight (lb) |
|---|---|---|---|---|---|---|---|---|---|---|
| Lamb and mutton | | | | | | | | | | |
| 1993 | | | | | | | | | | |
| I | 82 | 85 | 8 | 15 | 108 | 2 | 7 | 98 | 0.4 | 0.3 |
| II | 88 | 89 | 7 | 14 | 110 | 2 | 13 | 95 | 0.4 | 0.3 |
| III | 80 | 81 | 13 | 13 | 107 | 2 | 13 | 91 | 0.4 | 0.3 |
| IV | 79 | 82 | 13 | 12 | 107 | 2 | 8 | 97 | 0.4 | 0.3 |
| Year | 329 | 337 | 8 | 53 | 398 | 8 | 8 | 381 | 1.5 | 1.3 |
| 1994 | | | | | | | | | | |
| I | 86 | 89 | 8 | 13 | 110 | 2 | 11 | 97 | 0.4 | 0.3 |
| II | 79 | 80 | 11 | 14 | 105 | 3 | 12 | 90 | 0.3 | 0.3 |
| III | 66 | 67 | 12 | 11 | 90 | 2 | 9 | 79 | 0.3 | 0.3 |
| IV | 73 | 76 | 9 | 13 | 98 | 2 | 11 | 85 | 0.3 | 0.3 |
| Year | 304 | 312 | 8 | 51 | 371 | 9 | 11 | 351 | 1.3 | 1.2 |
| 1995 | | | | | | | | | | |
| I[b] | 76 | 79 | 11 | 14 | 104 | 2 | 7 | 95 | 0.4 | 0.3 |
| II[b] | 76 | 77 | 7 | 14 | 98 | 2 | 10 | 86 | 0.3 | 0.3 |
| III[b] | 65 | 66 | 10 | 10 | 86 | 2 | 9 | 75 | 0.3 | 0.3 |
| IV[b] | 68 | 71 | 9 | 12 | 92 | 2 | 9 | 81 | 0.3 | 0.3 |
| Year | 285 | 293 | 11 | 50 | 354 | 8 | 9 | 337 | 1.3 | 1.1 |
| Total red meat | | | | | | | | | | |
| 1993 | 40,568 | 40,759 | 758 | 3,194 | 44,711 | 1,718 | 900 | 42,092 | 163.0 | 119.6 |
| 1994 | | | | | | | | | | |
| I | 10,083 | 10,149 | 900 | 900 | 11,949 | 465 | 1,043 | 10,441 | 40.2 | 29.4 |
| II | 10,431 | 10,460 | 1,043 | 823 | 12,326 | 509 | 1,005 | 10,812 | 41.5 | 30.4 |
| III | 10,838 | 10,867 | 1,005 | 766 | 12,638 | 549 | 970 | 11,119 | 42.6 | 31.2 |
| IV | 11,178 | 11,245 | 970 | 698 | 12,913 | 607 | 1,004 | 11,302 | 43.2 | 31.7 |
| Year | 42,530 | 42,721 | 900 | 3,187 | 46,808 | 2,130 | 1,004 | 43,674 | 167.4 | 122.8 |
| 1995 | | | | | | | | | | |
| I[b] | 10,600 | 10,666 | 1,004 | 899 | 12,569 | 537 | 948 | 11,084 | 42.2 | 31.0 |
| II[b] | 10,569 | 10,598 | 948 | 899 | 12,445 | 562 | 865 | 11,018 | 41.9 | 30.7 |
| III[b] | 10,958 | 10,987 | 865 | 830 | 12,682 | 562 | 819 | 11,301 | 42.8 | 31.4 |
| IV[b] | 10,992 | 11,059 | 819 | 787 | 12,665 | 577 | 839 | 11,249 | 42.5 | 31.2 |
| Year[b] | 43,119 | 43,310 | 1,004 | 3,415 | 47,729 | 2,238 | 839 | 44,652 | 169.5 | 124.3 |
| Total red meat and poultry | | | | | | | | | | |
| 1993 | | 68,087 | 1,408 | 3,194 | 72,688 | 3,953 | 1,515 | 67,221 | 260.3 | 207.6 |
| 1994 | | | | | | | | | | |
| I | | 16,986 | 1,515 | 900 | 19,401 | 1,106 | 1,769 | 16,526 | 63.6 | 50.5 |
| II | | 17,773 | 1,769 | 823 | 20,366 | 1,290 | 1,960 | 17,115 | 65.7 | 52.2 |
| III | | 18,429 | 1,960 | 766 | 21,155 | 1,324 | 2,055 | 17,777 | 68.1 | 54.2 |
| IV | | 18,655 | 2,055 | 693 | 21,403 | 1,525 | 1,700 | 18,178 | 69.4 | 55.6 |
| Year | | 71,844 | 1,515 | 3,182 | 76,541 | 5,245 | 1,700 | 69,596 | 266.8 | 212.5 |
| 1995 | | | | | | | | | | |
| I[b] | | 16,986 | 1,515 | 900 | 19,401 | 1,106 | 1,769 | 16,526 | 63.6 | 50.5 |
| II[b] | | 17,773 | 1,769 | 823 | 20,366 | 1,290 | 1,960 | 17,115 | 65.7 | 52.2 |
| III[b] | | 18,429 | 1,960 | 766 | 21,155 | 1,324 | 2,055 | 17,777 | 68.1 | 54.2 |
| IV[b] | | 18,655 | 2,055 | 693 | 21,403 | 1,525 | 1,700 | 18,178 | 69.4 | 55.6 |
| Year[b] | | 71,844 | 1,515 | 3,182 | 76,541 | 5,245 | 1,700 | 69,596 | 266.8 | 212.5 |

[a]Totals may not add due to rounding.

[b]Forecast.

## Lamb

Although sheep and lamb sales constituted only 9.5% of total meat animal receipts in 1993, in absolute terms this percentage translated into 651 million lb of lamb and mutton production worth $489 million. In 1994, Americans were forecast to purchase 1.2 lb of lamb meat per capita on a retail weight basis (Figure 14.1) and 1.4 lb per capita on a carcass weight basis.

Sheep are dual purpose animals, and wool receipts in 1993 accounted for 7% of total sheep cash-receipts.

**Table 14.2. Per capita trimmed, boneless equivalent consumption of red meat, poultry, and fish, (pounds) 1960–1993[a] (U.S. Department of Agriculture, various years)**

| Year | Poultry: Chicken | Poultry: Turkey | Beef | Pork | Veal and lamb | Fish and shellfish | Total |
|---|---|---|---|---|---|---|---|
| 1960 | 19.2 | 4.9 | 59.8 | 48.9 | 7.4 | 10.3 | 150.5 |
| 1966 | 24.7 | 6.3 | 73.8 | 43.1 | 5.8 | 10.9 | 164.6 |
| 1970 | 27.4 | 6.4 | 79.6 | 48.0 | 4.1 | 11.7 | 177.3 |
| 1976 | 28.5 | 7.0 | 88.8 | 40.3 | 3.9 | 12.9 | 181.4 |
| 1980 | 32.5 | 8.1 | 72.1 | 52.1 | 2.3 | 12.4 | 179.4 |
| 1987 | 39.1 | 11.6 | 69.5 | 45.6 | 2.3 | 16.1 | 184.2 |
| 1989 | 40.5 | 13.1 | 65.4 | 48.4 | 2.0 | 15.6 | 185.0 |
| 1990 | 42.2 | 13.8 | 64.0 | 46.4 | 1.9 | 15.0 | 183.3 |
| 1991 | 43.9 | 14.1 | 63.1 | 46.9 | 1.8 | 14.8 | 184.7 |
| 1992 | 45.9 | 14.2 | 62.8 | 49.5 | 1.8 | 14.7 | 188.8 |
| 1993[b] | 47.1 | 14.1 | 61.5 | 48.7 | 1.8 | 14.9 | 187.9 |

[a]U.S. Department of Agruculture. Various issues. Food Consumption, Prices, and Expenditures. Economic Research Service, U.S. Department of Agriculture, Washington, D.C.
[b]Estimates.

From 1970 to 1992, production of shorn wool declined about 48% in the United States, to 83 million lb, and commercial sheep and lamb slaughter declined by more than half (Figure 14.2).

Proportionally more lamb and mutton meat than beef or pork is imported and proportionally less is exported. Thus, in percentage terms, the lamb meat industry is the largest net importer of red meat products. Domestically produced sheep meat accounted for 85% of the 1994 lamb and mutton supply whereas less than 3% of total production was exported. These percentages compared with domestic production percentages of 89 and 94 and with export percentages of 6.3 and 2.9 for beef and pork, respectively.

Mexico, Canada, and Japan have been the largest U.S. export markets; Australia and New Zealand, the largest import sources. Although documentation is incomplete, most U.S. lamb imports are fresh or frozen whole-muscle meats. In 1993, only 27.6-thousand head of live sheep and lambs were imported while 844-thousand head were exported.

The January 1, 1994 total U.S. sheep and lamb inventory was 9.1 million head (Figure 14.1), approximately 9% smaller than the previous year's total. The growth phase beginning in 1986 ended after 1990. The January 1, 1994 inventory was 20% below the January 1, 1990 inventory. Inventory currently is less than one-half the 1970 level.

Poor revenues are related to the decline in lamb and mutton meat consumption, and it is unlikely that cash wool receipts have played an important role in management decisions relative to the role of flock size. The Wool Act 2-yr phase-out began in 1994. Inventory reductions are expected to continue, and the

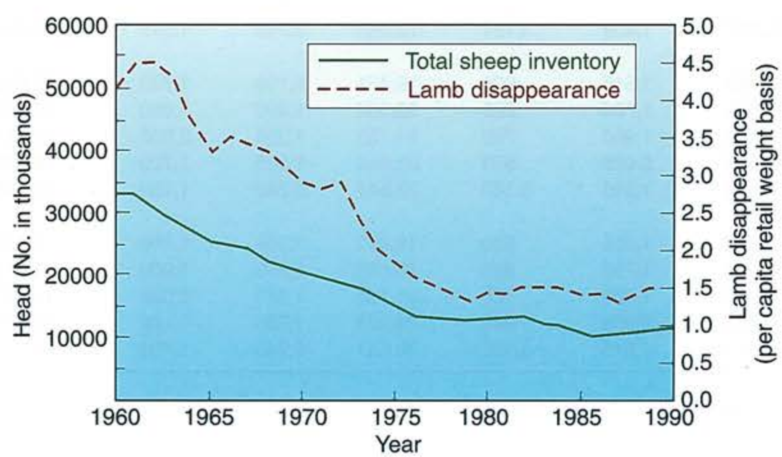


**Figure 14.1. United States sheep and lamb inventory along with per capita retail lamb disappearance between 1960 and 1990 (American Meat Institute, 1990).**

productive capabilities of the sheep industry are expected to continue declining.

All but a very small percentage of lamb meat is merchandised as chops, roasts, or ground products in retail fresh-meat display cases or as menu items at food-service establishments and restaurants. Imported lamb, when merchandised through retail stores, usually is vacuum packaged. But domestic lamb usually is packaged in plastic trays incorporating a clear film overwrap with high oxygen-transmission rates. Thus, there usually is a striking difference in perceived lean color between imported and domestic lamb products.

# Production Systems

## Beef

Beef production has become specialized such that there are now two general types of enterprises: cattle raising and cattle feeding. Maintaining a beef cow herd for the purpose of producing beef calves is called *cattle raising*, or *cow-calf production* (Table 14.3).

Feeder calves are the saleable product of cattle raising activities. Weaned calves may grow for a few months after weaning on the farm where they are born or may be sold to other cattle raisers for the growout, or stocker, phase. Because forage availability, weather, labor, capital, and other factors depend on location and season, calves are drawn to the areas and enterprises best suited for grazing at a certain time.

The great majority of steers and heifers after a period on grass or other forage are moved to a feedlot on which they are fed highly concentrated rations usually based on corn or grain sorghum. Some steer and heifer calves are fed to slaughter weight on their home farms. Cattle feeding has shifted from multiple-enterprise farmer feeders in the Corn Belt toward large specialized lots in the Plains, where cattle are fed to slaughter weights in the 1,000 to 1,300 lb range (Table 14.4).

Although cattle raising requires extensive forage land, cattle feeding requires little. Instead, feeding operations need adequate supplies of corn or other concentrates, favorable weather, and efficient technologies for turning concentrates into quality beef. Cattle feeding has become increasingly separated from cattle raising and concentrated in the Plains (Table 14.4).

**Table 14.3. Percent of total beef cows in 5 herd sizes and by region, 1964–1987 (1992)**

| Year | 1–19 | 20–99 | 100–199 | 200–499 | ≥500 |
|---|---|---|---|---|---|
| 1964 | 20.4 | 42.3 | 13.5 | 12.5 | 11.3 |
| 1978 | 14.2 | 41.3 | 15.6 | 15.2 | 13.7 |
| 1987 | 12.8 | 39.6 | 16.4 | 16.6 | 14.6 |
| | | | Region (%) | | |
| | N.E. | South | N. Central | G. Plains | West |
| 1964 | 0.9 | 23.9 | 15.5 | 38.6 | 21.1 |
| 1978 | 1.1 | 23.6 | 17.3 | 37.8 | 20.2 |
| 1987 | 1.0 | 23.0 | 14.9 | 39.0 | 22.1 |

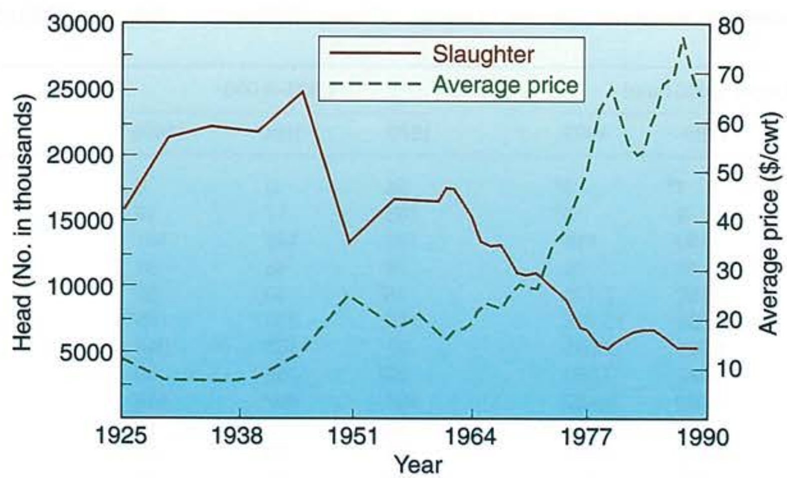


**Figure 14.2.** **United States sheep and lamb slaughter, along with average prices received by the farmer between 1925 and 1990 (American Meat Institute, 1990).**

Beef cattle are raised in every state. Types and sizes of cattle operations differ greatly and include Kentucky bluegrass pastures on which calves are born and raised in 20-cow herds; Iowa corn farms on which 50-cow herds consume crop residue; and Montana ranges on which 1,000-cow herds graze. The average U.S. beef cow herd in 1992 had 37 cows, and 93% of cattle operations had fewer than 100.

In 1993, four Plains states—Texas, Kansas, Nebraska, and Colorado—marketed more than 74% of the 22,376,000 fed cattle produced in the 13 major cattle feeding states. Eighty-seven large lots of 32,000 head or more finished 35% of the fed cattle. The 42,503 small lots with a capacity of fewer than 1,000 head marketed 13% of the cattle.

The shift in cattle feeding to the four dominant states by 1989 can be attributed, in part, to technological developments in grain production and to reduced transportation costs. Both proximity to increasing supplies of feeder cattle and development of efficient slaughter plants in the four states also helped increase output.

## Pork

United States swine production is centered in the Midwest (Table 14.5), and Iowa accounts for approximately 25% of production. Although 60% of U.S. hog operations produce fewer than 100 head/yr, these operations account for only 4.5% of hog inventory. Conversely, only 14.6% of U.S. hog operations produce more than 500 head/yr but account for 75% of the inventory.

## Lamb

Ewe flocks are maintained on range or grasslands, mountainous areas, or harvested cropland. In many parts of the world, sheep are the main source of meat, milk, and fiber for human subsistence. Historically, sheep have been bred for production either of fine or long wools or of mutton and lamb. The crossing of fine-wool with meat types has led to the development of dual-purpose breeds.

Several production schemes—purebred breeders, slaughter lamb producers, feeder lamb producers, and feedlot operators—are represented in the sheep industry. The purebred sector specializes in the development of genetic attributes transferrable to commercial ewe flocks through the sale of breeding stock. Slaughter lamb producers and feeder lamb producers together are referred to as *commercial operators* and primarily maintain ewes producing lambs for consumption. Commercial operators are either *farm-flock operators* or *range-sheep operators*. The former manage small flocks of ewes; the latter, very large flocks on large parcels of land. Farm flock operations exist primarily east of the Plains states; range operations, in the West.

Feedlot operators produce grain-fed lambs as the final stage (*finishing*) in preparation for slaughter. Feedlot lambs usually are obtained from large range-operators, who can maintain ownership and contract with feedlots to finish for slaughter or can sell the

**Table 14.4. Number of cattle feedlots by capacity groups, 13 states, 1970 and 1989 (Krause, 1991) and 1993 (U.S. Department of Agriculture, 1994)**

| | Under 1,000 head | | | 1,000–8,000 | | | ⊕∠8,000 | | |
|---|---|---|---|---|---|---|---|---|---|
| State | 1970 | 1989 | 1993 | 1970 | 1989 | 1993 | 1970 | 1989 | 1993 |
| Arizona | 8 | 7[a] | 4[a] | 28 | 0 | 0 | 24 | 8 | 7 |
| California | 153 | 9 | 9[a] | 195 | 17 | 10 | 77 | 29 | 20 |
| Colorado | 654 | 130 | 118 | 149 | 132 | 141 | 35 | 33 | 36 |
| Idaho | 546 | 45 | 78 | 78 | 45 | 34 | 11 | 13 | 13[a] |
| Illinois | 23,952 | 7,850 | 7,170 | 48[a] | 50 | 55[a] | 0 | 0 | 0 |
| Iowa | 41,829 | 16,250 | 15,105 | 166 | 250 | 195[a] | 5 | 0 | 0 |
| Kansas | 8,868 | 1,626 | 2,065 | 91 | 183 | 244 | 41 | 91 | 91 |
| Minnesota | 18,612 | 5,945 | 7,950 | 38 | 55 | 50 | 0 | 0 | 0 |
| Nebraska | 18,400 | 8,320 | 5,400 | 484 | 407 | 519 | 30 | 73 | 81 |
| Oklahoma | 753 | 223[a] | 190 | 36 | 11 | 11[a] | 11 | 16 | 14[a] |
| South Dakota | 9,049 | 4,142 | 3,900 | 48 | 58[a] | 98[a] | 3 | 0 | 0 |
| Texas | 1,300 | 639 | 502 | 140 | 51 | 37 | 90 | 110 | 101 |
| Washington | 262 | 49[a] | 18[a] | 23 | 5 | 6[a] | 7 | 11 | 6[a] |

[a]Lots from larger size groups were included to avoid disclosing individual operations.

lambs to a feedlot or to another owner. Lambs are fed high-energy rations in dry-lot pens to enhance growth and weight gain rates.

In 1994, more than 53% of all U.S. sheep were located in six states. The top ten lamb production and slaughter states are presented in Table 14.6. Ewes maintained for breeding purposes are more dispersed, however. Of the total number of lambs on feed on January 1, 1994, 62.5% were located in five states. In 1992, about 97,890 sheep production farms averaged 105 head each; ewe flock sizes, however, ranged from 20 to 8,000 head, depending on operation type.

**Table 14.5. Top ten pork production, 1993, and slaughter states, 1992 (American Meat Institute, 1994[a], 1993[b])**

| Rank | State | Total hogs produced[a] (1,000 head) | State | Hogs slaughtered[b] (1,000 head) |
|---|---|---|---|---|
| 1 | Iowa | 24,127 | Iowa | 29,684.4 |
| 2 | Illinois | 9,659 | Minnesota | 8,812.8 |
| 3 | Minnesota | 8,320 | Illinois | 8,603.8 |
| 4 | North Carolina | 8,097 | Nebraska | 5,896.6 |
| 5 | Indiana | 9,524 | South Dakota | 5,337.4 |
| 6 | Nebraska | 2,480 | Michigan | a |
| 7 | Missouri | 5,094 | Indiana | 4,702.1 |
| 8 | South Dakota | 3,086 | Missouri | a |
| 9 | Ohio | 3,084 | Ohio | 2,832.3 |
| 10 | Kansas | 2,472 | Pennsylvania | 2,222.8 |
| 11 | | | California | a |

**Table 14.6. Top ten lamb production and slaughtering states (U.S. Department of Agriculture, 1995)**

| Rank | State | Sheep and lambs on farms (Jan. 1, 1994) (1,000 head) | State | Sheep and lamb slaughter (Commercial, 1993) (1,000 head) |
|---|---|---|---|---|
| 1 | Texas | 1,710 | Colorado | 1,564 |
| 2 | California | 895 | South Dakota | 168 |
| 3 | Wyoming | 880 | New Jersey | 125 |
| 4 | Colorado | 660 | Pennsylvania | 81 |
| 5 | South Dakota | 591 | New York | 77 |
| 6 | Montana | 534 | New Mexico | 72 |
| 7 | Utah | 490 | Virginia | 26 |
| 8 | Oregon | 415 | Ohio | 20 |
| 9 | New Mexico | 405 | Wisconsin | 12 |
| 10 | Iowa | 320 | Kansas | 3 |

# Marketing System and Industry Organization

## Marketing Channel

### Beef

The great numbers of cattle available from individual feedlots have made centrally located assembly facilities unnecessary for most slaughter cattle sales. Public livestock markets now account for only a small part of the sales of slaughter steers and heifers (6.2% in 1990) (U.S. Department of Agriculture, 1992b). Although the details of direct transactions differ considerably, most large feedlots sell cattle directly to visiting packer buyers.

Cattle are traded on a live, a dressed, or a carcass basis. In 1990, 38% of slaughtered cattle were purchased on a grade and carcass weight basis (U.S. Department of Agriculture, 1992a); in 1980, 27%. Carcass-basis selling is more popular in the Corn Belt, the Northern Plains, and the Mountain states than in the Southern Plains states. Although it is easier to determine final value by means of attributes such as quality grade and yield grade, some cattle feeders prefer to have transaction price determined before cattle leave the feedlot.

### Pork

Although the pork-slaughter industry also is centered in the Midwest (Table 14.5), sizeable pork-processing facilities exist throughout the country. Market hogs usually are sold directly from producer to packer. In some areas in which there are a great number of small farms, packers operate buying stations that group hogs for transport to packing plants.

After slaughter, most pork is chilled for 18 to 24 hr before being fabricated into wholesale cuts. These cuts either are vacuum packaged and boxed for shipment to retail outlets or are bulk packaged in combination for shipment to processing operations.

### Lamb

Once finished, slaughter lambs either are marketed directly from feedlots to packers or are sold to packers through auction barns. Because the U.S. lamb slaughter industry now is quite consolidated, few market lambs are sold through sale barns, and most lamb feeding occurs in close proximity to slaughter facilities.

## Processing Sector

### Beef

The number of fed cattle marketed in the United States doubled between 1960 and 1978 and dropped 14% by 1981. The 1978 level has yet to be regained. Slaughter weight of fed cattle has increased since 1960; thus, although slightly fewer fed cattle have been marketed in recent than in past years, total weight of fed cattle has remained fairly constant.

Beef subsector-stage separation and specialization, which have led to improved production efficiency, also have created information and communication barriers that marketing and pricing systems are obliged to overcome. The size and the nature of most beef packing operations necessitate more specialized buying and selling than in any other segment of the industry. Indeed, the beef-packing industry in the United States continues to evidence the trend toward fewer and larger meat packing firms in the Plains and the western Corn Belt. Simultaneously, the advent of super feedlots allows some cattle feeders to sell more cattle than many packers buy in 1 yr.

Among the many factors shaping the structure of the meat-packing industry are livestock inventory cycles, labor strikes, labor cost-containment strategies, bankruptcies, mergers, and acquisitions. Horizontal mergers have extended, or integrated, the operations of several large firms to include numerous species of livestock. Poultry, pork, and beef now are processed by single firms, some of which also have vertical interests such as livestock production and grain merchandising and processing.

A series of bankruptcies, consolidations, mergers, and acquisitions in the 1980s led to rapidly declining firm numbers and to increasing market concentration in the meat-packing industry. Between 1975 and 1989, the number of firms reporting purchases of livestock for slaughter decreased by one-half (Table 14.7), and the percentage of steer and heifer slaughter accounted for by the four largest firms increased from 25 in 1975 to 80 in 1993 (Table 14.8). Share of total fed-beef production boxed by the top four packers reached 84% in 1990. Hog slaughter concentration remains much lower although it too has increased recently, to 43–44% (U.S. Department of Agriculture, 1995).

The impact of increased industrial concentration is unknown. The ERS and university researchers have shown that significant economies of scale exist for meat-packing plants. Large, efficient plants likely will have lower slaughter and processing costs than small ones will. The former therefore can improve marketing efficiency, which can lead to higher prices for livestock producers and/or lower prices for consumers.

Increased concentration also can mean fewer bidders for livestock and can create the fear that packers will gain market power and exhibit noncompetitive characteristics. Such fears have caused industrial groups and others to reexamine concentration and performance in meat packing. Recent increases in *captive supplies*, or livestock purchased on contract or through other control arrangements long before animals are ready for slaughter, also have renewed concern among producers.

A few studies examining whether concentration effects exist have reported some minor effects on livestock prices. But other studies have produced little evidence of poor market performance. The ERS price-spread data indicate that with high and increasing concentration levels, the farmers' share of the retail value of the USDA Choice beef dollar changed little in the decade before 1994. Farmers' share for hogs declined during the same period. The 1994 decrease resulted from the rapid decrease in farm prices beginning in May. By the end of 1995, the ERS should

**Table 14.7. Number of firms purchasing livestock for slaughter (U.S. Department of Agriculture, 1991b)**

| Year | Steers and heifers | Cows and bulls | Hogs | Sheep and lambs |
|---|---|---|---|---|
| 1975 | 656 | 714 | 440 | 193 |
| 1980 | 561 | 579 | 446 | 190 |
| 1985 | 389 | 426 | 338 | 154 |
| 1988 | 321 | 345 | 298 | 127 |
| 1989 | 282 | 319 | 277 | 124 |
| 1990 | 275 | 307 | 290 | 130 |

**Table 14.8. Percent of livestock slaughter accounted for by 4 largest firms (U.S. Department of Agriculture, 1995)**

| Year | Steers and heifers | Boxed fed beef | Cows and bulls | Hogs | Sheep and lambs |
|---|---|---|---|---|---|
| 1975 | 25.3 | NA[a] | 10.5 | 33.1 | 57.5 |
| 1980 | 35.7 | 52.9 | 9.7 | 33.6 | 55.9 |
| 1985 | 50.3 | 61.5 | 17.2 | 32.2 | 51.2 |
| 1988 | 69.7 | 79.3 | 18.4 | 33.5 | 76.5 |
| 1989 | 69.5 | 79.2 | 17.5 | 37.0 | 73.7 |
| 1990 | 72.0 | 84.0 | 20.0 | 40.0 | 70.0 |
| 1991 | 73.0 | NA | 23.0 | 42.0 | 77.0 |
| 1992 | 78.0 | NA | 24.0 | 44.0 | 78.0 |
| 1993 | 80.0 | NA | 26.0 | 43.0 | 74.0 |

[a]NA = not available

### Lamb

Average live slaughter-weights for lambs can range from 115 to 125 lb, depending on time of year. Packer-buyers normally price lambs based on the type of production system under which they were raised, the percentage of expected or actual dressing, and the carcass weight at slaughter.

Market information used in lamb trade decision making is confirmed and provided daily by the *USDA–AMS Livestock and Grain Market News*. Lamb production systems affecting prices and carcass attributes include

1. feedlot raised—finished in feedlots on high-energy diets;
2. imperial—finished in the Imperial Valley of California, on alfalfa;
3. spring—slaughtered in April or May at weaning;
4. clover—finished on clover pastures in California;
5. grass-fed—finished on grass in Washington or Oregon; and
6. mountain raised—slaughtered directly off of mountain pastures.

## Price-Quality Relations

### Beef

The matter of pricing to value is complex. Some observers tend to fix on a certain attribute or component of value without considering other relevant factors. Just as one can buy a car that goes very fast or that carries a large load or that gets good gas mileage—but not a car that does all three, effects of different attributes often are offsetting. With fed cattle, marbling usually is considered desirable; so is high cutability, high dressing percentage, physiological youth, low condemnation rate, heavy carcass (low average processing cost), good hide, little mud or dirt on the animal, and so on.

There are so many attributes—even buyer/seller characteristics such as financial reliability can come into play—that constructing a pricing formula agreeable to both buyer and seller is difficult. In many instances, a transaction price can be negotiated much more quickly than a detailed agreement.

Value based marketing (*Grade and Yield*) methods determine with relative accuracy the value of carcasses according to standardized characteristics, on an individual-animal basis and not on a pen-averaging basis. More than one-third of steers and heifers are being sold Grade and Yield, but the proportion will increase as both retail and wholesale pricing technologies, e.g., Computer Assisted Retail Decision Support (CARDS), continue to improve and as brand-naming capabilities, e.g., the Certified Angus Beef program™, are adopted.

### Pork

Several decades ago, meat packers in the United States established carcass-merit buying guidelines for the purchase of market hogs. These guidelines generated price differentials reflecting existing compositional differences and thus have been important in stimulating the increased leanness of pork during the last 20 yr. Of all price discovery points, one of the most critical is between hog producers and first-handlers. A number of merit hog-buying programs exist in the U.S. industry, but all differ in terms of value differentials for lean versus fat tissues.

Kauffman et al. (1988) surveyed 13 U.S. pork-packing companies to obtain information about their methods of hog procurement and their views of the future. Twelve had carcass-merit buying programs; all used hot-carcass weight (discounts if too heavy or too light) and fat measurements, and eight used the dorsal midline last-rib location. Two companies evaluated the off-midline tenth-rib location by means of mechanical lean-probes. Five considered muscling; two, quality indicators. Packers ranked the benefits of the carcass-merit system in this order, from most to least important:

1. gives producers incentive to produce lean hogs,
2. constitutes efficient method by which companies purchase hogs,
3. attracts producers, and
4. increases value of product purchased.

When asked to rank the disadvantages of the carcass-merit system, packers ranked the disadvantages in this order, from most important to least:

1. Loss is incurred due to sorting.
2. Discounts are assessed for fat carcasses.
3. Price differentials are too small.
4. Payment is delayed.
5. Packer is reluctant to gamble on merit of carcasses.
6. Producer lacks confidence in grading system.

It seems that most of the activity generated by carcass-merit buying programs in the United States has occurred in the past 8 yr. Undoubtedly, carcass-know whether the 1994 farmers' share decrease will continue to decline.

The report of the National Cattlemen's Association (NCA) Beef Industry Concentration/Integration Task Force, released in October 1989, recognized the importance of size economies in meat packing and their role in the evolution of livestock-marketing structures. Generally, the NCA report judged the beef-packing industry competitive and efficient. The task force did recommend, however, that "no more mergers or acquisitions of beef slaughter facilities by the Big Three packers (ConAgra, Excel and IBP) be allowed."

### Pork

Pork-slaughter and processing operations differ considerably in terms of size. The four largest hog-slaughtering companies control 43% of the market. Concentration in the hog industry has increased about 10% during the last 10 yr. Although concentration is less intense for the processed pork industry, numerous corporate mergers and acquisitions recently have increased both concentration in the processing industry and integration across the pork slaughter-to-retail industry.

### Lamb

In 1993, U.S. packing companies slaughtered 5.2 million sheep, of which 94% were lambs and yearlings. There were 711 operational federally inspected lamb slaughter facilities nationwide in 1993, but more than 95% of all sheep were slaughtered in less than 4% (31 plants) of these facilities, with each plant slaughtering more than 10,000 head annually. Since 1970, the four largest lamb-packing companies have accounted for between 45 and 78% of lamb slaughter. Currently, they account for approximately 75%.

## Pricing Methods

### Beef

Several marketing methods are used to bring buyers and sellers of stocker and feeder cattle together. Because cow-calf operations are relatively small and widely dispersed geographically, traditional livestock auctions and terminal markets still are essential to assembling great numbers of feeder cattle for efficient sales.

Many calves also are sold privately through *order buyers*, i.e., third parties who for a fee locate and purchase livestock of the type desired. A new and increasingly important method of marketing feeder cattle is video auctions beamed over satellite to buyers, who bid by telephone.

Futures markets are a source of information about what traders feel the trend of prices will be in a certain month. These markets perform two basic functions: (1) price setting through speculative activity and (2) hedging. Cattle feeders may use futures transactions in such a way as to offset the effects of an adverse price change in the cash market. Industry participants may use futures markets directly or as a source of information.

Most slaughter cattle are purchased for delivery within about one week, but packers increasingly are contracting or making arrangements to purchase on a forward basis. Some transactions are arranged months ahead of the date on which cattle will be ready for slaughter. Market information is available from USDA and private sources about both prices and quantities marketed. Industry participants can monitor this information by phone, radio, TV, daily market sheets, futures prices, and other means.

Price is determined as a result of the interaction of supply and demand, but each participant usually has a unique view of the two factors. Negotiation therefore normally occurs, or alternative buyers or sellers are contacted. Certain markets and regions may have more competitors than others do, a factor affecting price at least subtly.

### Pork

Price discovery for pork and its products traditionally has centered around *The National Provisioner Yellow Sheet* (*The National Provisioner*, 1991). But during the mid-1980s, many of the large pork-processors began pricing based on scaled formulae involving carcass composition, e.g., relative proportions of muscle, fat, or bone in the carcass. Today, the *USDA-AMS Livestock and Grain Market News (Federal-State Market News)* disseminates live pork values based on *lean value pricing*—a matrix of price adjustments from a base for characteristic traits related to cutability and quality.

Today, carcass fatness is predicted by means of visual and/or instrumental evaluation systems, and animals are priced according to their expected leanness in relation to a specified base. If an animal is expected to be leaner than the base, then the animal returns a premium, and vice versa. Long and short hedging, as well as options markets, are used to hedge prices of live hogs. Wholesale pork is traded according to buyer specifications of, for instance, fat-trim level and storage conditions, based on formula pricing schemes.

buying programs should benefit the entire swine industry by (1) increasing producer understanding, acceptance, and use of carcass-merit pricing systems; (2) translating with relative accuracy carcass-value differences into prices received by producers; and (3) expediting movement of various types of hogs to the packers most desiring them. Relatively accurate price reflection throughout the marketing system should facilitate efficient pork production to meet future consumer demand.

### Lamb

Tatum et al. (1989) conducted a survey to determine the effects of sex, carcass weight, and production system on lamb cutability traits. Data indicated that slaughter lambs have become fatter over the last two decades and that approximately 40% had USDA yield grades indicating excessive fatness. Ewe lambs were fatter than wether lambs and had less desirable USDA yield grades.

Lambs finished in feedlots for extended periods evidently were fed beyond their logical slaughter endpoints and usually were fatter than lambs reared under other production systems. The authors identified two features of the current pricing system that encourage production of overly fat lambs.

1. The highest prices generally are paid for lambs with superior dressing percentages. Because dressing percentage increases with weight and carcass fatness, the current pricing system drives slaughter weight and fatness, particularly when grain is cheap and lamb expensive. If dressing percentage were removed from pricing formulae or calculated in such a way that it no longer included waste fat, then the incentive to overfeed before slaughter would be reduced greatly.
2. The pricing system includes no mechanism providing price incentives for production of high-cutability carcasses. The USDA yield grading system, which classifies lamb carcasses according to expected cutability, never has received widespread acceptance in the lamb industry. Instead, an arbitrary system of weight discounts has been used. When a large part of the slaughter supply is overweight and too fat, heavy carcasses are discounted. A system based on weight discounts, however, provides inequitable cutability incentives. Thus, a market classification system is needed to reflect individual differences accurately in terms of lean meat yield. On such differences a pricing system could be structured to provide economic incentives for the production of lean lambs.

# Quality Measurement

## Important Attributes

#### Beef

Historically, the industry generally defined *beef quality* as synonymous with *palatability*, i.e., tenderness, juiciness, and cooked product flavor, and measured quality in terms of USDA quality grades. But the general definition of *quality*, as well as consumer perceptions of it, may be changing. Consumers have become health, service, and value oriented. And they are becoming increasingly diverse as the business environment becomes global. Traditionally, marbling, maturity, firmness, color, and texture were the most important measurable factors used in determining quality grade and thus quality. Today, palatability still is a key component of quality, but several quality audits (See "Quality-Related Issues" in this chapter.) suggest that the general definition now is much broader and includes factors such as excessive fatness, compliance with ordering specifications, workmanship, customer service, individual cut size, and box weight.

According to Pierce (1974), in relation to the historical definition of *quality*, standards for beef carcass grades link quality grade to eating quality, or "tenderness, juiciness, and flavor." In 1975, the *USDA Official Standards for Grades of Carcass Beef* (Agricultural Marketing Service, 1989) defined *quality grade* as "the palatability indicating characteristics of the lean." When it seemed that traditional measures of quality no longer were adequate, the USDA—AMS responded by developing other service options for customers wishing to distinguish their products in a particular market. Services now available, in addition to traditional grading, offer flexible capabilities to demonstrate commitment—through third-party conformity assessment—to "producing what you say you produce." Included in these services are product assessment and certification, contractual verification, "brand-naming" programs, and process verification.

Both the degree to which palatability can be measured and the degree to which the measured factors of maturity, texture, firmness, color, and marbling predict palatability or its components of juiciness, tenderness, and flavor have been the subject of extensive research over the last several decades. Some researchers have reported close associations between USDA quality grades and palatability measures (Covington et al., 1970; Davis et al., 1979; Jennings et al., 1978; McBee and Wiles, 1967). Other researchers have found little or no relation between quality grade or marbling and measured palatability (Berry et al., 1974; Campion et al., 1975; Garcia de Siles et al., 1977; Parrish et al., 1973; Tuma et al., 1962).

Since biblical times and doubtless earlier, fatness has been linked to beef eating quality, and much research has been directed toward clarifying why this characteristic, especially marbling, is important. Some researchers have noted that fattening is one of the consequences of a high-energy diet and that the effect of such a diet on palatability is indirect, i.e., fat simply indicates that a high-energy ration has been used. The underlying relation is that increased palatability flows from the feeding regime, not from the fat itself. (See, for example, Adams et al., 1977; Dolezal et al., 1982; Harrison et al., 1978; Tatum et al., 1980.)

Another indirect link between fat and palatability is the possible effect of subcutaneous fat on cold shortening. Research has shown that a layer of fat causes carcasses to chill relatively slowly, lessens sarcomere shortening, and improves meat tenderness (Dutson et al., 1975; Marsh and Lochner, 1981; Smith et al., 1976).

Smith et al. (1983), after reviewing a great body of research and the mechanisms by which beef grades relate to flavor, concluded that "It now seems quite likely that USDA quality grade is related to flavor of beef because grade indirectly assesses the extent to which flavor and/or aroma compounds are likely to be present in high vs. low concentrations in the meat."

> Carcasses from older animals, leaner animals, and animals not fed large amounts of grain—animals for which there is high likelihood that they would produce meat that is less desirable in flavor—are assigned low USDA quality grades, while carcasses from young animals, fatter animals, and animals fed large quantities of grain—animals for which there is high likelihood that they would produce meat that is "beefy" and more desirable in flavor—are assigned high USDA quality grades. (Smith et al., 1976)

Beef yield grades traditionally were considered a quantity measure as opposed to a quality measure. But as the definition of *quality* has broadened and as exterior trimming of fat has increased (less than 0.25 inches' being allowed externally), yield also is showing up in definitions of *quality*. Beef carcasses with low numerical yield grades (1 or 2) yield high percentages of boneless, closely trimmed retail cuts relative to hot carcass weight. The measure affects relative desirability and ultimate retail value of the product. Fat carcasses are less valuable than lean carcasses, especially within the same quality grade.

### Pork

Carcass leanness, lean color, lean firmness, and muscle pH are the primary attributes affecting pork carcass value. Pork value declines with the occurrence of two stress related conditions—pale, soft, and exudative (PSE) flesh; and dark, firm, and dry (DFD) flesh—affecting lean quality and subsequent acceptability and value. Both conditions, which cause poor lean appearance and palatability, make pork unsuitable for retail sales as well. Additionally, PSE pork, because of the decreased muscle pH, lacks processing functionality; and DFD pork, because of increased muscle pH, is quite susceptible to microbial spoilage.

Excess fat is a commodity with little market value. Consumer studies consistently reveal that consumers prefer to purchase pork products with little or no trimmable fat. The retail food industry is responding to these demands by presenting products closely trimmed of excess fat and often nearly totally boneless. The pork industry worldwide likely will continue to react to this demand for leanness by producing lean market-hogs and by removing excess fat before presentation.

In the short term, fat is being removed with a knife; in the long term, it likely will be removed through selection and management. The swine industry should receive more money for leaner carcasses, and the importance of dressing percentage (proportion of carcass to live weight) should decline—especially to the extent that this attribute is influenced by fat rather than by muscle.

As the value of lean pigs increases, producers, packers, and retailers must become knowledgeable about product composition. For example, if they fail to recognize what their products are worth and why they are valuable to packers, producers never can expect to receive full value.

Significant changes in hog types have been evident throughout the history of U.S. swine production, especially during the past three or four decades. During only part of the last 150 yr that swine have been prominent in the meat supply has lean meat been the goal of the swine industry and the consumer.

Changes made in swine type were to a great extent the result of fad and fancy rather than of consumer preference. From early American history until well into the current century, swine were raised for the edible fats and oil, with lean meat receiving secondary emphasis.

Salt pork was one of the principal cured products 50 yr ago. Packers paid a premium for heavy, excessively fat carcasses; and producers entered their animals in contests recognizing the heaviest, fattest, highest dressing hogs. The early Poland China's, the white hogs of Pennsylvania's Chester County, and the Jersey Reds all grew to enormous sizes. In 1842, Poland China's are reported to have weighed as much as 1378 lb and Jersey Red as much as 1268 lb. As producers became interested in developing definite types for the breeds, refinement and quality were emphasized, and size decreased.

By the late 1920s, competition from plant source oils escalated, and pork producers began emphasizing selection of swine for meat production. But World War II, during which a dramatic increase in world demand for fats and oils occurred, interrupted the move toward the meat type hog. Only in the 1950s did demand for animal fat decline again and selection for a meat-type hog reemerge as a priority. From 1950 through 1975, per-capita lard consumption declined.

Marketplace demands are changing. Today's producers are reacting to changing demands, which are being reflected back to seedstock producers. Today's producers also can make informed decisions regarding the genetics best fitting the environment and most consistent with consumer targets.

The USDA (Parham and Agnew, 1982) has sampled the pork-carcass population three times (in 1960, n = 45,000 carcasses; in 1967–1968, n = 57,000 carcasses; and in 1980, n = 36,000 carcasses). Because grade standards were the same in the 1967–1968 and the 1980 surveys, only these two data sets will be used in comparisons. In 1980, almost 96% of the pork carcasses graded U.S. Nos. 1 and 2, compared with 50% in 1967–1968 (Table 14.9). From 1967–1980, percentage of carcasses grading U.S. No. 1 increased about 64 points, to 72%.

Measurements of carcass length increased and *average back fat thickness* (the average of three dorsal midline fat-depth measurements) decreased during the same period (Table 14.10). Average back fat thickness improved (decreased) by almost 20%, whereas carcass length increased by less than 0.5 in. (less than 2%).

Exemplifying the compositional distinctions among pork carcasses receiving different USDA grades, Table 14.11 lists the yields of major and minor pork cuts trimmed to 0.25 or 0.0 in. external fat thickness (Cross et al., 1975; Terry and Savell, 1988).

Table 14.11 indicates that as numerical USDA grade increased, percentages ham, loin, Boston butt, and picnic shoulder decreased. When the four major lean cuts were trimmed to 0.0 in. external fat, trimmed fat percentages increased with USDA grade. These data demonstrate the relations among fat percentage, carcass yield, and USDA grade. As consumers pressure the industry to remove excess fat, compositional differences among USDA grades become more significant.

According to Topel (1986), leaders of the purebred swine industry have encouraged a type change resulting in increased fat deposition. Data in Table 14.12 indicate that limited or no improvements in carcass length or in *Musculus longissimus* area were evident from 1980 to 1983. During that period, fat depth over the tenth rib actually increased by more than 8%.

It seems, therefore, that the U.S. swine industry dramatically improved the leanness of carcasses from 1967 to 1980 but effected little improvement from 1980 to 1983. Since 1983, the swine industry has continued to improve the leanness of carcasses.

**Table 14.9. Changes in percentages of pork carcasses falling into the various grades between 1967–1968 and 1980 (Parham and Agnew, 1982)**

| USDA Grade | 1967–1968 | 1980 |
|---|---|---|
| 1 | 8.2 | 71.7 |
| 2 | 42.1 | 24.2 |
| 3 | 35.7 | 3.7 |
| 4 | 12.2 | 0.3 |
| Utility | 1.8 | 0.1 |

**Table 14.10. Average length and backfat thickness for selected grades for barrow and gilt carcasses (Parham and Agnew, 1982)**

| Grade/Measure | 1967–1968 | 1980 |
|---|---|---|
| U.S. No. 1 | | |
| Length (cm) | 77.22 | 78.74 |
| Avg. backfat thickness (cm) | 3.81 | 3.10 |
| U.S. No. 2 | | |
| Length (cm) | 76.96 | 78.23 |
| Avg. backfat thickness (cm) | 4.54 | 3.96 |
| U.S. No. 3 | | |
| Length (cm) | 77.22 | 78.23 |
| Avg. backfat thickness (cm) | 5.41 | 4.93 |

## Lamb

According to Smith et al. (1986), major value-determining quality characteristics for ovine carcasses include (1) *class*—age at slaughter, (2) characteristics related to palatability, and (3) *cutability*—percentage yield of trimmed major retail cuts. Recent marketing programs have used the phrase "lean, light and luscious" to describe and to promote lamb meat. But the only term that can be used today is "luscious," for lamb is neither "light" nor "lean."

In fact, most carcasses are excessively fat. The research of the past few years, therefore, has shifted in emphasis from palatability to cutability assessment. Much lamb palatability research conducted during the 1960s and the 1970s still is valid because the industry has changed neither feeding nor marketing systems.

Maturity groups provide the most consistent indicators of ultimate palatability. Young lambs (A maturity) are three to twenty-five times more likely to produce leg cuts with satisfactory overall desirability scores than are either *B Maturity*, i.e., older lambs, or yearling mutton maturity groups, respectively (Carpenter et al., 1968). Tenderness scores for leg retail cuts from A maturity carcasses usually are high regardless of fatness degree, but, for yearling mutton carcasses, low levels of fatness or quality decrease the tenderness of retail cuts.

Marbling affects juiciness by enhancing meat's water holding capacity, by lubricating muscle fibers during cooking, by increasing meat tenderness and thus the sensation of juiciness, and by stimulating salivary flow during mastication (Smith and Carpenter, 1974). Data for lamb indicate a moderate relation between fat and juiciness. Relations between fat and flavor seem moderately strong in lamb (Smith and Carpenter, 1974).

Tenderness measurements taken with Warner-Bratzler shear machines are more affected by cooking methodology and core position than by marbling and color. Even though fat content of the longissimus muscle is correlated positively with tenderness, the magnitude of this correlation is quite small.

Another explanation of increased tenderness resulting from increased overall carcass fatness level was proposed by Smith et al. (1976). These researchers found that increased carcass fatness leads to a number of postmortem symptoms: slower chill rates, maintenance of higher temperatures conducive to autolytic enzyme degradation, less cold shortening of sarcomeres, lower ultimate muscle pH, and softer connective tissue. In short, fat carcasses are relatively tender: increased fatness results in decreased postmortem chilling rate, which enhances tenderness.

**Table 14.11. Percentage yield of major and minor cuts from pork carcasses of different USDA grades when trimmed to either 0.64 cm or 0 cm fat (Cross et al., 1975; Terry and Savell, 1988)**

| Carcass component | Surface fat trimmed to less than 0.64 cm in thickness | | | | All surface fat removed | | | |
|---|---|---|---|---|---|---|---|---|
| | U.S. No. | | | | U.S. No. | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Ham | 23.3 | 22.1 | 21.0 | 20.3 | 19.3 | 17.4 | 15.9 | 14.7 |
| Loin | 21.4 | 20.6 | 19.4 | 18.2 | 19.0 | 18.3 | 17.0 | 14.8 |
| Boston butt | 7.7 | 7.4 | 6.8 | 6.4 | 7.3 | 7.1 | 6.5 | 5.8 |
| Picnic shoulder | 11.0 | 10.5 | 9.6 | 9.0 | 9.5 | 8.9 | 7.9 | 6.8 |
| Subtotal | 63.4 | 60.6 | 56.8 | 53.9 | 55.1 | 51.7 | 47.3 | 42.1 |
| Ham fat | 1.7 | 1.7 | 1.9 | 2.1 | 5.7 | 6.4 | 6.9 | 7.6 |
| Loin fat | 6.4 | 8.4 | 10.9 | 12.9 | 8.8 | 10.7 | 13.3 | 17.3 |
| Boston butt fat | 2.0 | 2.2 | 2.5 | 2.7 | 2.3 | 2.6 | 2.8 | 3.4 |
| Picnic fat | 0.7 | 0.8 | 0.8 | 0.8 | 2.2 | 2.4 | 2.4 | 2.6 |
| Subtotal | 10.8 | 13.1 | 16.1 | 18.5 | 19.0 | 22.1 | 25.4 | 30.9 |
| Belly | 14.6 | 15.4 | 16.3 | 16.9 | — | — | — | — |
| Jowl | 4.1 | 3.7 | 4.5 | 4.6 | — | — | — | — |
| Spareribs | 3.2 | 3.1 | 3.0 | 2.9 | — | — | — | — |
| Neckbones | 1.7 | 1.6 | 1.5 | 1.4 | — | — | — | — |
| Ham lean | 0.15 | 0.12 | 0.09 | 0.07 | — | — | — | — |
| Hanging tender | 0.16 | 0.14 | 0.16 | 0.10 | — | — | — | — |
| Sternum | 0.38 | 0.38 | 0.38 | 0.38 | — | — | — | — |
| Tail | 0.25 | 0.21 | 0.23 | 0.22 | — | — | — | — |
| Hind foot | 1.6 | 1.5 | 1.4 | 1.3 | — | — | — | — |
| Front foot | 1.2 | 1.1 | 1.1 | 1.0 | — | — | — | — |
| Carcass wt. (kg) | 61.5 | 66.3 | 64.8 | 69.4 | — | — | — | — |
| USDA grade | 1.3 | 2.4 | 3.4 | 4.3 | — | — | — | — |

**Table 14.12. Five-year averages for carcass shows (carcass data adjusted to 107 kg) (Topel, 1986)**

| Year | Total hogs in show | Total carcasses evaluated at 10th rib | Weight (kg) | Length (cm) | 10th-rib fat (cm) | *Musculus longissimus* area ($cm^2$) |
|---|---|---|---|---|---|---|
| 1980 | 12,787 | 12,787 | 100.4 | 81.5 | 2.43 | 33.5 |
| 1981 | 11,970 | 11,970 | 100.0 | 82.0 | 2.36 | 33.5 |
| 1982 | 10,438 | 3,264 | 104.4 | 81.8 | 2.41 | 34.2 |
| 1983 | 8,969 | 2,888 | 104.9 | 81.8 | 2.59 | 33.5 |

Superior conformation implies a great proportion of edible meat to bone and a great proportion of carcass weight in desirable cuts. Carcasses that are quite thickly muscled; wide and thick in relation to length; and plump, full, and well rounded in appearance exhibit superior conformation.

Inferior conformation implies a small proportion of edible meat to bone and of carcass weight in desirable cuts. Such carcasses are quite thinly muscled; narrow in relation to length; and angular, thin, and sunken in appearance.

Lamb-carcass marketing historically revolved around carcass weight groups and quality grades, with little emphasis on cutability. But when advantageous to the seller, USDA quality grades were used in merchandising. Certain restaurants, steakhouses, and retail outlets advertised and identified U.S. Prime and Choice lamb. Imprinted on the surface of lamb carcasses were USDA quality names in purple ink.

Unless in the upper weight ranges or excessively fat, Prime carcasses when scarce might have a slight advantage in terms of carcass price over Choice carcasses that are neither excessively heavy nor excessively fat. Unlike beef, lamb carcasses grading Prime are not always in great demand, in large part because of the excessive fatness associated with many high-quality carcasses.

Marketing practices for the lamb industry are changing inasmuch as economic awareness of cutability traits is increasing. On July 6, 1992, as a result of prompting from the lamb industry, the Official U.S. Standards for grades of lamb, yearling mutton, and mutton carcasses were revised to emphasize cutability traits. If graded, lamb carcasses now must be "rolled" with both quality and yield grade insignias.

This factor, in conjunction with changes in the calculation of revised yield grades, is allowing retailers to purchase lamb cuts complying with certain fatness standards. And, consequently, emphasis has shifted to the pricing of live market lambs in terms of fatness rather than in terms of dressing percentage or weight. Lean lamb products at retail eventually will result.

Conformation score, flank streaking score, and overall quality grade are correlated greatly with reduced product yield. Thus, premiums should not be paid for high-quality carcasses if they are deemed excessively fat, for excessive fatness does little to increase lamb palatability.

Within the USDA quality grading system, stratification of lamb carcasses according to flank streaking results in a positive relation with overall satisfaction scores. Increases in the degree of flank streaking (lean quality) correspond to improved flavor, juiciness, tenderness, and overall satisfaction scores by trained taste panelists and to moderate decreases in cooking loss. Flank streaking and feathering between the ribs both were used before 1982 as indicators of lean quality. These factors were used instead of marbling because lamb traditionally was marketed intact and unribbed, by packers.

Current USDA quality and yield grade systems seem at contrary purposes—one (quality) encourages fatness and the other (yield) penalizes it. Fat is deposited in a number of different areas within the lamb's body, and each site has different functions in the live animal. In the carcass, only intramuscular fat contributes directly to meat quality. *Marbling*, i.e., intramuscular fat, is related positively to palatability of cooked lamb.

Unfortunately, in red meat, marbling is deposited last. And thus by the time the meat is sufficiently marbled to qualify for the highest quality grade, it has deposited too much kidney and pelvic, intermuscular (seam), and subcutaneous fat (Smith, 1988).

## Grades and Standards: Description

### Beef

Although widely misunderstood, the grade name *Choice* is one of the most widely recognized of the commodity grade names. Most fresh steak and roast cuts are sold with the USDA quality grade identified, especially those qualifying for USDA Select, Choice, or Prime grades.

> If U.S. Department of Agriculture quality grades were intended originally to predict the palatability of cooked beef, it is interesting that the first official grade standards (U.S. Department of Agriculture, 1926) do not say that; no mention is made in those standards of "expected palatability." In fact, the words "palatability," "flavor," "juiciness," and "tenderness" do not appear in that document; the expressed intent of grading, at that time, was "to have comparability between the [wholesale meat market news service] reports issued from different markets. (Smith et al., 1983)

#### Feeder Cattle[41]

Current feeder-cattle standards, which became effective in 1979, were designed to describe the various types of feeder cattle being produced. Although few such animals are graded officially, grades are used primarily as a basis on which to report federal and state livestock market price. They also are used as a tool for sorting cattle at special sales during which feëder cattle are graded officially and ownership is commingled. A number of colloquial terms, e.g., *Okie Number 1* or *Black Baldie*, still are used by cattlemen to describe feeder cattle.

Current grades are based on two attributes: frame size and muscle thickness, two of the most important genetic factors affecting quality in feeder cattle. The former is related to the weight at which, under normal feeding and management practices, an animal will produce a carcass of a given USDA quality grade. large framed animals require more time in the feedlot than small framed animals do and are expected to weigh more at the same quality grade. Thickness is related to muscle/bone ratio and, for a given degree of fatness, to carcass yield grade. Thickly muscled animals are expected to be composed of a relatively great percentage of lean meat.

The feeder cattle standards recognize three frame sizes, i.e., Small, medium, and large; and three thickness grades, i.e., 1, 2, and 3—1 being thickest. A grade of Inferior is specified for feeder cattle that are gaining poorly because of mismanagement, disease, parasitism, or underfeeding. Double-muscled feeder cattle also are graded Inferior.

### Slaughter Cattle

Grades for slaughter cattle contain the descriptions and the specifications necessary for ascribing to live cattle that quality grade and/or yield grade expected after slaughter. Price reports listing prices for live, Choice, Yield Grade No. 3 steers are based on expected grades.

Several factors, including the steer's genetic ability to deposit marbling rather than subcutaneous and seam fat, determine grade. In general, the higher the energy level of the ration fed and the longer the animal remains on feed, the more likely it will be to move through the quality grades from Standard to Select to Choice to Prime (less marbling to more marbling) and to move through yield grades (leaner to fatter). *Dressing percentage*, i.e., ratio of hot carcass weight to live weight, also is likely to increase.

### Carcass-Beef Grades

Official U.S. carcass-beef grades describe two separate characteristics affecting value: (1) the predicted cutability classification segregating live animals or carcasses based on the rates of edible to nonedible carcass components; and (2) the characteristics predicting palatability of cooked lean meat, i.e., *quality grade*.

The yield grade of a beef carcass is determined according to four carcass characteristics:

1. Fat thickness over the ribeye muscle. This measure may be adjusted for more or less fat in areas such as brisket, plate, flank, cod or udder, inside round, rump, and/or hips. Each one-tenth-in. increase (decrease) in fat thickness over the ribeye increases (decreases) yield grade by one-quarter of a yield grade.
2. Amount of kidney, pelvic, and heart fat, which is measured subjectively as a percentage of carcass weight. Each 1% increase (decrease) of this type of fat increases (decreases) yield grade by 20% of a yield grade.
3. Area, in tenths of square inches, of the ribeye muscle exposed by ribbing, a factor usually estimated subjectively. An increase (decrease) of one square in. of ribeye area decreases (increases) yield grade by approximately 30% of a yield grade.
4. Hot carcass weight, or chilled weight × 102%. A 100-lb increase (decrease) in hot carcass weight decreases (increases) yield grade by approximately 40% of a yield grade.

In determinations of quality grade, cattle are divided into two groups: (1) steers, heifers, and cows and (2) bullocks. Eight quality-grade designations are applicable to steer and heifer carcasses: Prime, Choice, Select, Standard, Commercial, Utility, Cutter, and Canner. Bullocks are eligible for Prime, Choice, Select, and Standard only. Cows are graded the same as steers and heifers are, except that cows cannot grade Prime.

To facilitate carcass grading, the ribeye muscle must be exposed by a cut between the 12th and the 13th ribs. Factors taken into account during this process are marbling, firmness, color, and texture of the lean muscle; and age or maturity as evaluated in terms of size, shape, and ossification of bone and cartilage. Split chine bones are important indicators of age.

In the youngest beef carcass, lean meat will be quite finely textured and light cherry-red. In more mature carcasses, lean meat will be coarser and redder. Bullocks are treated separately from steers, heifers, and cows, especially with regard to color.

[41]Dolezal et al. (1982) was used for much of this section.

Marbling and maturity usually are the most important factors in determinations of quality grade. Marbling is measured in degrees ranging upwards from "devoid" to "extremely abundant" (Figure 14.3). The amount of marbling required for a carcass to qualify for a given grade increases with maturity. For example, the minimum marbling requirement for Choice ranges from a "small" amount for the youngest group to a minimum "modest" amount for carcasses of the maximum maturity permitted by the grade (Figure 14.4). This example assumes that all other factors, e.g., firmness, color, and texture, are consistent with the grade.

### Pork

Despite the availability of official USDA grades for pork carcasses (U.S. Department of Agriculture, 1985), none was graded in 1994. The USDA pork grades are U.S. Nos. 1, 2, 3, and 4 and U.S. Utility, which describes a carcass displaying unacceptable quality. Otherwise, grades are determined by a simple mathematical formula accounting for midline back fat thickness of the carcass at the last rib and for ham muscling score. The lower the numerical grade, the leaner the carcass (Table 14.13).

Numerical grades are calculated as follows, with back fat thickness measured in inches, and muscle score ranging from 1 to 3 (1 = thin, 3 = thick): USDA grade = four times the last rib back fat thickness, in inches, minus the muscle score. A carcass with a

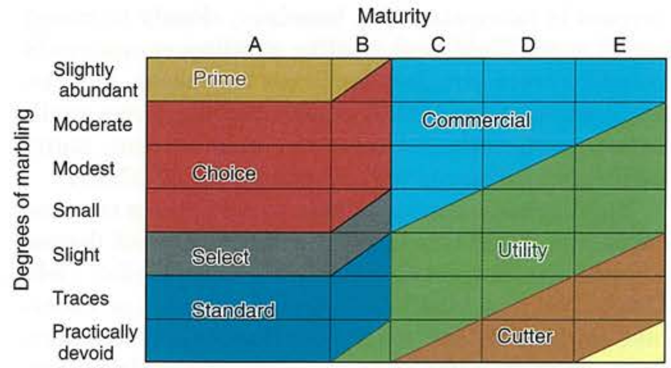


**Figure 14.4. Current relations among marbling, maturity, and beef carcass quality grade.**

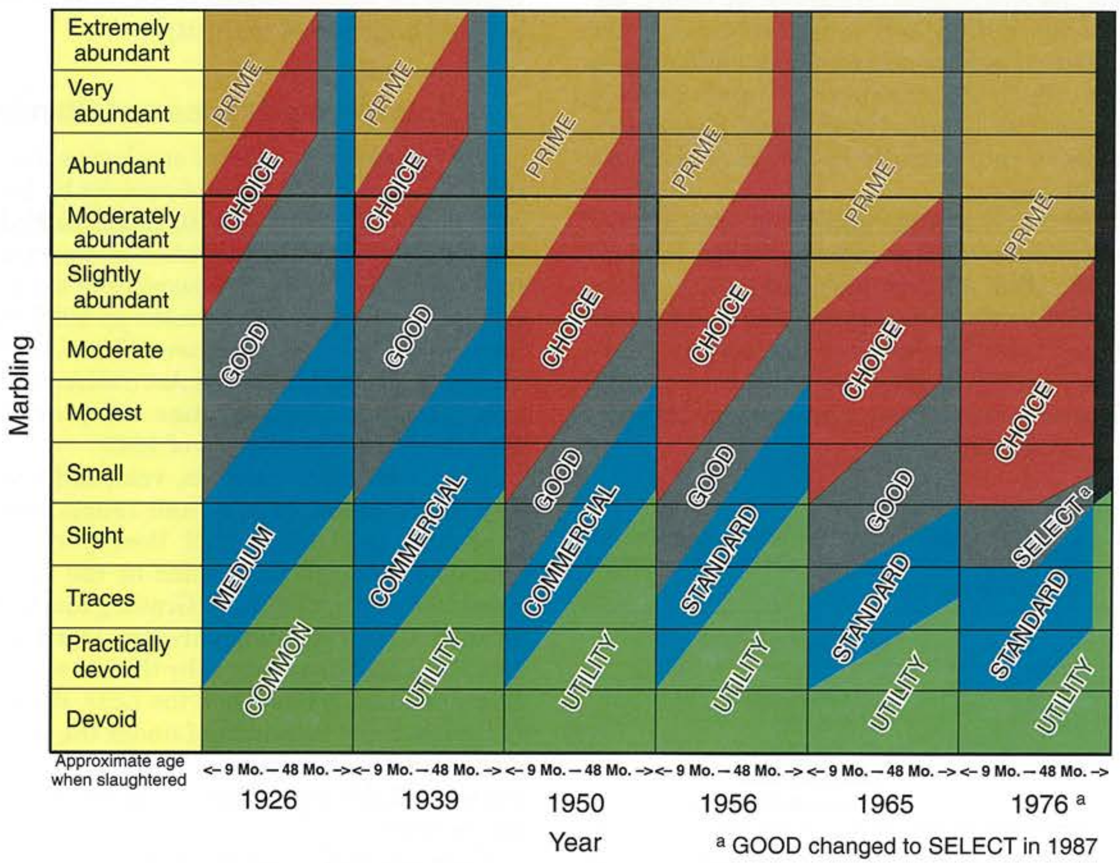


**Figure 14.3. Relations among marbling, age, and grade, by year of major change in grade standards.**

muscle score of one (1.0) cannot qualify for U.S. No. 1.

### Lamb

The newly revised USDA grading system for lamb carcasses has two components. One classifies carcasses according to *palatability*, i.e., flavor, juiciness, and tenderness, and another according to *cutability*, i.e., the amount of saleable product produced when the carcass is fabricated into boneless, closely trimmed retail cuts. Yield and quality grading components recently were coupled for lamb carcasses, that is, application of one USDA grade now mandates application of the other. Under the new system, many additional carcasses will be graded for cutability.

Yield grades are applicable to all classes of ovine carcasses. Yield Grade No. 1 denotes a great degree of cutability, or a small amount of trimmable fat; Yield Grade No. 5, a small degree of cutability, or excessive trimmable fat. After grading-system revisions took effect on July 6, 1992, yield grades for lamb carcasses became based solely on evaluation of the thickness of external fat opposite the ribeye muscle, at the 12th to 13th rib interface.

Moreover, for a carcass to be eligible for yield grading, internal fat (kidney and pelvic fat) deposit now must be removed before carcasses are chilled. Less external fat reflects greater cutability and therefore results in numerically lower yield grade. Higher cutability carcasses (numerically low yield grade) have greater retail value.

The USDA lamb-carcass quality grades are designed to segment carcasses in terms of palatability. Because estimation of consumer palatability is the ultimate goal of lamb-carcass quality evaluation, such appraisals are based on assumed palatability-quality relations. Quality grades are not an acceptable means of segregating carcasses into groups differing in terms of cutability.

**Table 14.13. Expected yields of the four lean cuts based on chilled carcass weight by grade (U.S. Department of Agriculture, 1985)**

| Pork grade | Yield of lean cuts[a] (%) |
|---|---|
| U.S. No. 1 | 60.4 and greater |
| U.S. No. 2 | 57.4 to 60.3 |
| U.S. No. 3 | 54.4 to 57.3 |
| U.S. No. 4 | Less than 54.4 |
| U.S. Utility | Unacceptable quality |

[a]Percent trimmed ham, loin, picnic shoulder, and Boston shoulder based on chilled carcass weight.

Lamb-quality grade standards were written separately for lamb, yearling mutton, and mutton. Four quality grades exist within each maturity class—Prime, Choice, Good, and Utility for lamb and yearling mutton; Choice, Good, Utility, and Cull for mutton. Quality grades are hierarchical in nature, with Prime considered the most desirable for expected palatability characteristics.

Carcasses in the Prime grade produce cuts with the highest desirability ratings and the smallest proportion of undesirable taste-panel scores (Table 14.14). Utility lamb carcasses produce cuts with the most cooking loss, the lowest tenderness and overall satisfaction ratings, and the poorest scores for juiciness, tenderness, and overall satisfaction. These carcasses, however, contain cuts with the most desirable flavor scores.

There essentially is no difference between Choice and Good grades with respect to overall palatability or desirability ratios for cooked lamb cuts from loin or rack, but across all cuts the percentage of undesirable taste-panel ratings increased with decreased lean quality and quality grade. Increases in cut fatness due to intramuscular fat deposition cannot compensate for the decreased tenderness of cuts associated with increased maturity.

## Authority for Grades and Standards

Beef graders are federal employees, but the grading service is voluntary and paid for by the firms requesting it. On February 10, 1925, the Federal Meat Grading Service was established by an act of Congress to be provided under the auspices of the USDA–Bureau of Agricultural Economics. In 1939, meat grading was transferred to the new USDA–AMS. In 1946, the Agricultural Marketing Act (AMA) reemphasized and extended responsibilities and provisions of the Federal Meat Grading Act of 1925.

Beef, pork, lamb, mutton, veal, calf, chicken, turkey, duck, geese, pigeon, and rabbit currently are graded by the USDA–AMS. Beef, pork, lamb, mutton, veal, and calf are graded by the Livestock and Seed Division (LSD), Meat Grading and Certification Branch. Grade standards are developed and subjected to the legislative process by the Livestock and Meat Standardization Branch of the LSD. Before grading, carcasses must be prepared under the supervision of either federal or state meat inspectors. Federal grading is available on a voluntary basis; its cost is borne by the user.

Federal graders are trained before deployment to packing plants, which must provide them office and lockerroom facilities separate from those used by plant employees. When grading carcasses, the USDA grader evaluates each carcass according to criteria established in the official standards and applies the grade by stamping the carcass with an official grading shield in blue, edible ink. Stamps are stored securely.

Other government agencies such as the Food Safety and Inspection Service, the APHIS, the FDA, and the National Institutes of Health (NIH) also are important sources of information and authority.

**Table 14.14. Percentages of desirable or undesirable panel scores for primal cuts within maturity classes, USDA quality score groups, and USDA final grades (Carpenter et al., 1968)**

| Trait | Flavor | Juiciness | Tenderness | Overall satisfaction |
|---|---|---|---|---|
| Maturity class | | | | |
| Desirable[a] | | | | |
| A | 42.5 | 42.5 | 67.5 | 37.5 |
| B | 42.5 | 20.0 | 32.5 | 25.0 |
| YM | 35.0 | 27.5 | 57.5 | 25.0 |
| Undesirable[b] | | | | |
| A | 5.0 | 0.0 | 0.0 | 5.0 |
| B | 2.5 | 7.5 | 7.5 | 5.0 |
| YM | 5.0 | 10.0 | 12.5 | 10.0 |
| Lean quality scores[c] | | | | |
| Desirable[a] | | | | |
| Prime | 46.1 | 30.7 | 61.5 | 30.7 |
| Choice | 45.0 | 35.0 | 61.6 | 38.3 |
| Good | 35.7 | 25.0 | 46.4 | 17.8 |
| Utility | 26.3 | 21.0 | 23.3 | 15.7 |
| Undesirable[b] | | | | |
| Prime | 0.0 | 0.0 | 0.0 | 0.0 |
| Choice | 5.0 | 5.0 | 6.6 | 4.0 |
| Good | 3.5 | 3.5 | 3.5 | 7.1 |
| Utility | 5.2 | 15.7 | 15.7 | 10.5 |
| Final quality grades[c] | | | | |
| Desirable[a] | | | | |
| Prime | 42.8 | 42.8 | 71.4 | 42.8 |
| Choice | 43.2 | 31.3 | 58.2 | 35.8 |
| Good | 31.5 | 31.5 | 44.7 | 18.4 |
| Utility | 50.0 | 0.0 | 25.0 | 12.5 |
| Undesirable[b] | | | | |
| Prime | 0.0 | 0.0 | 0.0 | 0.0 |
| Choice | 4.4 | 4.4 | 5.9 | 5.9 |
| Good | 2.6 | 7.8 | 5.2 | 7.8 |
| Utility | 12.5 | 12.5 | 25.0 | 12.5 |

[a]Mean hedonic rating of 6.00 or greater.

[b]Mean hedonic rating of 4.99 or smaller.

[c]Comparisons of consistency within grade levels treated as blocks. No differentiation is made relative to position (high, average, or low) with a given grade.

# History of Grades and Standards

## Beef

During the nation's early history, buyers and sellers of beef became increasingly separated by geography, tradition, and product knowledge. Distance heightened the need for uniform terminology in the marketplace and for unbiased judges of quality. Confused price reporting was discussed in the government's 1876 *Report of the Commissioner of Agriculture*, which described livestock prices in several major U.S. markets.

The terms *Prime*, *Choice*, and *Good* evidently were used widely in 1876, at least in the northern markets. Notable was the seemingly universal valuing of swine over cattle. Whereas three to five grade categories are used for cattle, only one category sufficed for sheep or swine. Price ranges for those animals therefore were relatively narrow.

Historians have examined many of the factors affecting beef grading, as well as the reasons for promoting it (See Kiehl and Rhodes, 1960). Alvin Sanders, editor of the *Breeder's Gazette*, ran a "long and fervent campaign in the columns of his newspaper," which credited him as instrumental in bringing about federal grades.

"Sanders's primary motivation appears many times in his editorials. He wished to promote an increased demand for wellbred and well fed beef which would increase the derived demand for purebred beef cattle" (Kiehl and Rhodes, 1960). Sanders referred to lean beef as *tiger-meat* and *cat-meat* in "'Cat Meat' and the Cornbelt" (*Breeders Gazette,* March 12, 1925, as reported by Kiehl and Rhodes, 1960). Sanders and others had a thinly veiled contempt for western range beef. Clearly, grading was motivated partly by a desire to differentiate midwestern corn-fed beef.

Another important player in the development of beef grades was Professor Herbert Mumford of the University of Illinois, who in 1902 wrote a series of bulletins entitled "Market Classes and Grades of Cattle with Suggestions for Interpreting Market Quotations."

In 1916, the need for uniform grades and market reporting led Congress to establish the National Livestock Market News Service. At the same time, tentative uniform class and grade nomenclature based largely on Professor Mumford's bulletins was developed. To facilitate beef grading for the U.S. Shipping Board and Veterans Bureau Hospitals, these standards were refined and published in mimeograph form in 1923. In 1924, Congress passed the Agricultural Products Inspection and Grading Act, which authorized federal grading of livestock and meat. The 1946 AMA authorized the secretary of agriculture to form the AMS, which has existed over various executive branch administrations under different infrastructures and titles. All livestock and meat marketing responsibilities, including grading, certification, product assessment, and process control accreditation, have since been under the auspices of the 1946 AMA.

A series of ten public hearings was held in 1925 throughout the United States. The purpose of this series was to give producers, packers, purveyors, market reporters, teachers, and other interested parties the opportunity to express their opinions about beef grades and to suggest improvements.

Partly because of the efforts of a group of producer and feeder representatives who had just formed the Better Beef Association, the 1927 "U.S. Standards for Grades of Carcass Beef" was published in *Service and Regulatory Announcements No. 99*, and a 1-yr free trial period began in May of that year. Standards for slaughter cattle, veal and calf, and lamb and mutton followed within a few years.

Packer groups opposed the grading system, calling it unworkable, and in response the Institute of American Meat Packers published a "Standard Beef Grading System and Packers' Guide for Grading as Developed by the Committee on Marketing (Beef) and Approved by the Executive Committee." Although many packers used this system for an extended period, either alone or in conjunction with USDA grades, its use now is minimal.

Another organization deeply involved in the early development and implementation of meat grades was the National Live Stock and Meat Board (NLMB). Considered a neutral party fairly well trusted by packers, producers, and feeders, this organization was assigned the task of developing a workable grading system for use during the 1-yr trial period in 1927.

The NLMB designed the system used, both during and after the trial period, and printed thousands of public information pamphlets for distribution nationwide. In the late 1920s, during the early years of the service, the Board even paid a portion of federal graders' salaries.

At the end of the 1-yr trial basis, grading was continued on a voluntary, fee basis. Although only a small proportion of beef was graded in the early years (Figure 14.5), the USDA grading program was boosted by the federal price-control programs during World War II, when federal grading was mandatory. During the war, use of the Prime grade was prohibited, evidently to discourage feeding grain to already fat cattle. Beef grading also was mandatory during the Korean conflict.

Mandatory federal grading had two effects: (1) consumers were satisfied and impressed with the system and (2) regional and local packers discovered that by selling Prime, Choice, and Good grades, they could compete with national packer brands or house graded beef. Thus, federal grades contributed to the decline of national packers and to the emergence of regional and local packers, as well as to improved technology and transportation and increased cattle feeding in the Plains. These benefits lasted until approximately the mid-1960s, when the trend toward large concentrated firms resumed.

Many amendments have been made to the standards. The initial standards included Prime, Choice, Good, Medium, Common, Cutter, and Low Cutter grades. And grading initially was based on conformation (shape); finish (quality, color, and distribution of fats), and quality (age, firmness, and texture of flesh, marbling, and lean color).

Changes have involved revising the grade names, adding or dropping categories, and revising the boundaries separating grades, especially the delineation between marbling and maturity (Table 14.15, Figures 14.3 and 14.4).

Several successive revisions have reduced the marbling required to qualify a carcass as Choice or Prime. Some cattle now grading Prime would have graded Choice under the original standards (Figure 14.3). Interested groups advocate that the boundaries

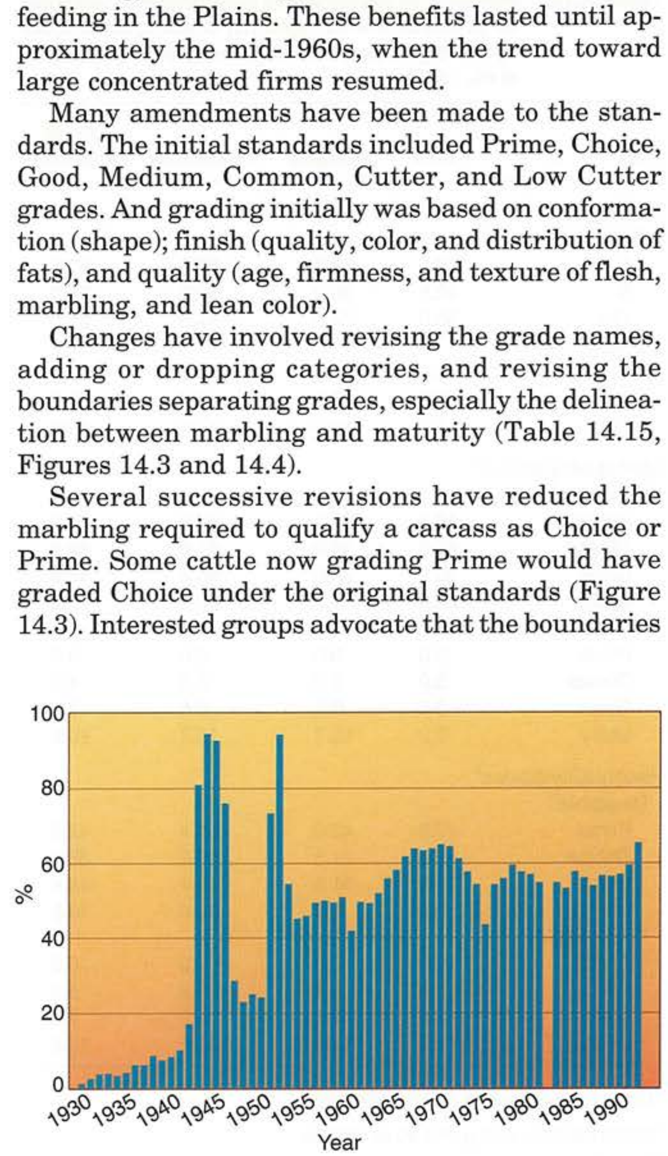


**Figure 14.5. Beef quality graded as a percentage of federally inspected beef production (U.S. Department of Agriculture, various years).**

be revised further, but not all agree on the rationale for or the direction of such revision. (See *Issues* subheading.)

**Table 14.15. Chronology of major changes to U.S. beef grade standards**

| Year of change | Description of change |
|---|---|
| 1939 | Provide a single standard for steer, heifer, and cow beef.<br>Renamed:<br>Medium to Commercial,<br>Common to Utility,<br>Low Cutter to Canner. |
| 1941 | Common terminology for all beef:<br>Prime, Choice, Good, Commercial, Utility, Cutter, and Canner. |
| 1949 | Reference to fat color eliminated |
| 1950 | Combined Prime and Choice into Prime; Good became Choice; divided Commercial into Good for young top half and older, lower half into Commercial. |
| 1956 | Commercial divided based on maturity: young animals became Standard, and older, Commercial. |
| 1962 | Cutability grading introduced on a trial basis. |
| 1965 | Cutability Groups officially added to standards.<br>Carcasses could be quality graded only, or yield graded only, or both quality graded and yield graded at the user's option.<br>Reduced marbling requirements for animals of intermediate age.<br>Required ribbing of carcasses prior to grading.<br>Eliminated finish as a grading factor. |
| 1973 | Introduced the Bullock class.<br>Bull retained as class but quality grades for bull eliminated.<br>References to Cutability Groups changed to Yield Grades. |
| 1976 | (Proposed earlier but delayed in court.)<br>Conformation eliminated as a grading factor.<br>Marbling required to offset increasing maturity reduced in Choice and Prime, but increased for youngest Good (see Figure 14.3). Maximum maturity allowed for steer, heifer, and cow beef in the Good and Standard grades reduced to the same as that permitted in the Prime and Choice grades.<br>If grade marked for either quality or yield, carcasses must be grade marked for both quality and yield (termed "coupling"). |
| 1987 | Good renamed Select. |
| 1989 | Quality grade and yield grade decoupled. Users could again grade for either or both. Purpose was to allow carcasses with fat removed on the slaughter floor ("hot fat removal") to be quality graded. |

## Pork and Lamb

Tentative standards for pork carcass grades were published in 1931 and made official in 1933. Pork-carcass grade standards last were changed in 1985 as a direct result of pork carcass composition research conducted at Texas A&M University (Cross et al., 1973; Cross et al., 1975). These changes simplified the grading system to include one measure each of fatness and of muscling.

Official standards for lamb carcasses were established in 1931 and went into effect that year. In 1940, the first amendment changed grade designations medium and Common to Commercial and Utility, respectively. In 1951, grades underwent another major change. Prime and Choice grades were combined and designated *Prime*; Good was renamed *Choice*—which became the highest grade for carcasses with maturities exceeding yearling mutton; the top two-thirds of Commercial was designated *Good* while the lower one-third was combined with the top two-thirds of Utility and designated *Utility*; and the lower one-third of Utility was combined with Cull and designated *Cull*. That amendment also listed the minimum requirements for each grade, specified the grade requirements for varying degrees of maturity, and clarified the methods for differentiating among lamb, yearling mutton, and mutton carcasses.

In 1957, the standards were modified to limit the quality requirements for Prime and Choice grade carcasses from mature lambs. Quality requirements for the Good grade of young lambs were increased, and conformation considerations adapted within each grade. These changes had been recommended by an industrywide committee appointed by the National Wool Growers Association. In 1960, conformation and quality standards for lambs in Prime and Choice grades were relaxed and a minimum external-fat thickness requirement was added.

In 1969, yield grade standards were added for optional use with quality grades. Current research indicated that carcasses of the same quality grade and weight group classification often differed greatly in terms of trimmed retail-cut yield. No changes were made to the quality grade aspect of the standards.

In 1982, changes to the standards permitted carcasses with only one break joint to be classified as lamb if their other maturity characteristics were typical of the animal. Additionally, feathering requirements were dropped, shifting the emphasis for lean quality to fat flank streaking. Other modifications included quality and conformation-compensation standardization within the various grades, addition of muscling requirements to the conformation descriptions, and elimination of the Cull grade for lamb and yearling mutton carcasses.

The most recent revision of official grade standards for lambs occurred in July 1992. With that revision, quality grades were unaffected. Yield and quality grades, however, were coupled so that application of one grade mandated application of both grades. Moreover, the yield-grade system was revised to include a single factor in the prediction of composition—external fat depth.

Previously, yield-grade factors had included both an estimation of the percentage of carcass weight comprised of internal fat (kidney and pelvic fat) and a subjective evaluation of leg conformation (a predictor of muscling). When percentage internal fat was removed as a consideration, a great deal of the grades' ability to predict total fatness variability was lost. The grading system therefore now requires that kidney and pelvic fat be removed to a level not to exceed 1% of carcass weight.

# Measurement Technology

## Beef

Many technologies have been devised to automate grading mechanically or electronically and to determine objectively certain attributes of meat animals. Topel and Kauffman (1988) have summarized the effectiveness and the cost of approximately 30 different technologies (Table 14.16). Currently, the most accurate and reliable technical systems also are the most expensive and impractical. Topel and Kauffman summarize:

> Many techniques are available to estimate body composition but their accuracies are not outstanding. Most can account for 60 to 80% of the variation in muscle, fat, or bone of the carcass. Thus more accurate methods are needed for researchers working in the body composition field. Based on recent literature, it may be possible to improve accuracy with such new methods as computerized tomography and NMR imaging. The cost of the equipment currently prevents their widespread use, but with further research on new methods, we may, in the near future, develop the ultimate technique—one that is cost effective, simple, and accurate. (p. 269)

For the 1992–1993 funding year, as a result of the Total Body Electric Conductivity (TOBEC)/pork carcass research at Purdue University, the Beef Product Technology Subcommittee of the NLMB has listed electromagnetic scanning as a research priority. A beef-industry sponsored project is being conducted by researchers at Purdue (J. Forrest) and at the University of Nebraska (C. Calkins), who are attempting to develop on-line electromagnetic grading systems for beef. Results to date are promising.

## Pork and Lamb

Researchers at the University of Illinois recently evaluated the effects of operator error on the accuracy of fat-depth estimates across A-mode and B-mode machines (McLaren et al., 1991). During live scanning, the A-mode machine underestimated fat-depth measures in all three meat species, especially in pork and cattle. Additionally, although differing from operator to operator, correlations for ultrasonic measures of fat depth with carcass measures were higher with the B-mode machine.

Variability across operators was credited to variable abilities to locate scan site, as well as to variable interpretations of scanning results, with the latter probably contributing more to variation in results. The Illinois studies confirmed the need to remove human error from instrument-grading and live-animal evaluation systems.

Estimates of fatness in swine and beef usually are quite accurate when made for either live animals or carcasses. One of the advantages of an ultrasonic system is that it may be able to evaluate both (May et al., 1994; Terry et al., 1989). Further development will be required, however, if muscling is to be evaluated effectively (May et al., 1994; Smith et al., 1992a).

Recent research by May et al. (1994) suggested that ultrasonic measures of fatness before slaughter effectively predicted trimmable carcass fat ($r = -.78$) and boneless, trimmed subprimal yields ($r = -.73$), but ultrasonic measures of ribeye area were ineffective ($P > 0.05$) predictors of both factors ($r = .07$ for both variables).

Perhaps the next most useful advancement, in terms of predicting carcass composition and quality in real time, will be the artificial neural networking of computer systems handling digitized data. Inspired by the structure of the human brain and constituting a thoroughly novel approach to computing, these systems train themselves through trial and error to solve complex pattern recognition problems, to identify handwritten characters, and to identify objects viewed from different perspectives. Such systems

Table 14.16. Technologies for determining live and carcass composition (Topel and Kauffman, 1988)

| Technique | Effectiveness | Cost/difficulties |
|---|---|---|
| Linear measurement | | |
| Live animals | Not useful in predicting muscle, fat, and bone | Difficult to handle animals |
| Carcass | Good, but not excellent measures of body composition | Simple and inexpensive |
| Back fat probe | Reasonably accurate, easy to standardize | Inexpensive, requires animal restraint, some blood or pain |
| Reflectance probe (used primarily for pork) | Widely used in Europe, $r^2 = .82$ for fat, $r^2 = .77$ for lean | Readings take 1 minute; cost high but not excessive; can measure quality also |
| Live weight | Commonly used, practical, can be accurate when genetic background is known | Still the major and sometimes only method used; inexpensive and fast |
| Visual assessment and subjective evaluation | Account for 20 to 40% (untrained), 50% (trained), and 75% (experienced) evaluators | Inexpensive; problem distinguishing between fat and muscle |
| Ultrasonics (applied to live animals) | Very experienced operators can accurately predict carcass composition | Nondestructive; significant variation in equipment by various manufacturers |
| Video image analysis (carcass and meat) | Used in Europe; CD = 96.3 for yield grade; reported reliable as expert 3-member committee | Technical problems with electronic equipment |
| Whole-body $^{40}K$ counting | Has proved useful in research projects | Requires a $^{40}K$ Whole Body Counter |
| Body density | Accuracy varies from average to good; is less accurate for younger animals | Techniques are slow and difficult |
| Electronic meat-measuring equipment | Results too variable to be acceptable | Each machine has to be individually calibrated |
| Anyl-ray | Fast, requires only a small sample and has a high degree of accuracy | Is used on regular basis in United States |
| Tissue sawdust technique | Gives good estimates from frozen carcasses but not feasible for commercial applicators | Time-consuming slight devaluation of the carcass |
| Dilution techniques | Depends on the tracer used but may be too variable to give good estimation of total body water | Difficult |
| Urea dilution | A good way to estimate total body water, but is limited in its level of accuracy for total body fat | Too complex for industrial application |
| Computerized Tomography | Great potential for future use on live animals in the livestock industry | Expensive, time consuming, and must anesthetize the animal |
| Nuclear Magnetic Resonance Imaging | Has great potential, but limited data on usefulness for predicting body consumption traits | Expensive, complex, need resources to develop |
| Near-Infrared Reflectance | Needs more work (refinement) but may be useful in predicting body consumption | Is simple and uses fairly inexpensive equipment |
| Soluble short-lived radioactive gas tracers | The hypothesis has not been tested, but a good theoretical basis exists for the concept | Not tested |

usually are better than conventional computers at completing these tasks (Thane, 1992).

McCauley et al. (1992) reported that adaptive logic networks perform better than other beef-fat ultrasound image prediction methods and offer a viable alternative to statistical techniques predicting composition by means of B-scan image technology. Similar advancements in intramuscular fat prediction by means of A-mode scanning were reported by Whittaker et al. (1991).

Forrest et al. (1989), in a review of potential on-line pork-carcass evaluation methodologies, concluded that the "technology exists for further development of highly sophisticated, accurate, rapid methods for determination of carcass composition and value in modern high-volume slaughter facilities." Pork industry efforts to develop on-line carcass-and product-evaluation equipment helped researchers at Purdue acquire funding for the development of accurate, rapid, on-line pork-carcass grading systems using the TOBEC HA-2 electromagnetic scanner (Forrest et al., 1989).

Regression equation $R^2$ values for predicting, independent of gender, levels of fat-free lean ($R^2 = .92$) and of back fat or carcass weight have indicated that the system may constitute a feasible alternative to dissection (Kuei et al., 1991). Two TOBEC machines now are being used commercially in the United States—one in Iowa and another in Indiana, where production rates approach 700 head/d.

Reflectance fat-probes (Hennessy, Fat-O-Meater, Destron, etc.) already have gained acceptance in several countries, especially for use on lamb and lamb carcasses. Although evaluation of pork and lamb fat probes is ongoing in the United States, they are not used commercially much. One drawback of reflectance probes has been the need for human intervention in determining scan sites and performing procedures. Fat probes most likely would have a greater potential if economical robotics were developed to remove or to limit human error.

At the University of Guelph, where optical connective tissue probes are being developed, Swatland (1991) has found that probes evaluating connective tissue characteristics have the potential to predict a component of muscle toughness. According to this researcher, connective tissue probe could be combined with a back fat probe for use in quality grading. Additional research is needed for the technology to become commercially feasible.

In Australia, video image analysis is used for carcasses, and, as already described, its ability to predict marbling score is being studied in conjunction with ultrasound and discriminate analysis techniques at Texas Tech University (Green et al., 1991).

Although NMR imaging and X-ray tomography offer exciting prospects in terms of resolution capabilities, the expense of adopting a system using either method for on-line grading in commercial production facilities remains inhibitory. Thus, very little research has been conducted to develop NMR or X-ray tomography based grading systems.

Most work with computerized axial tomography (CAT) systems occurs in the medical community. When used with animals, the CAT system primarily has been part of veterinary physiology research in dogs (Burke, 1991) although it also has been part of compositional research in rats (Ross et al., 1991). Positive results recently were published by researchers in Denmark (Sorensen et al., 1987), who used CAT scanning to estimate parenchymal tissue in heifer mammary tissue during pubertal development. Positive results (r-values between .61 and .81) were found. Positron emission tomography remains, however, a relatively new technology that is in the developmental stage and about which little information is available.

A recent development of considerable interest in the United States has been the development of elastographic techniques. The fruit of collaboration between University of Texas Health Science Center at Houston and Texas A&M University, elastography has a great potential to develop instrumentation predicting palatability characteristics in muscle.

Elastography responds to externally applied physical stress by means of ultrasonic pulses tracking internal displacements of small tissue elements. Strain values, or the difference between precompression and postcompression signals, are converted to Young's modulus values, which in turn are used to develop an image (elastogram).

Preliminary evaluation indicated that the procedure may describe muscle structure at the muscle-bundle level. Details have been discussed by Ophir et al. (1991) and were presented at the 1992 International Congress of Meat Technologists in France. If the technology is to become commercially feasible, however, extensive development must take place.

## Quality-Related Issues

### Beef

The beef industry is changing. Most industrial segments agree that retail value should reflect consumer demand and confidence. Retailers, for instance, are beginning to purchase product trimmed near the fatness levels displayed in the retail case. Traditionally, commodity wholesale products had as much as .75–1.0 in. of external fat. Eventual objectives are to price, irrespective of the market sector, based on the merit of individual items rather than on averages and to communicate those signals throughout and across all marketing sectors within the industry.

To provide products meeting consumer demand, retailers decreased beef fatness by more than 27% during the 1980s (Savell et al., 1991). In an industry effort to begin sending price based signals across marketing sectors, the Beef Industry Council (BIC) of the NLMB sponsored the development by Texas A&M of Computer Assisted Retail Decision Software (CARDS) software for retailers. This software has been extremely successful in educating retailers about why value-added (more highly-trimmed, customer-friendly) meat products are more economically efficient, even at substantially higher initial prices. Although, generally speaking, excess fat no longer is passed to the domestic end-user, it still develops in animals and must be removed.

A National Beef Quality Audit (NBQA) was conducted in 1991 and 1992 by researchers at Colorado State University, Texas A&M University, West Texas State University, and Texas Tech University and by representatives of the USDA–AMS (Smith et al., 1992b). The NCA commissioned the study to "conduct a quality audit of slaughter steer/heifers (their carcasses, cuts and dress-off/offal items) for the U.S. beef industry, establishing baselines for present quality shortfalls and identifying targets for desired quality levels by the year 2001."

Data from the NBQA study indicated that more than one-fourth of the value of slaughter cattle in 1991 was lost (Lambert, 1992). Of this value, 78% of the loss resulted because of defective composition traits, and 10% resulted from defective palatability traits. If the loss could be recovered within the industry, it could be used to enhance beef's position in the marketplace. When losses due to all production related defects were considered, the U.S. beef industry lost $279.82/steer and heifer slaughtered in 1991.

Results of the 1991 NBQA study prompted development of four overall strategies for "improving the consistency and competitiveness of beef" (Smith et al., 1992b):

1. Attack waste—reduce excessive external and seam fat, improve overall cutability, and increase the industry's understanding of the value of closely trimmed product.
2. Enhance taste—improve overall palatability, increase tenderness, and ensure sufficient marbling.
3. Improve management—lessen the occurrence of injection site blemishes, hide problems (due to brands, insects, parasites, and mud/feces/urine), bruises, liver abscesses, and dark cutter incidence, and improve implantation practices and protocols.
4. Control weight—reduce the excessive weights of live cattle and carcasses, and diminish the occurrence of excessive weights of beef in boxes and of excessively large ribeyes/loineyes.

Since 1992, when results of the NBQA were published, Cattle-Fax (a membership oriented, market intelligence service of the NCA) has developed a model-indexing system to sample target defects and strategies identified in the study and has published results of the index to indicate industry improvements. Beginning in 1995, the NCA again will contract with three universities (Texas A&M, Colorado State, and Oklahoma State) to conduct a follow-up audit assessing the degree to which quality performance has improved or declined since the landmark 1991 study.

In 1994, the USDA–AMS, the U.S. Meat Export Federation (USMEF), and Colorado State University cooperated in an International Beef Quality Audit (IBQA; Morgan et al., 1995). A primary objective of the project was to develop baseline information about how *quality* is defined and perceived by foreign users of U.S. beef products. This information was to be disseminated to the industry. The premise for conducting the project was that recent expansion of market access for agricultural products alone would not ensure increased U.S. exports. As market access improved because of global reductions in tariffs and in nontariff barriers to trade, proactive and aggressive competition would ensue that over a short period would have a substantial effect on the success of U.S. endeavors to increase international trade.

The IBQA indicated that a perception of highly palatable grain-fed products from the United States is the driving force behind distinguishing U.S. beef products from competitors in other markets and that U.S. grades, specifications, and food safety inspection are extremely important in characterizing such perceived value. The report identified areas of concern for exporters that included (1) excessive external fat trim in relation to the specifications under which the product price was negotiated, (2) shipping boxes and individual meat items that are excessively heavy, (3) insufficient customer service, (4) inadequate shelf life, especially for chilled fresh products, (5) excessive purge (liquid) accumulation in vacuum packaging bags, (6) torn/crushed boxes, (7) loss of vacuum packaging integrity (leakers), (8) poor overall workmanship, and (9) inadequate/insufficient label information on shipping containers.

The beef industry recently has begun to address other, less popular quality concerns as they relate to consumers. Colorado State University and the NCA released initial results from a nonfed-beef quality audit (Smith et al., 1995). In that project, because ground and further processed beef products have become such important components of overall beef sales, the researchers tried to establish (1) which quality factors were costing the industry money in lost efficiencies and customer dissatisfaction and (2) which quality deficiencies might be managed more extensively and improved to increase the salvage value of culled cows. The study will provide a backdrop of management information well into the next decade.

Lastly, the industry decided in 1993 to ask the customer about product satisfaction after beef was provided to them to prepare as they liked. This study—the *Beef Customer Satisfaction Report of 1995* conducted by Texas A&M University, Colorado State University, and the NLMB—was concluded only recently, and no officially published data are available. Initial presentations of the data indicate, however, that the term *quality* may be much more profound than typically is thought by the industry. Customer satisfaction with beef and therefore customer response to variable levels of quality seem quite diverse, depending on USDA grades, demographic characteristics, cooking methods, and an extremely wide array of other factors. In other words, attempts to define *quality* may be futile because it is perceived differently by different individuals and is assessed relative to price.

## Heterogeneity

One complication attending the palatability question is that many disagree about what is desirable or undesirable to eat. Numerous factors can affect what a consumer considers desirable or chooses to buy. Commodities for which there is universal agreement regarding what is good or bad economists describe as *homogeneous in demand*. Commodities for which there is no such agreement economists describe as *heterogeneous in demand*.

Beef traditionally has been treated as though demand is homogeneous and that it is appropriate to call one grade (Choice) more palatable than another (Good/Select). Prime thus is assumed more palatable than Choice, which is assumed more palatable than Select. As a consequence, it is natural to expect Prime to cost more than Choice and Choice to cost more than Select. As early as the 1950s, however, researchers reported that some consumers preferred Good (now Select) to Choice beef even when priced equally and that geography played a part in this finding.

Increasingly, beef is viewed as heterogeneous in demand. Increasing emphasis on decreasing dietary fat, especially saturated fat, highlights the contradiction inherent in cultivating both marbling and leanness. Beef industry experts now attempt to segment the market so that those who wish may buy well marbled beef (inferred to be more palatable) and others may buy lean beef (inferred to be healthier).

Yet consumers may not consider marbling and leanness opposites. A retail food chain in the Northeast (First National) recently was reported to be the first in that area to offer Select beef cuts in its meat case, but using the name *Premium Cut*. The firm, which reportedly sells Select at the same price as it does Choice based its pricing decision on the fact that consumers are conditioned to pay more for leaner ground beef (*Cattle Buyers Weekly*, June 3, 1991, 3). The National Consumer Retail Beef Study (Savell and Cross, 1986) documents that consumers have widely different preferences regarding the importance of marbling and fat relative to taste and texture.

Canadian policy makers continue to debate the use of marbling in the nation's beef grading system. Don Raymond (1992), Associate Director of Grading Programs for Agriculture Canada, reported that Canada always has considered marbling a useful factor but discontinued its use in 1986 because the industry no longer was presenting cattle for grading in a manner conducive to assessing it. Carcass presentation, however, has changed since 1986, and marbling has become part of the grading system again. Canadian grade changes emphasizing leanness requirements became effective on April 5, 1992.

## Quality Incentives

Much has been written criticizing the U.S. cattle/beef pricing system for its failure to reward or to penalize producers of livestock for high- or low-valued stock. The source of this criticism is average pricing, or the tendency to price livestock based on average quality rather than on specific quality attributes of individual animals or carcasses.

Critics charge that the paucity of premiums for certain attributes undermines incentives to improve cattle breeding and production practices:

> The scientific community must understand that most producers and buyers of livestock in the United States prefer the use of live weight and visual assessment methods for estimating body composition because of their practicality, low cost, and rapidity in making the measurements. This must reflect the limited interest of the U.S. livestock industry in reducing fat in meat producing animals by objective methods. One reason for this is the small margin paid by the packing industry for trim, well muscled animals versus fat, less muscular ones. We need an improved marketing program that will pay farmers for producing trim, muscular animals. A system of this type will encourage the use of more objective methods for selection of breeding animals and the marketing of animals for meat production. (Topel and Kauffman, 1988, 269)

The process is equivocal because quantity and quality attributes differ greatly from breed to breed and from animal to animal, even if appearances are quite similar. Because cattle typically pass through many owners and because cattle from widely separate sources become commingled in the feedlot, it generally is impossible for the cattle feeder to remain abreast of the animals' genetic histories. The other important factor affecting how fat animals are at slaughter is how long and how much they are fed. If the cattle feeder chooses to feed for extended periods, he or she weighs input prices, especially feed prices, against discounts and premiums for quality and/or yield grade changes and considers the expected changes in price.

## Relating Consumer Preferences to Live-Animal Characteristics

One of the oldest and the most complex marketing systems of any agricultural product, the beef industry nonetheless has no direct communication between rancher and consumer. Although other communication channels are important and provide information to decision makers, the most important is market-price signals.

Some studies have simulated the differences in profit-maximizing decisions made by firms at successive stages of the marketing chain, given various levels of information about value attributes of animals and meat at each stage. Substantially different production and marketing decisions, e.g., type of breed produced and length of time on feed, ensue depending on amount and type of price information used and stage at which profit is maximized (Nelson, 1976; Purcell and Nelson, 1976).

Different factors are important at each production stage. Factors vital at the cow-calf stage are of little or no importance at retail and vice versa. The most important thing to a cow-calf producer is to wean and to sell a large, healthy calf: other considerations such as ability to marble with little external or seam fat or to gain rapidly are overwhelmed by death loss or calving considerations.

Likewise, a cattle feeder is more interested in healthy cattle and in rapid and efficient weight gain than is the retailer; death loss or inefficient gain again overwhelm other considerations.

The meat packer demands heavy cattle, which reduce processing costs/lb whereas the retailer demands beef requiring moderate trimming and pleasing to the consumer in regard to color, package size, and price.

Beef grades are an important part of the beef pricing process because a great proportion of fed beef is graded and because grades are important at farm, wholesale, and retail levels. Nearly all price reports for cattle and beef, whether from the USDA or from private sources, relate price to feeder, slaughter, or carcass grades, and to sex, weight, and perhaps conformation type. Frequently, however, only the most common combinations are traded in sufficient numbers to make reporting of separate prices for all combinations feasible.

It generally is difficult, for example, to determine prevailing price difference for a Choice, Yield Grade No. 1, 1,200 lb steer versus a Choice, Yield Grade No. 2, 1,200 lb steer. Because slaughter steers and heifers commonly are sold on a live basis, any cattle lot contains a mixture of grades and yield grades trading on an agreed-upon single price. Price reports therefore are based on these blends.

A recent NCA study concluded that USDA quality grading failed to control variation in taste ratings or tenderness values to the degree necessary to ensure that the consumer is offered consistent beef products. The study stated that what is needed is a tenderness-consistency control program checking both prekill factors, e.g., breeding, feeding, and quality grading, and postkill factors, e.g., electrical stimulation, blade tenderization, and cooking (*Drovers Journal*, 1991, 18).

## Relating Price and Quality

From 1953 until 1991, 50 to 60% of all beef slaughtered actually was graded for quality (Figure 14.5). Most Cull cow and bull carcasses and some steer and heifer carcasses remain ungraded. Ungraded steers and heifers (and a few cows) often are called *no-rolls* because the grade mark is not rolled onto the carcass. Choice historically has accounted for more than 80% of quality-graded beef although the proportion graded Select has increased rapidly since the 1987 name change (Figure 14.6). Yield Grade Nos. 2 and 3 account approximately equally for 85 to 95% of all yield graded carcasses (Figure 14.7). The incidence of Yield Grade No. 1 is increasing.

When the Good grade was renamed *Select* in 1987, a trend began to grade more such beef. But the real increase in the percentage of beef graded occurred in 1989, when yield and quality were decoupled.

So few steer and heifer carcasses are graded other than Choice or Select that prices seldom are reported for the other grades. Choice typically commands a premium over Select ranging from only $1 or $2/cwt in some months to well over $10/cwt in others (Figures 14.8, 14.9, and 14.10).

One might expect that, because yield grade is a quantity measure, the premium for high yielding carcasses would be more stable than the quality grade difference. But price differences also change considerably over time. For example, between January 1986 and September 1991, monthly average price differences ranged from just over $7/cwt to greater than $20/cwt (Figure 14.8). Live prices also average higher for Choice than for lower grades (Figure 14.11).

The determinants of these premiums or discounts for grade classification are complex. Basically, there are supply and demand schedules for specific beef types, just as for any other commodity, although these schedules are difficult to quantify statistically (Nelson, 1977). Recent emphasis on lean meat may cause the demand for lean grades to increase and that for fatter grades to decline.

In the past, Choice premiums have been large when packers have had difficulty filling orders for that grade. And premiums for Yield Grade No. 3 over No. 4 increased when cattle feeders as a group have held cattle back hoping for cattle prices to increase. When cattle are held back, the proportion of Yield Grade No. 4 increases, and packers have trouble selling without discounting greatly or trimming off excess fat themselves.

Consumers have come to expect that Select beef will be cheaper than Choice (Figures 14.12–14.15),

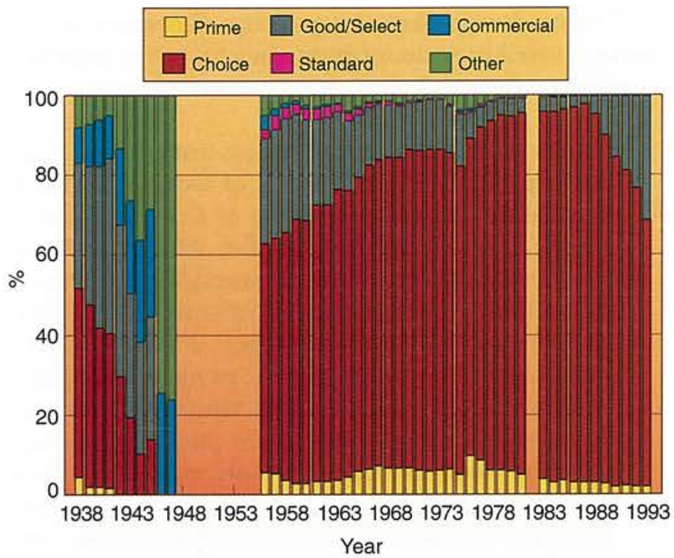


Figure 14.6. Distribution of beef quality graded by quality grade (U.S. Department of Agriculture, various years).

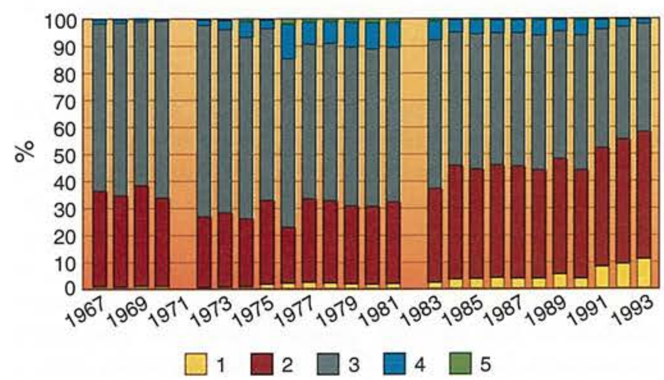


Figure 14.7. Beef yield graded percentage by yield grade, 1967–1992 (U.S. Department of Agriculture, various years).

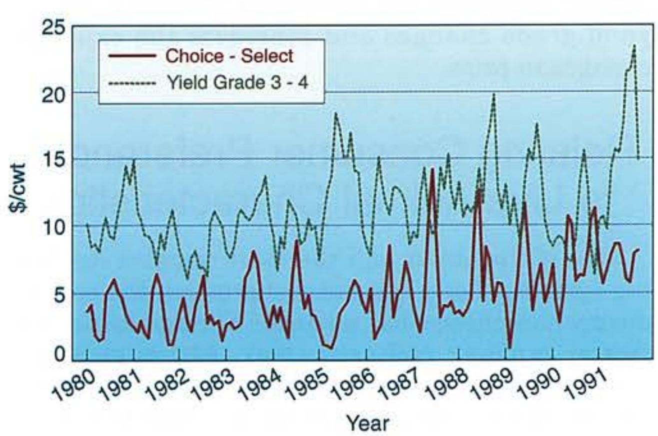


Figure 14.8. Premiums for quality and yield grades—Choice–Select and Yield Grade Nos. 3 and 4 (carcass beef prices) (Western Livestock Marketing Information Project, various years).

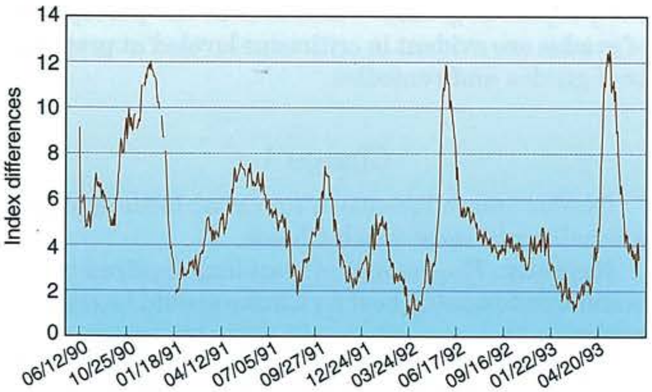


**Figure 14.9.** **Carcass Price Equivalent Index, Choice Price Index minus Select Price Index, based on beef cutout value, live prices, and hide and offal value (U.S. Department of Agriculture, various years).**

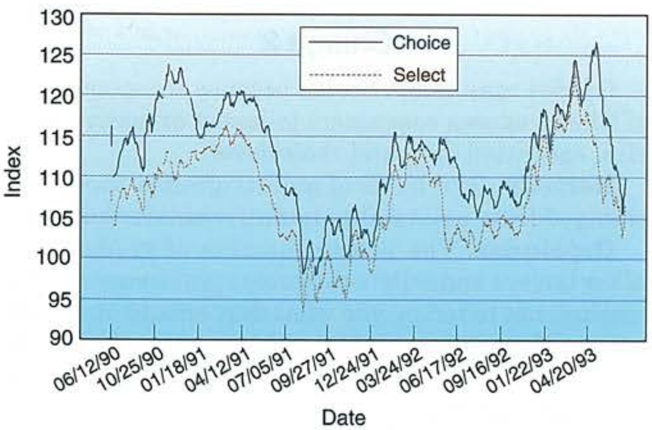


**Figure 14.10.** **Carcass Price Equivalent Indexes, Choice and Select, based on boxed beef cutout value, live prices, and hide and offal value (U.S. Department of Agriculture, various years).**

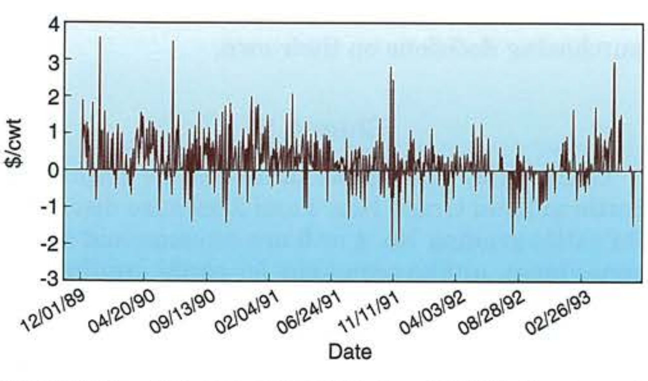


**Figure 14.11.** **Live steer prices (80 minus 35% Choice dressed weight) (U.S. Department of Agriculture, various years).**

but this price relation may change. Selects have been primarily a by-product, i.e., failed Choice. If demand for Select picks up (30% of quality graded steers and heifers now are Select) and cattle feeders design feeding programs for lean beef, economics will dictate whether the grade can continue to receive a discount. The northeast chain selling Select as Premium and at the same price as Choice may indicate future pric-

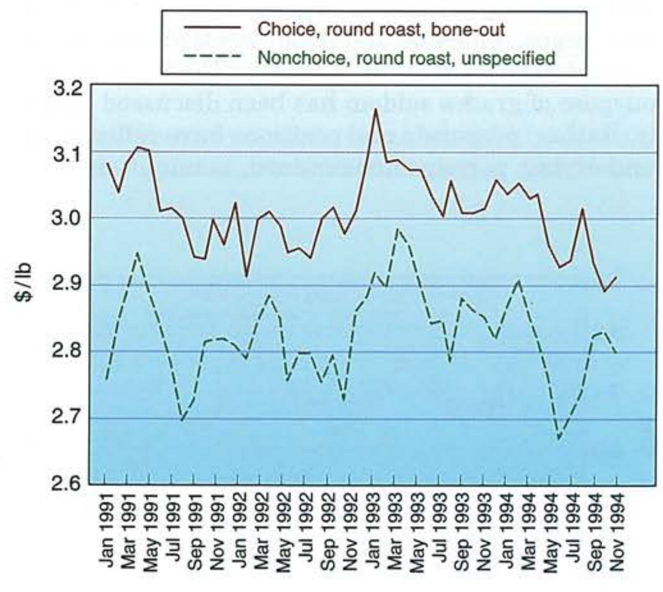


**Figure 14.12.** **Retail price: Choice and non-Choice round roast (U.S. Department of Labor, Bureau of Labor Statistics, various years).**

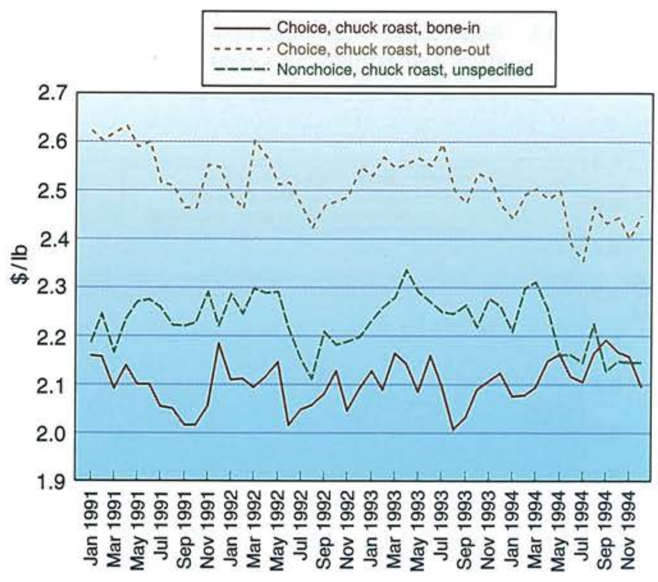


**Figure 14.13.** **Retail price: Choice and non-Choice chuck roast (U.S. Department of Labor, Bureau of Labor Statistics, various years).**

ing policy.

## Relevance of Grades as Quality Measures

Discussion of beef grades can raise surprisingly controversial issues because of a continuing disparity of opinion about what grades are, what they do, and what they should do. A generic set of hypothetical charges, remedies, and rejoinders typifies past and present debates about beef grades. The fundamental purpose of grades seldom has been discussed directly. Rather, proposals and positions have reflected an underlying, perhaps unexamined, assumption about the purpose of grades. Variations in the perceptions of grades are evident in criticisms leveled at proposed beef grades and remedies.

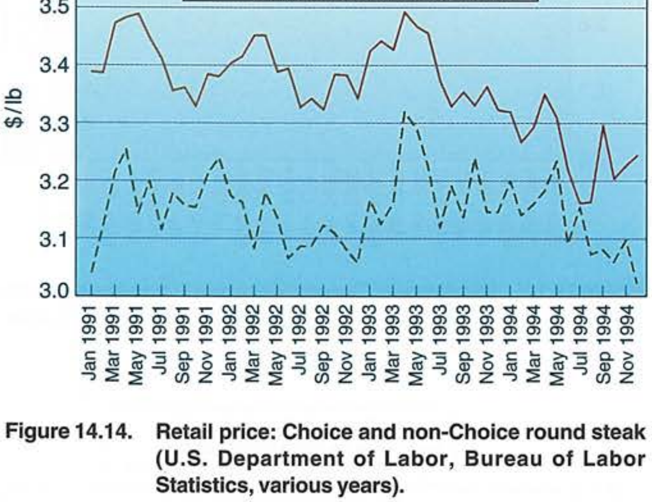


**Figure 14.14. Retail price: Choice and non-Choice round steak (U.S. Department of Labor, Bureau of Labor Statistics, various years).**

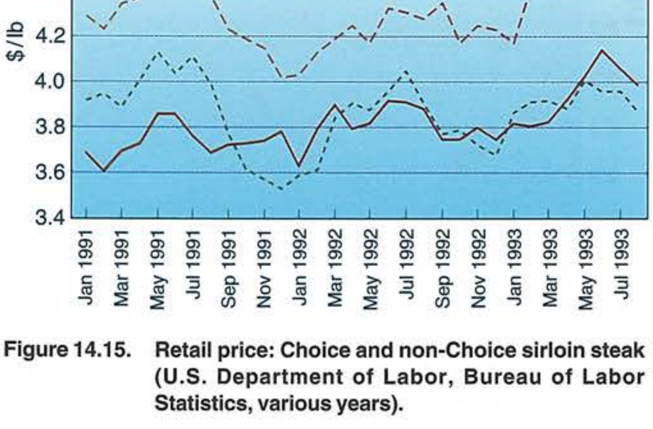


**Figure 14.15. Retail price: Choice and non-Choice sirloin steak (U.S. Department of Labor, Bureau of Labor Statistics, various years).**

### Charge 1

Grades create incentives for cattle feeders to feed animals until most reach Choice.

**Remedy.** The amount of marbling required by the standards to qualify beef for Choice should be reduced again.

**Rejoinder.** Cattle feeders are not locked in. Theory and empirical data indicate that cattle producers respond rationally to changes in input and output prices. When grain prices are high for an extended period, average weights tend to decline, as does the percentage of steers and heifers grading Choice.

### Charge 2

Grades may affect health because the popularity of Choice causes consumers to ingest excessive calories, saturated fats, and cholesterol.

**Remedy.** The basis of quality grades should be changed from palatability to nutrition attributes.

**Rejoinder.** The proper function of grades is to allow buyers and sellers to express preferences in the market, not to tell people what they should or should not purchase. Any food is seldom either absolutely good or absolutely bad for a consumer: it is the total diet that matters.

Both labeling and nutrition education programs should provide consumers with the information needed to compose healthful diets and to make wise purchases. A great deal of information about the nutrient content of beef is readily available, by grade and by cut of meat. Consumers should make informed purchasing decisions on their own.

### Charge 3

Grades may undermine incentives for improving cattle to Yield Grade Nos. 1 and 2 because discounts for cattle grading No. 4 or 5 are common and sometimes large, unlike premiums for cattle grading No. 1 or 2.

**Remedy.** Beef packers should be required to pay both premiums and discounts for yield grade, according to a fixed price schedule.

**Rejoinder.** Transaction prices reflect a wide range of value-affecting attributes and conditions. Isolating one attribute simply may expose other offsetting values. For example, cattle with low yield grades tend also to have both low carcass weights and low dressing percentages; thus, their processing cost may be relatively high. Moreover, Choice and Yield Grade No. 1 carcasses seldom appear with sufficient consistency or in sufficient numbers for packers to merchandise effectively.

### Charge 4

Grades may be a hindrance to progress in pricing beef breeding and feeding technology because the current system pays the producer to "fatten" cattle until they grade Choice.

**Remedy.** Beef quality grades should be eliminated.

**Rejoinder.** Neither consumers nor farmers are locked in. Alternatives to Choice are readily available. It is simple economics, a balance of willingness to pay (demand) and cost to produce (supply) that make Choice the preponderant grade. In fact, it is the popularity of Choice in the face of criticism and viable alternatives that inspires confidence in the existence of economic equilibrium. Since uncoupling (that is, allowing either yield or quality to be graded without the other), was permitted in 1989, use of quality grades can be relatively flexible.

The language of the charges and of their rejoinders reflects weighty questions regarding, for example, pragmatic operational rules:

1. whether, or how long, beef carcasses should be chilled before grading;
2. whether beef trimmed of fat before grading should be required to have the grade mark placed upside down on the carcass; and
3. whether a human or an instrument should be used to assign grades.

On a broader and more philosophical level, these questions arise:

1. Should grading be financed by public or private funds; who should set the standards; and should grading be voluntary or mandatory?
2. Should grades identify attributes indicating palatability; should grades indicate what is considered nutritious or healthful for consumers; and should grades be purely objective and accommodate whatever attributes seem important to buyers and to sellers?
3. Whichever attributes are chosen, should grades be normative, directly denoting what is considered "better" or "worse" (if so, whose judgment should be used?); or should nonjudgmental standards be used, which allow the sorting of products into categories reflecting no preconception of which are desirable?
4. Should grades be expected to increase the total demand for beef and so increase the total value of what is sold, i.e., increase producer gross returns and, possibly, consumer costs; should grades reduce total industry costs and consumer prices by improving marketing and pricing efficiency; or should grades be expected to ensure pricing equity to all buyers and sellers even if equity requires increased total marketing cost?

Cattlemen, meat packers, consumer groups, health professionals, economists, and meat scientists all may have a different perspective on what grades should accomplish and for whom. And it cannot be assumed that members of these groups agree among themselves on these issues.

## Pork

#### Obtaining Accurate Value Endpoint Measurements

Accurate measurement of carcass composition is critical to the swine industry because composition is related so closely to ultimate carcass value. Composition therefore is an important quality feature across all marketing chain segments. Because compositional endpoints are viewed inconsistently within the field of animal science, confusion regarding the effects of various management systems occurs.

When evaluating treatment effects, animal nutritionists and geneticists study whole-body or carcass chemical composition to discern relative efficiencies. Physically separable compositional components are directly or indirectly related to the marketable product from a meat animal.

Separable components provide evidence of treatment differences on an economic but not always on a biologic level. And the definition of *physically separable components* is a matter of debate. Berg and Butterfield (1968) defined *physically separable fat, lean, and bone* as compositional endpoints. Murphey et al. (1960) used boneless, closely trimmed retail cuts from the round, loin, rib, and chuck as tools in an economic evaluation of differences in composition of beef carcasses. Kauffman et al. (1975) argued for the use of physically separable lean on a lipid-free basis as a compositional endpoint.

Researchers throughout the world use various methods to define and to measure composition. This diversity makes a comparison of experimental results both challenging and error prone. Efforts to standardize methods in Europe were initiated in the 1950s by the European Association of Animal Production (EAAP), which collected information on swine progeny testing and on carcass evaluation in member countries. Efforts now are being made in Europe to standardize beef- and pork-carcass evaluation methods and to increase the awareness of techniques used in different countries throughout the continent. The American Meat Science Association (1967) and Cross (1982) also have developed recommendations for carcass-evaluation and composition-measurement procedures.

### Defining Measurement Endpoints

Carcass evaluation research must satisfy economic objectives. Carcass leanness, or salable meat yield, is considered by many the most important single economic endpoint. But how is this endpoint defined? To begin with, a baseline or a standard reference endpoint should be established that would be the ideal endpoint if time, labor, facilities, and product value deterioration were not factors. When composition is estimated, for example, from measurement or indicator cut information, an attempt is made to approximate this endpoint.

Recommended endpoints are listed in Table 14.17. No single endpoint will satisfy the different experimental approaches that together constitute a multidisciplinary animal/meat science. The term *endpoint* in this context is defined as the compositional aspect of paramount importance in a given experiment.

Information can be obtained about an endpoint by means of direct or indirect methods. As discussed, the direct approach to obtaining the desired endpoints listed in Table 14.17 is time consuming and subject to considerable human error. If skilled labor is not used, error can be unacceptably high.

Scientists are searching continually for means by

**Table 14.17. Recommended endpoints**

| Endpoint | Required techniques | Applications | Advantages | Disadvantages |
|---|---|---|---|---|
| Whole body chemical composition (also empty) | Dissection<br>Grinding<br>Mixing<br>Proximate analysis | Feeding trials and specific energy balance studies<br>Detail growth studies that include feed intake and development of all tissues<br>Reproductive studies that require the analysis of all body parts and their efficiencies | Obtain maximum information regarding chemical constituents of the body | Time consuming<br>Costly<br>Product loss<br>Does not differentiate between body tissues<br>Sampling problems |
| Physical carcass dissection techniques | Dissection of fat, lean and bone<br>Weighing | Growth and nutritional studies when it's important to determine the extent to which specific nutrients are retained in the carcass<br>Studies involving the control of growth and distribution of various tissues | Accounts for differences in distribution of various gross carcass tissues | Time consuming<br>Costly<br>Requires skilled labor<br>Subject to large error<br>Does not account for variation in intramuscular fat<br>Product devaluation |
| Fat-constant muscle mass | Dissection<br>Grinding<br>Mixing<br>Proximate analysis | Growth and nutrition related studies of tissues | Gives value of whole carcass | Costly<br>Time consuming<br>Requires skilled labor<br>Product devaluation<br>Sampling problems |
| Saleable product | Boning<br>Trimming | Practical cutting tests in the marketplace<br>Relates to industry value | Rapid to obtain<br>Less costly<br>Doesn't devalue a carcass<br>Doesn't assume proportionality is constant for all carcasses | Difficult to standardize trim<br>Ignores intramuscular fat and skeletal variation<br>Not indicative of muscle: bone if bone isn't removed |

which to predict these endpoints accurately through simple, nondestructive, and therefore relatively inexpensive means. Methods range from simple carcass measurements and specific gravity to complex physical dissection of indicator cuts. Development of such methodologies should enhance carcass compositional quality by promoting continuity in research efforts.

### Value Based Marketing

Pork prices at the retail level should reflect consumer preferences. If this occurred, consumer preferences in the form of high prices for lean pork would be passed through the marketing channel to producers, who would be able to use the information to adjust production and breeding practices. Under most pork marketing systems, however, differences in prices paid by consumers are not being passed back to producers (Kauffman et al., 1988).

To improve price signal quality, various pricing systems have been developed that link producer payment to true carcass value. The USDA live weight grades, the back fat carcass weight grids, e.g., the *National Pork Producers' Council Guide to Lean Pork Value,* and the percentage lean system recently implemented by Hatfield Quality Meats all are examples of such systems. Whereas each is a better discriminator of carcass value than a single live weight price is, only the percentage-lean system makes a direct link between lean quantity and producer payment.

For a number of behavioral, technical, and economic reasons, the move to value based payments has been slow. These reasons include negative producer and packer attitudes toward carcass merit pricing; lack of objective, reliable carcass evaluation technologies; and high implementation costs.

Over the past few years, many of the technical obstacles involved in evaluating pork carcass composition have been removed. Yet one key question remains: How is one best to tie producer payment to true value? An accurate value-based marketing system must send clear signals from consumer to producer.

### Carcass Fatness

Numerous studies have documented gross compositional (fat, lean, and bone) differences among pork carcasses. These differences are influenced by differences in fat deposition, muscling, sex, breed, etc. Data in Table 14.18 summarize carcass and yield traits from selected research studies conducted over the past 50 yr. Perhaps the only variable remaining fairly stable was carcass length.

Data from Terry and Savell's 1988 study indicate that carcasses with less than 1.3 in. average back fat thickness (three dorsal midline measurements) still contain more than 40% separable fat. It thus seems that the first pork-quality problem stems from carcasses' remaining excessively fat and that cutability attributes can be improved considerably.

Breed and genetic selection history effects on carcass composition have been publicized little. Bruner and Swiger (1968), conducting an extensive study of more than 2,500 pigs representing six breeds (Table 14.19), found that Poland and Hampshire pigs generally had less average back fat, greater lean-cut percentage, and larger *Musculus longissimus* areas than the other four breeds did. Yorkshire, Duroc, and Landrace carcasses had the most back fat and the smallest *M. longissimus* areas. Percentages for the four lean cuts followed a similar pattern. Such genetic advantages have yet to be exploited.

**Table 14.18. Summary of carcass and yield traits among several studies**

| Reference | n = | Carcass wt. (kg) | Carcass length (cm) | Mean backfat thickness (cm) | *M. longissimus* area (cm) | Four lean cuts (%)[a] |
|---|---|---|---|---|---|---|
| Warner et al. (1934) | 79 | 74.2 | — | — | — | — |
| Hankins and Hiner (1937) | 240 | 78.7 | — | — | — | 42.1 |
| Holland and Hazel (1958) | 105 | 64.4 | 74.2 | 3.68 | 21.3 | 46.5 |
| Cross et al. (1975) | 316 | 69.3 | 77.2 | 3.18 | 27.7 | 58.0 |
| Smith and Carpenter (1973) | 70 | 65.8 | 75.7 | 3.48 | 28.4 | 53.0 |
| Cross et al. (1973) | 403 | 65.8 | 77.2 | 3.86 | 23.9 | — |
| Aberle et al. (1977) | 25 | 72.0 | 77.2 | 3.30 | 27.7 | 54.8 |
| Fahey et al. (1977) | 41 | 72.0 | 76.7 | 2.95 | 33.6 | 51.1 |
| Edwards et al. (1980) | 359 | 65.3 | 77.5 | 3.78 | 24.5 | 57.3 |
| Grisdale et al. (1984) | 185 | 84.4 | 84.3 | 3.28 | 35.5 | — |

[a]Bone-in (0.60 cm external fat trim).

### Castration

In swine, castration has less effect on growth rate and on carcass composition than in either cattle or sheep. But castration does promote earlier maturity in swine than in cattle or sheep—possibly because of differences in physiological age at the time of the procedure.

In general, differences in the growth rates of boars and of barrows have been small (Seideman et al., 1982). Although differences in feed efficiency also have been small, they have tended to favor boars. Prescott and Laming (1964), citing 12 studies, reported that growth rate and feed efficiency for boars were 1.5 lb/d and 1.5 lb feed/lb live weight gain, respectively.

Siers (1975) reported that gilts and boars produced carcasses with significantly larger *Musculus longissimus* areas and greater ham and loin percentages than barrows did.

Prescott and Laming (1964), citing four to seven references, reported that boars had an average dressing percentage of 74.7%, an average back fat thickness of 1.2 in., and an average *Musculus longissimus* area of 4.1 in.$^2$, whereas barrows averaged 76.1%, 1.5 in., and 4.0 in.$^2$, respectively. Thus, advantages in terms of compositional traits, excluding their effects on dressing percentage, favor production of boars.

Seideman et al. (1982) summarized boar and barrow differences as follows: "advantages of boars in growth characteristics and carcass merit are not as large as those of bulls and rams, but may be worthy of consideration nonetheless." The growth characteristics and the carcass merit of boars possibly could be improved; before extensive research is conducted to elucidate growth patterns for those traits, however, the problem of boar odor should be investigated. Cause and effect relations in this area have not been elucidated fully and therefore have impeded potential progress in carcass merit grading.

## Quality Prediction Equations

Because carcass composition is an inherent quality component in the determination of value, mathematical and statistical methods have been used as alternative means of evaluating economically important carcass compositional traits. Such methods often have been underutilized, however, because of complexity at the applied level.

Numerous studies have examined the effectiveness of using different live animal and carcass characteristics to predict compositional endpoints. The accuracy and the precision of these techniques are paramount if the resulting equation is to be useful. Relations therefore must exist between measured and predicted carcass traits. Most early research was conducted on a small scale and used data collected as part of feeding and breeding studies. Sample populations seldom were ideal for examining the suitability of predictors for a range of practical applications.

Kempster et al. (1982) summarized the accuracy of various carcass trait predictors compared with that of carcass dissection:

1. Carcass dimensions and *Musculus longissimus* dimensions are poor individual predictors.
2. Visual fat assessments, fat thicknesses, and specific gravity determinations are more precise, possibly in that order.

**Table 14.19. Comparison of sex and breed effects on carcass composition[a] (Bruner and Swiger, 1968)**

| Effect | n = | Carcass wt. (kg) | Carcass length (cm) | Average backfat thickness (cm) | *Musculus longissimus* area (cm$^2$) | Ham (%) | Loin (%) | Four lean cuts (%)[a] |
|---|---|---|---|---|---|---|---|---|
| Sex | | | | | | | | |
| Gilt | 1,497 | 66.7 | 75.9 | 3.6 | 27.7 | 21.0 | 16.5 | 54.6 |
| Barrow | 1,011 | 66.7 | 74.9 | 3.8 | 24.5 | 19.0 | 15.9 | 52.9 |
| Breed | | | | | | | | |
| Yorkshire | 773 | 67.1 | 77.2 | 3.9 | 25.2 | 19.9 | 16.1 | 53.2 |
| Duroc | 213 | 66.7 | 73.9 | 3.8 | 24.5 | 20.0 | 15.6 | 53.0 |
| Poland | 270 | 67.6 | 73.9 | 3.5 | 29.0 | 21.4 | 16.2 | 54.9 |
| Hampshire | 686 | 67.1 | 75.4 | 3.5 | 27.1 | 20.7 | 17.0 | 55.2 |
| Spotted | 214 | 67.2 | 74.9 | 3.7 | 26.5 | 20.5 | 15.9 | 53.2 |
| Landrace | 352 | 66.2 | 77.7 | 3.6 | 24.5 | 20.3 | 16.3 | 53.2 |
| Total | 2,508 | | | | | | | |

[a]Pigs removed from test at approximately 95 kg live weight.

## Relating Measurement to Value

Many studies have reported the relation (correlation) between linear and area measurements and salable product yield. An example from Cross et al. (1973) appears in Table 14.20. Five singular measurements of back fat thickness (dorsal midline) were significantly (P < 0.01) related to lean cut yields, as were their averages. Off-midline fat-depth measurements over the *Musculus longissimus* were better (P < 0.05) predictors of lean cut yield than any of the five dorsal midline-fat thickness measurements were.

Smith and Carpenter (1973) agreed, stating that off-midline measurements of fat depth were more indicative of carcass leanness/fatness than traditional dorsal midline measurements of back fat were. Among the muscling indices, *Musculus longissimus* area at the last rib (r = .59) was related more closely to percentage of the four lean cuts than was USDA muscling score (r = .34), ham cushion thickness (r = .51), lumbar lean depth (r = .28), chine depth (r = .21), shoulder lean thickness (r = .31), or *M. longissimus* area at the 10th rib (r = .48).

**Table 14.20. Correlation coefficients between carcass measurements and percentages of lean cuts (Cross et al., 1975)**

| Measurement | Ham and loin (%) | Four lean cuts (%) |
|---|---|---|
| Carcass weight | −.21 | −.19 |
| Carcass length | .36 | .33 |
| Backfat thickness (first rib) | −.63 | −.63 |
| Backfat thickness (midpoint, first and last rib) | −.75 | −.74 |
| Backfat thickness (last rib) | −.70 | −.72 |
| Backfat thickness (midpoint, last rib, and last lumbar) | −.67 | −.68 |
| Backfat thickness (vertebra last lumbar) | −.75 | −.77 |
| Backfat thickness (average of five measurements) | −.79 | −.80 |
| Backfat thickness (average of three measurements) | −.78 | −.81 |
| U.S.D.A. muscling score | .35 | .34 |
| U.S.D.A. carcass grade | −.35 | −.35 |
| Ham cushion thickness | .50 | .51 |
| Fat thickness over the ham | −.66 | −.68 |
| Lumbar lean depth | .35 | .28 |
| Chine depth | .19 | .21 |
| Shoulder lean thickness | .31 | .31 |
| Fat thickness over the shoulder | −.69 | −.65 |
| Longissimus muscle area (10th rib) | .45 | .48 |
| Longissimus muscle area (last rib) | .57 | .59 |
| Fat depth (10th rib) | −.85 | −.83 |
| Fat depth (last rib) | −.88 | −.88 |
| Combined fat measurement (10th rib) | −.86 | −.83 |
| Combined fat measurement (last rib) | −.87 | −.87 |

Several pork compositional prediction equation traits appear in the literature. These indicate several lean and/or fat endpoints. A number of popular equations appear in Table 14.21.

These recommendations should be considered in the selection of a prediction equation:

1. Equations should be developed on a population resembling that to which they will be applied.
2. Equations should be validated on a population resembling that to which they will be applied.
3. A balance should be established between the numbers of animals subjected to complete side dissection and the numbers on which only predicting measurements are taken. This balance should be cost effective and statistically valid.
4. Prediction equations should be used that have proved the most reliable in regard to the endpoint.

Linear area and sample cut data points are obtained more accurately on large numbers of animals and well may be more cost effective. Integration of these techniques into mechanical evaluation instruments may enhance producer ability to predict compositional traits. If product quality is to be maximized across all marketing segments, this ability is necessary.

## Development of Technology Measuring Value

Before products can be marketed based on ultimate value at the consumer level, the meat industry must be able to evaluate both quality and quantity of lean meat in a carcass. Technology or instrumentation will have to be accurate, fast, reliable, economical, adaptable, and durable. Because of the diversity of operations, a single technology is unlikely to be adopted universally. And the information provided by a given technology will be used differently from one operation to the next.

Several techniques for assessing pork carcass composition have limitations precluding their use by the meat industry. Examples include potassium 40 counting, dilution, radioactive gas tracing, and X-ray computed topography. Nuclear magnetic resonance imaging currently is quite expensive, requires special shielding, and is slow. Its great predictive ability for body/carcass composition, however, warrants further research and development to reduce associated costs and to increase speed.

As mentioned, real time ultrasound imaging, optical fat-lean probes, and TOBEC are being investigated and have the potential for success.

If individuals within the U.S. meat industry are careless, time and money will be wasted when efforts are duplicated. Without question, objective grading to determine value is a priority in many countries, and major duplication may occur if efforts are disorganized. The industry thus should develop a plan with six objectives:

1. to identify the value traits that it wishes to measure;
2. to establish parameters for instrumental precision and accuracy;
3. to identify conditions under which the instrument would operate, e.g., speed, temperature, humidity, physical abuse;
4. to identify technologies available or likely to be available to meet these needs (Perhaps various institutions or countries can take different approaches with different technologies);
5. to identify (a) project leader(s) for each country

**Table 14.21. Summary of regression equations used to predict pork carcass components**

| Regression equations[a] | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Effect | | | | | | | | |
| Number of observations | 70 | 41 | 185 | 403 | 250 | 316 | 403 | 41 |
| Mean for dependent variable | 44.82 | 51.10 | — | — | 53.00 | 57.95 | — | — |
| SD[b] for dependent variable | 3.74 | 3.40 | — | — | 3.13 | 3.10 | — | — |
| Coefficient of variation | 8.34 | 6.65 | — | — | 5.91 | 5.35 | — | — |
| Intercept | 27.85 | 44.40 | 66.62 | 37.00 | 54.65 | 67.68 | 69.48 | −7.49 |
| $R^2$ x 100 | 78.08 | 68.40 | 65.88 | 89.46 | 74.19 | 75.40 | 85.82 | 83.00 |
| Standard error | 2.06 | 2.00 | 2.43 | — | 1.63 | 1.60 | — | 3.20 |
| | | | | ß Values | | | | |
| Independent variables | | | | | | | | |
| Carcass length (cm) | 0.33 | | | 0.07 | 0.11 | | | |
| M. longissimus area, ($cm^2$) | 0.21 | | 0.102 | 0.33 | 0.28 | 0.16 | | |
| M. longissimus area ($in.^2$) | | 2.73 | | | | | | 4.96 |
| Fat depth, 10th rib (cm) | −3.43 | | 4.01 | −3.32 | −1.36 | −1.95 | −4.11 | |
| Fat depth, 10th rib (in.) | | −8.06 | | | | | | −10.98 |
| Average backfat thickness (cm) | | | | | −2.00 | −2.47 | | |
| Average backfat thickness of five measurements (cm) | | | | | | | | |
| Cold carcass weight (kg) | | | | | −0.20 | | | |
| Hot carcass weight (kg) | | | | | | | | 0.46 |
| Adjusted hot carcass weight (lb) | | | | | | | | |
| USDA muscling score | | | | | | | 0.09 | |
| Days on test | | | | | | | | |
| Initial live weight on test (lb) | | | | | | | | |

[a]Authors and dependent variables:

| | |
|---|---|
| 1. Smith and Carpenter, (1973) | % separable lean |
| 2. Fahey et al. (1977) | % fat-free muscle |
| 3. Grisdale et al. (1984) | % fat standardized (10%) lean |
| 4. Cross et al. (1973) | % lean in four lean cuts |
| 5. Smith and Carpenter (1973) | % four lean cuts |
| 6. Cross et al. (1973) | % four lean cuts |
| 7. Cross et al. (1975) | % four lean cuts |
| 8. Fahey et al. (1977) | Pounds of fat-free muscle |

[b]SD = standard deviation.

and (a) potential source(s) of funding; and
6. to establish goals or milestones to speed progress.

## Lamb

### Factors Predicting Palatability

The USDA quality grades of lamb carcasses are based on evaluations of (1) estimated physiological age of the animal at slaughter, assessed by observation of muscle color on the interior surfaces of the body cavity and by observation of color and shape of rib bones and ossification of cannon bones or trotters; (2) amount and distribution of streaks of fat across the surface of the primary flank muscle, factors used as indirect indicators of the amount of marbling expected in the ribeye; and (3) conformation of the carcass, as indicated by width, bulge, and plumpness of muscles, which together indicate muscle to bone ratio of the carcass.

Quality grade standards (U.S. Department of Agriculture, 1992a) are intended to apply to all ovine carcasses without regard to sex at slaughter. But male carcasses indicating buckiness (thick, heavy necks and shoulders) are discounted from one-half of a grade to two full grades, depending on the extent of the problem.

Skeletal maturity is determined based on presence or absence of the spool joint and on width and color of the rib bones. Carcasses with two break joints (the alternative to spool joints) are classified A Maturity lamb carcasses; one break and one spool joint implies either B Maturity or yearling mutton classification; two spool joints imply mutton. Rib bone color and shape are evaluated to help determine carcass maturity. Carcasses with red, round ribs are considered young; those with wide, flat, white ribs, old.

Lean maturity is determined by evaluating muscle color and firmness. The standards specify a minimum degree of firmness of lean and fat for each grade. Lean color in upper and lower flanks plays an important role in final maturity scores of lambs. Generally, the darker the lean color, the older the carcass. Skeletal and lean factors of maturity are evaluated, and the carcass is assigned to one of four possible maturity groups.

Maturity groups are A, B, yearling mutton, and mutton. Associated chronological ages of each maturity group are A Maturity: 3 to 8 mo; B maturity: 8 to 14 mo; yearling mutton: 14 to 24 mo; and mutton: more than 24 mo.

Conformation is assessed and can be used to adjust quality scores upwards, but adjustments of no more than one-third of a grade are allowed. Quality scores are assigned based on the amount of fat streaking in the flanks, a characteristic ranging from abundant to devoid. Carcasses with extensive flank streaking are expected to have a high corresponding marbling score.

To be eligible for Prime and Choice grades, carcasses must exhibit an adjusted fat thickness of 0.10 in. This minimum fat thickness requirement is included in the standards to control cold induced shortening during early postmortem chilling and to maintain shelf life. Many lamb carcasses are shipped from packing houses to breakers or to purveyors; dehydration and microbial growth of lean tissue are controlled in part by the thin layer of fat during transport.

Maturity, lean quality, and conformation scores are balanced to obtain a USDA quality grade. And the more youthful the carcass, the more extensive the fat streaking in the flanks and the greater the muscle to bone ratio—thus, the higher the USDA quality grade. Mutton carcasses are ineligible for the Prime grade regardless of the amount of flank streaking and carcass conformation.

Figure 14.16 illustrates the relations between flank streaking, maturity, and lean quality. Clearly, an increase in flank streaking is needed to compensate for increased physiological maturity if a given quality grade status is to be maintained.

### Quality-Measurement Ability

Current methods of assigning age or maturity scores to carcasses by means of USDA grading standards are decidedly biased against ewe lambs at ages

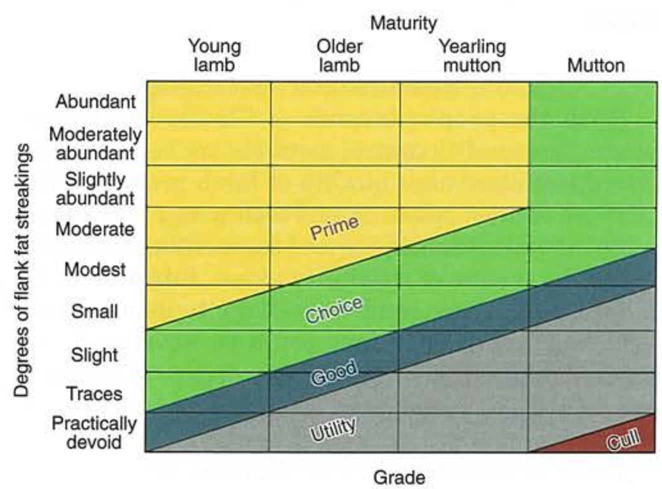


**Figure 14.16. Relations between maturity and lean quality in the assignment of a USDA quality grade (USDA Official Standards for lamb, yearling mutton, and mutton, 1982).**

exceeding 9 mo (Smith et al., 1970). Although ewe lambs seem to mature 60 to 120 d earlier than wether lambs, the effect of such maturation has no affect on palatability. At actual ages of 9 to 11 mo, up to 19 to 21 mo, 19 to 82% more ewes than wethers are ineligible for classification as lamb, yet palatability of cooked loins and legs favored ewes over wethers or was equal in 11 of 12 separate comparisons (Smith et al., 1970). Quality grading standards need to be altered to compensate for such findings.

Leaving carcasses *unribbed* (intact) during grading may have two negative outcomes. The first is a lack of direct marbling assessment. Under the current grading system, an indirect indicator, flank streaking of intramuscular fat, is used to determine palatability of lamb cuts. But flank streaking is only 15.2% accurate when used to predict palatability (Smith et al., 1970).

When carcasses are ribbed, marbling, lean color, firmness, and texture all are much better indicators of palatability than flank streaking is. For example, beef-quality grades are assigned according to marbling, color, firmness and texture characteristics of lean in the ribeye, and research has demonstrated that low marbling scores are associated with great percentages of undesirable ratings for overall tenderness, flavor desirability, and palatability (Tatum et al., 1982).

The second problem is a somewhat diminished accuracy of carcass composition prediction. Alternative measures for determining fat opposite the longissimus muscle, body wall thickness, and ribeye area could be used instead of the factors currently used to determine yield of saleable product (Smith et al., 1969).

#### Value-Measurement Technology

With the preponderance of Choice and Prime lambs, few quality control methods are being used to guarantee consistent quality of lamb products. The purpose of most research and technology is to determine means of identifying and segmenting lamb carcasses by means of cutability alone. Edwards et al. (1989) used ultrasound technology to demonstrate that regression equations could be developed and applied to identify with the same degree of accuracy lambs by this means as by a trained human evaluator.

Several researchers, e.g., Garrett et al. (1991), have demonstrated the usefulness of the Hennessy grading probe in determining lamb carcass composition. With increased demands by industrial organizations to revise and to modify lamb cutability standards, technology developed to estimate or to measure fat aid successful use of a cutability system.

## Information Dissemination/ Promotion Activities

Many institutions, both public and private, are involved in disseminating information about livestock and meat quality.

### Public Institutions

The **USDA–AMS Livestock and Seed Division** provides market price reporting services for livestock, meats, and grains (Livestock and Grain Market News branch; grading, certification, and "brand-naming" services (Meat Grading and Certification branch); oversight of marketing and promotional programs (Marketing Programs branch); federal procurement of products (Commodity Procurement branch); and development of standardized trade language (Livestock and Meat Standardization branch). Market information and prices are collected from all service branches and generally are reported on the basis of quality grade, yield grade, sex, and weight range.

The **USDA–NASS** provides basic data regarding beef slaughter by class, live and dressed weights, and meat production, as well as cattle on feed, cattle inventory, and farm level prices.

The **USDA–ERS** publishes basic price, supply, and use information. It also provides situation, outlook, economic research, and policy analyses with respect to beef production, price, and quality.

The **USDA-ARS** provides technical research and data on animal composition and meat quality. It also examines technical production relations among breeding, feeding, and other animal production technologies as they relate to meat quality. After being reorganized in 1995, the ARS also now provides research and data on the American diet and on the sources of food nutrients, by individuals. It lists the compositions and the nutritive values of meats of various quality descriptions.

Other government agencies also are important sources of information. These include the Food Safety and Inspection Service, the APHIS, the FDA, and the NIH. University research and extension programs provide information in many of the areas just outlined.

### Private or Quasi-Private Information Sources

There are many private sector and quasi-private information and promotion sources that address quality issues. Examples include the NLMB, the USMEF, the NCA, the American Meat Institute, the FMI, the American Heart Association, and the American Cancer Society.

Much of the scientific work on livestock and meat quality is published in the form of research journal articles in the publications *Journal of Animal Science*, *Journal of Food Science*, *Journal of Food Quality*, *Journal of Meat Science*, and *Sheep Research Journal*. For each of the species, the USDA–AMS works closely with responsible industry organizations in the development of new or in the revision of established official trade language.

## Livestock and Meat Promotion, Research, and Information

Beef is promoted by public and by private entities. Food stores and restaurants promote or feature beef regularly because of its importance to consumers. Private branding of fresh beef also is becoming quite common and currently is successful when programs are based on merchandising niche products selected from the total, diverse beef population. Classification is narrowed to the specification level, but specifications are of a flexible trade-language type that allows both third-party conformity assessment and proprietary brand-naming.

The Cattlemen's Beef Promotion and Research Board (CBPRB) is an important industry funded organization for determining and disseminating information about beef quality. The Beef Promotion and Research Act of 1985 authorized the establishment of a national industry-funded and -operated beef promotion and research program known as the *Beef Check-Off Program*. The Act provided for the establishment of a coordinated promotion and research program designed to strengthen the beef industry's position in the marketplace and to maintain and to expand foreign and domestic markets and uses for beef and beef products (U.S. Congress, 1985).

The program is financed by assessments on the sale of domestic and imported cattle and beef products. Regarding domestic live cattle sales, the Act requires that each person paying a producer for cattle shall collect an assessment ($1/head) from the producer and remit it to a qualified state beef council and to the board established under the Act. The states and the CBPRB each receive 50% of the check-off dollars collected.

The act designates the meaning of key terms relevant to the use of check-off funds. *Promotion* refers to any action, including paid advertising, designed to advance the image and desirability of beef and its products and having the express intent of improving the competitive position and stimulating the sales of beef and its products.

*Research* refers to studies testing the effectiveness of market development and promotion efforts, studies relating to the nutritional value of beef and its products, related food science research, and product development.

*Consumer information* refers to nutritional data and other information that will assist consumers and other persons in making evaluations and decisions regarding the purchase, preparation, and use of beef and its products.

*Industry information* refers to information and programs leading to the development of markets, marketing strategies, efficiency, and activities enhancing the cattle industry's image. The Beef Check-Off Program became effective on July 18, 1986, and assessments began October 1 of that year. A required referendum was held among all cattle producers and importers on May 10, 1988. Of the 256,505 valid votes, 78.9% were in favor of continuing the program.[2] After passage of the referendum, producers no longer could receive rebates for contributing to the program even when they disagreed with it. It is administered by the 107-members of the CBPRB, who are appointed based on nominations provided by the states to the secretary of agriculture. Ten members of the Board and ten individuals elected by the Federation of State Beef Councils make up the Beef Promotion Operating Committee (BPOC), which is responsible for developing budgets and awarding contracts for beef promotion, information, and research activities.

In 1990, $80 million in Check-Off revenues were divided between "Qualified State Beef Councils" and the Board. In 1990, most funds disbursed by the board were for promotion (Table 14.22).

In May 1991, the BPOC voted to adopt recommendations from a marketing study by Booz-Allen & Hamilton, Inc., which recommended halting the current national advertising campaign (Real Food for Real People) for a year to develop a bigger and more exciting campaign. The company also recommended developing the partnering concept with fast-food, food-service, packaging, and retail entities (*Texas Cattle Feeders Association Newsletter*, 1991).

Recently, cattle producers initiated an effort to merge the four major beef industry organizations into a single, more efficient organization. A long-range-strategy task force, comprised of beef industry leaders from the four major organizations, had recommended the action in December 1993 during the CBPRB annual meeting. The task force generally concluded that the combined financial resources of the four organizations could be used more efficiently, with less duplication, if the beef industry realigned to decrease staff, travel, and meeting requirements.

Organizations to be merged in the long-range beef industry plan include the CBPRB, the NCA (the grass-roots, private industry policy and lobbying force for cattlemen, primarily funded through membership and affiliate dues), the BIC of the NLMB (the promotion, consumer information, and research coordination group), and the USMEF (the trade group responsible for foreign market development and promotion; also funded by membership dues and by USDA Market Promotion funds). It now seems that some reorganization is imminent, but the final structure of the new group still is unclear. It does seem that (1) the USMEF will continue as a multispecies, subcontracting organization to the new structure, (2) the CBPRB will continue to exist independently, with a clear line separating it from the other functions and revenue sources of the new organization, and (3) although continuing to conduct multispecies projects, the NLMB will shift the beef staff into the new organization.

Similar to the beef program, a National Pork Board was formed by the Pork Promotion, Research, and Consumer Information Act of 1985 to "strengthen the position of the pork industry in the marketplace; and maintain, develop, and expand markets for pork and pork products." For funding, all hogs going to market currently are assessed at a rate of $0.35/$100 value (.35%), but a proposed revision to the order will increase the assessment to $.45/$100 (.45%) of market value in 1995.

Contracting organizations to the National Pork Board include the National Pork Producers' Council (NPPC), along with its state affiliates, and the Pork Industry Group of the NLMB. Additionally, the USMEF contracts with the NPPC and is involved in developing foreign markets and promoting pork and pork variety meats.

Evidently, the realignment of beef industry organizations into a single entity also will have an impact on pork groups. This is because several programs in the pork industry currently are tied together in multispecies efforts with those of the beef industry. Dismemberment of the NLMB (a multispecies organization) by removal of the BIC will have an especially dramatic effect on the residual capabilities and infrastructure of the Pork Industry Group. The Pork Industry Group very well may be incorporated into some single pork industry structure that in the end is similar to the newly formed group of the beef industry.

The American Sheep Industry Association (ASIA) and the Lamb Committee of the NLMB currently promote lamb and subcontract research projects to solve problems associated with lamb cutability and quality, to the extent that funds are available. But with the demise of the Wool and Mohair Act (the legislation that formerly allowed funds raised from import tariffs to be redistributed as a subsidy and for research and promotional purposes), promotion and research funds available to the sheep industry will disappear by 1996. To that end, the industry lobbied and was successful in obtaining new legislation—the Sheep Promotion, Research, and Information Act of 1994—to offset the loss of promotional funds. Although the legislation and authority to proceed now exists, at this time neither a Proposed nor a Final Order is published in the Code of Federal Regulations although this probably will change by mid to late 1995. Subsequent to publishing a Final Order, the industry still will require passage of a referendum before it will be capable of collecting assessments.

**Table 14.22. Revenues and expenses reported by the Cattlemen's Beef Promotion and Research Board in 1993 and 1994 (Cattlemen's Beef Promotion and Research Board, 1994)**

| | 1993 | 1994 |
|---|---|---|
| Revenues | | |
| Assessments | $44,231,377 | $44,032,187 |
| Interest | 690,806 | 646,632 |
| Other | 35,230 | 25,560 |
| Total revenues | 44,957,413 | 44,704,379 |
| Expenses | | |
| Program | | |
| Promotion | 24,776,330 | 25,270,225 |
| Research | 4,272,346 | 3,798,619 |
| Consumer information | 3,830,242 | 4,010,135 |
| Industry information | 4,630,958 | 5,093,905 |
| Foreign marketing | 3,273,988 | 5,487,151 |
| Producer communications | 490,532 | 454,091 |
| Program evaluation | 24,564 | 27,350 |
| Program development | 525,506 | 485,758 |
| Total program | 41,824,466 | 44,627,234 |
| USDA Oversight | 193,371 | 200,467 |
| Administration | 1,587,959 | 1,582,495 |
| Total expenses | 43,605,796 | 46,410,196 |

## Industry Changes

The industry is moving toward lean products. Pork has made the most headway in this regard, but the other red-meat industries are beginning to change. Industry structure also is being transformed, with firms at all levels decreasing in number and increasing in size.

The incidence of merchandizing by brand name has increased slowly but may be poised to take off for beef, lamb, and veal. Quality measurement by means of grades or brand names probably will become increasingly common.

## Glossary

**Captive supplies.** Livestock purchased on contract or through other control arrangements long before ready for slaughter.

**Cattle raising.** Maintaining a beef cow herd for the purpose of producing beef calves, or cow-calf production.

**Class.** Age of lambs at slaughter.

**Commercial operators.** Slaughter lamb producers and Feeder lamb producers together; those primarily maintaining ewes that produce lambs for consumption.

**Consumer information.** Nutritional data and additional information that will assist consumers and other persons in making decisions regarding purchase, preparation, and use of a product.

**Cow-Calf production.** See cattle raising.

**Cutability.** Amount of saleable product produced when the carcass is fabricated into boneless, closely trimmed retail cuts.

**Dressing percentage.** Ratio of hot carcass weight to live weight.

**Endpoint.** Compositional aspect of paramount importance in a given experiment.

**Farm-Flock operators.** Managers of small flocks of ewes.

**Feeder calves.** Saleable product of cattle raising activities.

**Finishing.** Final stage in preparation for slaughter.

**Grade and Yield.** Marketing method whereby value is determined according to expected USDA grade and dressing percentages. Can be calculated for individual animals or "pen averaged" across groups of animals.

**Heterogenous in demand.** Commodities for which there is no universal agreement regarding what is good or bad as described by economists.

**Homogenous in demand.** Commodities for which there is universal agreement regarding what is good or bad as described by economists.

**Industry information.** Information and programs leading to the development of markets, marketing strategies, efficiency, and image enhancing activities.

**Lean value pricing.** A matrix of price adjustments from a base for characteristic traits related to cutability and quality.

**Marbling.** Intramuscular fat related positively to palatability.

**No rolls.** Ungraded steers and heifers (and a few cows), so called because the grade mark is not rolled onto the carcass.

**Order buyers.** Third parties who for a fee locate and purchase livestock of the type desired.

**Palatability.** Flavor, juiciness, and tenderness. A predicted classification factor of all USDA "quality" grading systems for livestock and meat.

**Promotion.** Any action, including paid advertising, designed to advance the image and desirability of a product and having the express intent of improving competitive position and stimulating sales.

**Quality grade.** Characteristics predicting palatability of cooked lean meat.

**Range-Sheep operators.** Managers of very large flocks on large parcels of land.

**Unribbed.** Carcasses left intact during grading.

**Yield grade.** Predicted cutability classification segregating live animals or carcasses based on the ratio of edible to nonedible carcass components.

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# 15 Milk and Dairy Products

J. E. Legates[40]

## Introduction

Milk is a highly nutritious perishable commodity that must be produced and handled with specialized equipment under sanitary conditions. Milk destined for fluid consumption or for processing into manufactured dairy products must be marketed promptly. Because of its bulk, milk is expensive to transport from farm to market to consumer. It usually moves from the farm to plant or collection center in refrigerated tank trucks. Uneven seasonal supply and demand must be balanced by the production of a wide variety of manufactured dairy products with long storage lives.

## Production and Uses of Dairy Products

From whole milk and butter, demand for dairy products has shifted toward cheese and lowfat fluid. Lowfat fluid milk consumption has doubled since 1970, and today more lowfat milk is consumed than whole milk. The most striking change is the increase in average annual cheese consumption, now almost 25 lb per capita, in contrast to 8.5 lb in the 1960s. A considerable quantity of nonfat powder also is used in baking and in other food related manufacturing. Per capita use of milk equivalents in milk and dairy products slowed and declined slightly in the early 1980s. However, it increased to 558 lb per capita by 1988 (National Dairy Promotion and Research Board, 1989). Dairy product exports account for only 1 to 2% of total production (U.S. Department of Agriculture, 1990a).

Milk now is produced on a relatively few large, specialized dairy farms. Northcentral and northeastern states continue as major producing areas, with Pacific coast and southwestern states becoming increasingly important. The number of dairy farms continues to decline, and farm size and number of cows/herd to grow with increased capital investment. Milk production for 1989 was 145 billion lb, from about half the number of cows milked in the mid-1950s.

Eighty-nine percent of the milk marketed from farms in 1987, compared with 67% in 1950, met the Grade A sanitary requirements for fluid milk. Since 1970, milk output/hr of labor has increased nearly fourfold. The increase in efficiency has resulted largely from expanded production/cow through improved management, more liberal concentrate feeding, and genetic improvement of the dairy herd. Average annual production/cow more than doubled in the last 30 yr, rising to 14,358 lb in 1989.

## Marketing System Organization

With the large percentage of milk being produced under Grade A sanitary conditions, fluid milk and manufacturing sectors have become closely related. Most milk used in manufactured products is derived from Grade A milk not required to satisfy fluid milk demand.

Cooperatives have become increasingly important forces in the movement of milk from producer to processor. In 1989, 70% of milk was marketed through producer cooperatives, which procure, assemble, and coordinate a seasonally fluctuating milk supply (*Hoard's Dairyman*, 1990). Cooperatives provide for farm quality control, intermarket milk transfer, and seasonal surplus management. Early in the 1970s, cooperatives undertook an expansion of processing facilities—mostly for cheese and powder production, but with some entry into fluid milk processing. This trend clearly slowed and to an extent reversed itself in the latter part of the 1980s.

Food chains entered into fluid milk processing in the 1960s; since then, their importance as a channel for fluid milk sales has increased. Consumers purchase most fluid milk and other dairy products from supermarkets and convenience stores. A small and decreasing proportion of dairy products reaches con-

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sumers by means of home delivery.

Price supports undergird the pricing systems of milk sold by farmers to processors. Such supports originated with World War II legislation and were maintained through 1949 by the Agriculture Act of the previous year. The secretary of agriculture was directed to set a support price within the range of 75 to 90% parity to provide a milk supply able to meet consumer needs. The minimum support level was raised from 75 to 80% parity by legislation in 1960, 1973, 1977, and 1979.

The Agriculture and Food Act of 1981 introduced triggers on support price, relating the minimum support level to the amount of CCC purchases. The basic support level was $13.10/ctw. 1982 legislation, reflecting duress from continued surpluses, froze the support price for 2 yr and provided fees to milk producers so as to offset government costs partly. In 1983, the Dairy and Tobacco Adjustment Act (DTAA) lowered the price support to $12.60/ctw and gave the secretary of agriculture authority to lower the level further, according to the amount of milk equivalent purchased by the CCC. The FACT 1990 provided for a price support level of $10.10/ctw for milk at 3.67% fat, and the 1990 Budget Reconciliation Act assessed dairy producers the costs of administering the program.

The CCC purchases butter, nonfat dry milk, and cheese to support the average price of manufacturing-grade milk at the specified level. Prices to farmers for manufacturing-grade milk can exceed the support level if supply and demand permit. Prices have exceeded the support level in the short supply season; in the main, however, actual price received has been quite similar to support price.

Even under the federal support structure, the Minnesota-Wisconsin (M-W) price has been the most important factor in determining the price of milk. This price is the weighted average price paid for nonorder milk used for manufactured products in the two states. The M-W price, based on competitively determined values, avoids rigidity and distortion of administratively mandated prices. Unregulated levels also tend to encourage efficiency in manufacturing plants (U.S. Department of Agriculture, 1984).

Federal milk-marketing orders set minimum prices for processors to pay both farmers and cooperatives for Grade A milk in markets where producers have voted to sell milk under a federal order. Prices of milk for fluid use are established higher than those of Grade A milk for manufactured products. Proceeds for milk sales from each marketing order area are pooled, and farmers receive a blend or average price. Federal orders neither limit the quantity of milk produced or marketed nor prevent cooperatives from bargaining for above federal order minimum prices.

Class I includes milk used for fluid products; Class II, that used for fluid cream, ice cream, cottage cheese, and yogurt; Class III, that used for cheese, butter, and nonfat dry milk. Minimum class prices are established on the basis of specified relations to federal price support and M-W prices.

Minimum prices of Class I milk increase with distances of markets from the basing point of Eau Claire, Wisconsin. Moving from Eau Claire, minimum order Class I prices increased at a specified rate/ctw/100 miles. Actual Class I prices may exceed the federal order minimum price by negotiation for additional payments on the basis of either quality or supply guarantees.

Federal marketing orders for perishable products are designed to invest the market with stability and orderliness and to provide an environment enhancing market power among dairy producers through marketing cooperatives. The federal orders achieve these objectives by

1. setting under handler prices a floor limiting price shading and providing a bargaining base during price negotiations;
2. limiting handler ability to obtain less costly milk from other orders or unregulated supplies;
3. providing reblending privileges for milk receipts across marketing orders to allow cooperatives to redistribute returns to individual marketing order areas; and
4. providing auditing procedures to ensure honest accounting of milk use, weight, and evaluation.

Certain handlers, primarily cooperatives, provide a premium/ctw for milk with low leucocyte and bacterial counts. No critical information on the cost effectiveness of reducing leucocyte and bacterial counts is available, but its desirability generally is documented in terms of increased milk yields for producer and increased product yields and shelf lives for intermediate and ultimate consumers (Jones, 1985).

Component pricing is being used in some markets as yields of various products, e.g., fluid milk, butter, and cheese, are influenced differentially by milk constituents. Currently, fat can be separated readily from the nonfat portion, but milk protein content cannot. Consequently, the protein content in fluid products cannot be varied readily. Component emphasis on fat and nonfat solids seems the most reasonable for those purchasing milk for fluid consumption. Milk entering the manufacturing channels is evaluated for protein and fat contents. Lactose content in nonfat solids is an important flavor component of fluid milk but largely a by-product for cheese making processes.

For years, the price differential for milk has been based on fat content. Price received at the farm was increased or reduced depending on whether fat content was above or below a specified level. Although not fully recognizing milk's other valuable constituents, this procedure was reasonably appropriate during the butter economy. But easily conducted standardized tests were unavailable for fat.

Now, accurate and rapid tests are available for both fat and protein. And an increasing number of cheese plants are purchasing milk based on component pricing of both. Although the change has been slow, in the long term, it will not increase revenues for producers but will redistribute returns more equitably, in accord with fat and protein contents of milk from individual producers.

With cheese becoming an increasingly important fraction of dairy product sales, component pricing is in order. Fat differentials are driven by variation in the value of butter, but protein differentials are driven by variation in the values of other manufactured products, especially cheese. Pricing based on the content of both fat and nonfat solids seems appropriate for fluid milk.

Protein and nonfat solids are correlated positively with fat content; hence, a degree of variation in these constituents accompanies change in fat percentage. The use of fat content as a standard was accepted largely because its determiner—the Babcock test—was a fairly simply assay method.

In the 1960s, with the concern for fat in the diet and the emergence of cheese rather than butter as a primary dairy product, emphasis began to shift from the fat standard. Equally rapid and accurate methods for determining fat and protein by infrared technology provide a further impetus for market evaluation on protein content, especially of milk used for cheese. The excess milkfat in the market and the USDA's recent devaluation of fat (butter) compared with nonfat solids in determining its CCC reserve also erode the impact of the fat standard in the marketplace.

The dairy processing industry, like dairy production, has been characterized by a trend toward fewer and larger plants. From 1950 to 1980, the number of plants producing cottage cheese and butter decreased 90%. The number of plants producing hard cheese and ice creams decreased 75%. Facilities for processing milk and perishable products generally are located close to consumption areas. Frozen products and cottage cheese typically are produced as part of operations that also process fluid milk. These manufactured items serve to balance varying seasonal supply of milk, which is great in spring and limited in fall and early winter (U.S. Department of Agriculture, 1988).

## Quality Measurement in the Market Channel

*Quality* has been defined as a product's usefulness, desirability, and marketability. Consumer desires and needs are the major forces behind quality standards for milk. Yet a wide variety of markets and product uses also must be accommodated. Within the competitive framework of domestic and world markets, the industry strives to meet these various needs.

Taste is the major reason that consumers drink milk and eat dairy products. Notwithstanding, milk has exceptional nutritional properties, being high in protein and essential minerals and vitamins. Consumers also consider milk a "natural" product and become concerned when they suspect that "unnatural" ingredients have been added. The controversy regarding the use of bovine somatotropin (BST) is a vivid example of such concern.

In 1986, the allowable level of leucocytes in raw bulk milk from the farm was reduced from 1.5 million to 1.0 million/milliliter (ml) in the Pasteurized Milk Ordinance (PMO) by the U.S. Public Health Service/FDA. In 1993, the allowable leucocyte level was lowered further, to 750,000/ml.

This criterion provides an indirect index of mammary health. High leucocyte levels are associated with poor production, bacterial infection, and clinical mastitis; low levels, with increased FFA, sodium, and chloride contents, the last two being characteristic of mastitic milk. Thus, starter growth, rennet coagulation, and cheese yield may be influenced. It has been suggested that the shelf life of pasteurized dairy products also may be reduced when leucocyte counts are high (Jones, 1985).

Food safety is an important quality concern. Sanitary controls at the farm level and pasteurization have had important impacts on the alleviation of public health risk. A continuing concern is the risk of milk contaminated with antibiotics. Some humans have an acute sensitivity to minute amounts of antibiotics, which also can inhibit microbial activity in developing acidity, flavor, and curd characteristics in cultured products and cheese. The suggested withdrawal times for milk after treatment of the cow therefore must be followed strictly.

Product shelf life is important in all segments of the producer-consumer chain. Manufacturers desire long shelf life to avoid recall. Consumers desire long shelf life to avoid waste. Because both parties demand efficient use of milk and dairy products, milk use and farm return eventually should be affected.

Quality assurance standards for milk and dairy products are of prime importance because of the perishable nature of these products. Quality controls are administered by federal, state, and local programs involving farm and plant inspections, PMOs, interstate milk shippers agreements, and farm standards of milk production. Bacteria and leucocyte counts are determined periodically as indications of sanitation and animal health levels. When counts are excessive, milk from a farm may be unacceptable to plants.

Commodity grades and standards are not a factor in fluid milk marketing although different products with minimum milkfat and/or nonfat solids are defined by the states. The standardization section of the new national labeling legislation may change these definitions. Usage determines whether milk is Class I, II, or III for federal marketing orders.

Specific grade standards are established by the USDA for butter, casein, cheese, dry whole milk, nonfat dry milk, dry buttermilk, and dry whey. In 1943, butter became the first commodity for which U.S. Grades AA, A, and B were established. Before then, as today, private labels were important identifiers of quality in the marketplace for butter. The latest revision of butter grades occurred in 1989. Grades were established for cheddar cheese in 1950 and for Swiss cheese in 1953. Standards for Colby and Monterey Jack cheeses were established in 1973.

Grades for instant nonfat dry milk produced by means of the spray process were established in 1957; grade standards for dry buttermilk, dry whey, and dry whole milk, in 1954. Revisions of these grades were finished in the 1980s. Revisions of grades for dry whey and dry buttermilk are in progress.

Measurement technology has advanced greatly. Fat content initially was evaluated in terms of the quantity of churned butter in a volume of milk. But the Babcock test, developed in 1890 to determine fat content, had a major influence on the continuing emphasis on milkfat. Relatively easy tests for other constituents were unavailable. The Kjeldahl method for evaluating protein content and the lactometer for total solids provided satisfactory laboratory techniques, but time and expense made them unacceptable for routine testing. Recently, however, infrared technology has provided inexpensive but accurate and rapid tests for fat, protein, and total solids.

The Fossomatic cell count provides a rapid and reliable leucocyte count in lieu of a direct microscopic count. Microbiological tests conducted largely by public health officials require standard laboratory procedures, which although adequate are expensive. Laboratory tests for antibiotics and drugs now provide for detection of minute quantities, and some reasonably accurate field tests have been developed for rapid evaluations.

## Issues and Problems Related to Quality

Certain key issues loom that have potential impact on marketing and quality definitions. Among these issues are reconstitution of fluid milk, changes in federal orders and Class I differentials, pending use of BST, imitation products, and changes in definition of *fluid milk* to include a greater percentage of nonfat solids.

Imitation dairy products tend to capitalize on the reputation of the genuine product and to capture a significant portion of market share. Appropriate labeling and accurate advertisement are essential in all instances. The potential market for imitation products disciplines the dairy industry to maintain a high-quality product at a price differential acceptable to consumers.

Increasing the nonfat content in the definition of *fluid milk* has at least two rationales. First, added nonfat solids enhance flavor and acceptability to the consumer, thereby encouraging increased consumption. Second, use of additional nonfat solids in fluid milk would deter buildup of potential surpluses.

Currently, ingredients that could be used to reconstitute fluid milk or fluid product must be priced in accord with the value of Class I differentials, a major disincentive. Yet handlers with both Class I and manufacturing class sales can avoid Class I payments and reconstitution costs by reporting fresh milk purchases as manufacturing used and all fluid milk sales as reconstitutes. Such phantom manipulations nearly are impossible to police and make classified pricing unworkable. Existing tests cannot distinguish accurately between fresh and reconstituted milks.

If fallacious reconstitution could be prevented, estimates suggest that reconstituted milk would account for one-third or more of fluid milk consumption (Whipple, 1983). Farm prices for milk could decrease by as much as 15% in Florida and somewhat less in other areas of high-cost production. Farm prices in the Midwest probably would increase 1 to 2% if support prices were not operating. Gross farm receipts from milk sales would decrease because the industry would tend to locate in areas permitting low-cost production.

The potential for BST to increase milk output/cow adds to the concern over dairy surpluses. Additionally, consumers considering milk a pristine product view BST as an additive. Although the substance has been cleared by the FDA as not harmful to human health and approved for use on dairy cattle, many public interest groups continue to question this decision.

Concern also is being expressed about the ability of the M-W price to reflect accurately the competitive value of milk for manufacturing. The conversion of Grade B producers to Grade A requirements has narrowed the basis on which to determine the M-W price. Grade B manufacturing milk output in these two states decreased from 15 billion to 10 billion lb annually from 1970 to 1981. Simultaneously, the number of plants involved in the determinations of the M-W price decreased by 33%. Additionally, the value of Grade B milk is less than that of Grade A milk used for manufacturing, particularly when the Grade B volume becomes small. To accommodate small volumes of Grade B milk, plants often must incur the costs associated with dual-intake systems.

These concerns about the validity of the M-W price as a basis for milk pricing and marketing prompted the USDA to require hearings and recommendations for related amendments by June 1, 1992 (U.S. Department of Agriculture, 1990b). The USDA has delayed the decision on this matter, and no change in the M-W pricing base has been implemented.

## Information Dissemination

The National Dairy Council, the National Milk Producers Federation, and the Milk Industry Foundation conduct educational and promotional activities. Cooperatives and independent milk distributors undertake promotions often involving specific dairy-product brands or labels.

Land-grant universities, the USDA, and state departments of agriculture provide information about the dairy situation and trends. Price and quantity information is helpful to producers and processors.

Consumers increasingly are becoming aware of diet and health issues. And nutritional value is one of the primary reasons that consumers, who are especially worried about fat and cholesterol, and may confuse the two, purchase dairy products. The industry is challenged to help consumers keep the fat and cholesterol issues in proper perspective and to indicate how dairy products can be an important part of lowfat diets. The protein, mineral, and vitamin contents of milk make it especially appealing for such diets. Milk and dairy products are characterized by a relatively inelastic demand although educational and promotional efforts in recent years seem to have stimulated a modest increase in their use.

The DTAA of 1983 authorized the creation of the National Dairy Promotion and Research Board (NDPRB), whose goals are to provide an orderly procedure for financing and conducting coordinated programs of promotion, to strengthen the position of the dairy industry in the marketplace, and to maintain and to expand domestic and foreign markets. Assessment of dairy farmers provides the support for advertisement, nutrition, education, and research in product development. The Board has an annual revenue of about $75 million.

The United Dairy Industry Association, which includes state and regional units of the American Dairy Association, was active before passage of the 1983 Act. Efforts are being made to coordinate the promotional activities of the Association with those of the National Dairy Board.

## Anticipated Changes Influencing Quality

The dairy industry continues to be guided by changing consumer desires. And because consumers are interested in convenience, the industry is challenged to improve packaging, enhance shelf life, and develop new efficiency features.

Although the nutritional properties of milk are recognized widely, consumers are sensitive to diet and health issues. Concerns about dietary fat and cholesterol challenge the dairy industry to help consumers keep these issues in perspective. New products removing cholesterol, modifying milkfat, and incorporating lowfat cheeses and deserts with unique flavors and tastes are being developed by producer sponsored research. But packaging, shelf life, and convenience features must be improved if the modest increase in per capita milk equivalent consumption of recent years is to be maintained. Six Dairy Foods Research Centers have been established by the NDPRB to this end.

Lowfat fluid milk sales now exceed whole milk fluid sales. Potential changes in lowfat fluid milk standards to increase milk nonfat solids to above-average levels found naturally could increase the usage of nonfat milk solids. Advocates suggest that consumers prefer the taste of milk fortified with additional nonfat solids and that such milk is relatively nutritious. Nevertheless, sales of fortified lowfat and skim milk have declined, indicating that consumers do not believe that the benefits justify added costs.

Specific casein proteins have been shown to increase cheese yields. For kappa-casein, BB types have yielded about 10% more parmesan cheese than AA types have (Aleandri et al., 1990). This finding is merely a glimmer of the possibilities for modifying casein by means of selection and other genetic procedures. Dairy owners can alter the amounts of protein and fat in milk by selection on the basis of progeny tests and cow records. Although protein and fat contents are positively correlated genetically, there is some opportunity to increase protein content and to reduce or at least to maintain current fat levels in milk (Wilcox et al., 1971).

Ultra-high-temperature (UHT) processed milk with aseptic packaging prolongs shelf life extraordinarily. The major advantage seems to exist in locations outside major population centers. Because refrigeration is available in such a large proportion of U.S. homes, this type of milk probably will become a major force in the market only when packaging costs are reduced. Theoretically, UHT could be useful in foreign markets if cost competitiveness could be achieved.

Milk is bulky because of its water content. The use of membrane technology to remove water has enhanced the use of whey products. Because of its high cost, this technology, which could boost the retention of whey protein to increase cheese yield, is less likely to be used soon on the farm than in processing plants. In the Netherlands, where fluid milk consumption is rather low and cheese production of prime importance, component pricing includes a negative value for water.

International trade involves a small portion of total world milk production. Reportedly, between 3 to 6% of world production is processed and traded between countries. Clearly, milk is consumed largely in its country of origin. One-third of the world's dairy exports are provided by Australia and New Zealand, and another major portion is exported by countries in the EEC.

Great changes in exports or imports of dairy products seem unlikely soon. Import controls are essential for local price support programs to operate, and export subsidies in the EEC are unlikely to be reduced drastically. Annual imports to the United States are equivalent to 2 billion to 3 billion lb of milk, with cheese and casein the major products. United States exports of 1 billion to 2 billion lb of milk equivalent are likely to continue under current world trade conditions. Export subsidies and import barriers are major factors influencing the international market for dairy products.

With the emphasis on genetic improvement and the potential approval of BST, production likely will increase more rapidly than consumption. This eventuality will depress milk prices for manufacturing to federal support levels provided in the 1990 farm bill. Changes in interorder transportation differentials and regulations regarding reconstituted fluid milk could erode regional marketing strategies.

Market differentials previously based on fat content are trending toward a component pricing concept. Additional milk used for cheese production is being priced on the basis of protein and fat content. Movement toward pricing milk for fluid consumption on the basis of nonfat solids and fat components seems likely. Producers whose milk has low bacterial and leucocyte counts should be reimbursed for meeting these quality standards, for they impact shelf life and cheese yield.

A series of hearing were held by the USDA regarding possible changes in then current federal order regulations. A potential change in the Class I regional differentials was one of the points discussed. The Secretary was to take hearing results under advisement and, to the extent practical, make changes in the federal order regulations by January 1, 1992. The USDA now has confirmed maintenance of the current regional Class I price differentials.

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# 16 Channel Catfish

Richard T. Lovell[43]

## Introduction

Channel catfish (*Ictalurus punctatus*), freshwater, warmwater fish reproduced on the farm and grown to harvestable sizes of 0.5 kg (1 yr) to 1.5 kg (2 yr), grow optimally at temperatures of 22 to 30° C. They are fed 32% protein, grain based feed and require 1.4 to 1.8 kg feed/kg weight gain. Usually produced in 5–10 hectare (ha) (12.5–25 a.) ponds, catfish sometimes are produced in raceway systems. Yields range from 3,000 to 7,000 kg/ha/yr (2,600–6,200 lb/a./yr). Fish are harvested throughout the year and delivered alive to processing plants for processing and shipping in ice-pack (fresh) or frozen forms to market channels.

Traditionally regarded as a southern or a midwestern working person's fish, catfish has not shared the public image of such restaurant specialties as shrimp and snapper. But because of desirable eating qualities (no intramuscular bones, light flesh, mild flavor) and a vigorous marketing effort by the catfish industry, acceptance has increased across the country. Consumers are so attracted to the nutritional and health aspects of catfish and to its moderate price and appealing flavor, that annual industry growth has averaged 20% for the last 10 yr. Catfish currently ranks fourth behind tuna, cod, and shrimp in terms of popularity among American consumers of fish products.

## Production and Uses

### Production

Eighty-seven percent of the nation's catfish is produced in the lower Mississippi River flood plain (Mississippi, Arkansas, and Louisiana); 70% comes from Mississippi alone. Total acres in production in the United States in 1990 were 161,900 (Mississippi: 94,000; Arkansas: 20,500; Alabama: 18,600; Louisiana: 11,500; other states: 17,300); farm size ranged from 10 to 2,000 a. Farms of fewer than 200 a. usually needed supplemental income.

Farm raised catfish is used for human food. Purchasers are institutions, e.g., restaurants and lunch programs, supermarkets, and fish markets. Catfish are purchased as fresh or frozen noncooked products. Harvested fish are delivered to processing plants alive and are either immediately slaughtered or held alive in tanks with flowing water until slaughter. The processing flow scheme is as follows: heading, eviscerating, skinning, chilling, sizing, filleting, icing or freezing, and packaging. Most products are bulk packed (5 to 10 kg). Approximately 40% of catfish are ice packed, and 60% are frozen. Frozen fillets are injected with a polyphosphate solution (10% of weight) as a preservative and are glazed (2% of weight).

Major finishing products are fillets (0.1 to 0.3 kg) and whole sectional cuts from large fish, nuggets (belly wall), and a few further-processed products. Size-graded catfish fillets account for 47% of the marketed product; size-graded whole-dressed fish accounts for 31%; other products, e.g., nuggets, steaks, and value-added products, account for 22%. Only a small quantity of catfish products are processed further.

### Exports

No significant amount of catfish is exported in any form.

## Organization of the Marketing Channel

### Overview of the Market Channel

The market channel follows from farm to processing plant to distributor to institution or food market to consumer. Product ownership changes at each step.

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## Contract Production and Vertical Integration

Large catfish farms produce their own seedstock; small farms purchase seedstock from other farmers. Most feed is produced by farmer-owned feed mills. More than half of U.S. catfish are processed by one company—Delta Pride of Indianola, Mississippi, a farmer owned corporation purchasing fish from both stockholders and nonstockholders.

Several other producer-owned processing plants and several independent processing plants exist. Some corporations produce and process their fish. Although most catfish are not grown or sold under written contract as broiler chickens are, many farmers make oral agreements with processors to sell catfish, given the quantities of fish at the prevailing price at time of sale. Farmers produce or purchase their own feedstock, buy their own feed, and furnish their own labor, equipment, and technology.

Processing plants receive fish from their own production, stockholder production, and nonstockholder production, in that order. Farmers are paid after delivery.

## Pricing Practices and Strategies

Many catfish farmers in Mississippi belong to the Catfish Bargaining Association (CBA), an organization formed to establish pond-bank prices for farm raised catfish. This organization has been most influential when catfish supply has been great and prices have been low. Prices paid farmers and prices received for processed catfish essentially are market driven. When the supply of live catfish is small, the price paid farmers is constant for pond-run (all sizes) harvest. When supply is great, however, premium prices are paid for fish of optimal size. No quality attribute other than size is used in the pricing of live fish. Differences in prices received are based primarily on accessibility of the fish (distance from processing plant, convenience for harvest, etc.).

Prices of processed catfish are based on product, size, and processing method. Fillets of optimal size are the highest priced; next are optimally sized whole fish and steaks made from large fish. Iced, fresh products are higher priced than frozen products. Bulk packs are lower priced than small packaged units.

# Quality Measurement in the Market Channel

## Important Quality Attributes

Catfish should have a mild, delicate flavor free of any pond related (earthy-musty) or feed related off-flavors. Pond related off-flavor, a serious processor concern, is caused by compounds produced by aquatic microorganisms absorbed by fish through the gills. Processors use stringent subjective screening tests to prevent off-flavor fish from being processed. Although the consumer generally is unaware of this problem, occasionally off-flavor fish enter the market channel and seriously degrade the image of farm raised fish.

Farmers generally are paid for neither optimal size nor uniformity. Occasionally, during periods of oversupply, fish heavier than 1.8 kg are discounted. Minimum acceptable size is 0.3 kg; optimal fish size is 0.4 to 0.9 kg. Within this range, large fish yield optimal fillets, and small fish are marketed best whole. Because of production methods, the size of fish harvested from a single pond differs greatly.

Ideally, processed fish should have little dark muscle or surface fat (large fish have a layer of fat under the skin), a light to translucent color, and a smooth and muscular surface. The inside of the filleted muscle should be light to translucent and there should be no bloody spots, lesions, or yellow pigment.

A fresh odor is important in ice-packed fish, and absence of rancid odor or flavor is important in frozen fish. Poor frozen storage quality often is characteristic of large fish with great amounts of fat on the muscle surface.

Very little information is available on the bacterial quality of processed catfish. Limited survey data indicate that a total surface count of $10^3$ to $10^4$ organisms/$cm^2$ immediately after processing should be achievable with efficient processing. Because fish flesh is an excellent growth medium for bacteria and because a great percentage of processed catfish is marketed on ice, low initial bacteria count is important. Catfish products have not been recognized as significant sources of health microorganisms although—as with other animal food products—contamination may occur (through feeds, ponds, plants, etc.).

Currently, a great percentage (40%) of processed catfish is marketed fresh in ice-pack. But frozen catfish products generally maintain quality well when packed and stored properly. As markets increase and expand, a shift toward frozen products no doubt will occur.

### Quality Control at Each Point in the Market Channel

Although there is no mandatory on-site inspection for catfish processing, there is concern among government agencies, namely the FDA, the USDA, and the United State Department of Commerce (USDC), that this phase of the industry is unregulated. Several pieces of legislation have been proposed to provide mandatory inspection of seafood and aquaculture-product processing plants, but none has been passed. The public consensus is, however, that processing of these products inevitably will come under federal regulation.

The National Fisheries Institute (NFI), a private organization, in cooperation with the USDC, has developed for catfish an HACCP quality surveillance program that likely will be implemented when seafood and aquaculture inspection becomes mandatory. The NMFS of the USDC provides for the catfish producers voluntary inspection services, namely, continual on-site and lot inspections.

The only grade offered by the USDC, USDC Grade A, indicates that the product meets USDC criteria for quality and manufacturing practices and was processed under federal inspection (PUFI). Random samples of a product within a lot may be evaluated by an inspector, who need not be on site continually; the product will carry the label *USDC Lot Inspected.*

Most catfish processors in the United States belong to The Catfish Institute (TCI), a promotion and marketing association. This agency, with the assistance of the USDC, has established guidelines for manufacturing practices, and processing plants may indicate compliance by means of a package label.

### Grades and Standards

Grades or standards for catfish products generally are not used. The voluntary grading and inspection service offered by the USDC through the NMFS already described usually is used at the buyer's request, primarily for government purchases. Quality grades for catfish products may be of limited value because of the small variation in similar types of catfish products. The PUFI label, however, would enhance consumer confidence in quality and safety of products. Identity standards for catfish products have not been developed but would be useful in pricing and order filling and would minimize the opportunity for deception in marketing.

### Measurement Technology

There are no objective tests for the quality of catfish products. Before fish are slaughtered, the most serious quality flaw, i.e., off-flavor, is evaluated subjectively by one or more designated persons in the processing plant. Fish are evaluated approximately 10 d before harvest, 1 d before harvest, and upon delivery to the plant. Although compounds causing off-flavor have been identified, objective tests are impractical because the taste threshold is so low (fewer than 10 ppb). Bacterial analyses are used for in-plant quality control but not for regulatory purposes.

## Issues and Problems Related to Quality

### Price-Quality Relations

Off-flavor catfish are unacceptable to processors. (The off-flavor eventually will disappear from fish left in the pond, and they can be marketed.) Farmers are paid for neither size nor uniformity although live fish heavier than 1.8 kg sometimes are discounted if fish supply is great and price low. No other discounts for size or quality in live fish exist. Filets are the valuable processed product. Fish too small or too large for filleting are processed into whole-dressed fish or steaks and sold at low prices.

### Grades and Quality Attributes in Processed Catfish

Because of uniform quality among similar catfish products, need for grades is limited. Flavor should not be a criterion for grading catfish products because off-flavor fish should not be processed. Off-color, however, may be a criterion because carotenoid pigments from feed sometimes impart to the flesh a yellowish color not affecting flavor—only consumer bias. Bloody spots or other blemishes on the flesh also could be a grade attribute. Although size sometimes influences price of processed products, the relation is inconsistent.

# Information Dissemination

## Price Information

Prices paid to both farmers and processors are reported monthly by the USDA–NASS.

## Quality Information

Land grant universities, through the CES and the TCI, provide educational programs and literature about nutritional and quality attributes of catfish products.

## Promoting and Advertising

The Catfish Industry promotes Mississippi farm raised catfish through national media, exhibits, and other promotional programs. The institute is funded by a $0.50/t check-off on all fish feeds sold in Mississippi. In 1990, the value of such feeds exceeded $2.5 million. The Catfish Farmers of America, a national trade organization, represents the industry on various matters, sponsors an annual trade show and technical workshop, and publishes *The Catfish Journal.* Several states have catfish-farmer trade organizations.

# Anticipated Industry Changes Influencing Quality

## Utilization

### New Products and Processes

Increasing numbers of value-added products will be the major change. Included will be breaded and precooked products, controlled portions, and fabricated deboned flesh and fish pieces. A greater percentage of catfish products will be frozen and a smaller percentage ice packed. Greatest demand will be for fillets because of consumer preferences for boneless fish. A great percentage of catfish products will be marketed frozen because they maintain quality in frozen storage and because freezing preservation will allow market extension. Products meeting export market demand will be designed.

### Domestic and Export Demand

Because catfish can be produced at a relatively low cost and production can be increased manifoldly in the United States, catfish products will become a major export product. This change will not occur quickly, however, because of the potential for market expansion in the United States and because of foreign consumers' unfamiliarity with farm raised catfish.

## Production

### Geographic

Catfish farming will continue to concentrate in the Mississippi River flood plain but will expand southward because of relatively favorable water resources and warm temperatures. Catfish farming will expand in other areas in the South as well, such as South Carolina, Georgia, Florida, Alabama, and Texas. Foreign production of catfish by American owned or participating operations will be significant. Initial processing plants will remain located near farms, and vice versa. Further-processing operations may be located, not near production sites, but near user sites.

### Genetics

Genetic improvements primarily will affect production characteristics such as growth, feed efficiency, and stress tolerance. large muscled fish and high dressing yield are quality attributes for which to breed. And later maturing species (blue catfish) or strains may mean faster growth with less body fat. *Albinoism*, i.e., white pigmentation, is a reproducible trait, and some breeders have albino lines of brood stock. The flesh of albino catfish is lighter than that of dark catfish.

### Cultural Practices

Responding to price incentives offered by processors, farmers will produce more uniform and optimally sized fish. There will be fewer large fish (heavier than 1.8 kg). Pond-related off-flavor will be better controlled on the farm.

### Quantity Produced (User Demand)

Because of increased consumer familiarity and low price, the role of catfish in American diets will grow with per capita consumption of fish. Moreover, the fish most often consumed by the average U.S. consumer may become catfish.

## Marketing Structure

### Marketing Channel

Value-added processing will be separated from initial processing. large clients, such as McDonald's, will become the primary users, requesting specialized products such as portion-controlled fish pieces.

#### Firm Size and Type

Large corporations with established marketing organizations, such as ConAgra, Gold Kist, and Tyson's, may become more involved in the catfish industry and may use more sophisticated marketing strategies.

#### Vertical Integration and Contract Production

Vertical integration likely will be primarily within the business; in other words, the operation will produce its own feed and seedstock and will grow, process, and market the fish. Because of production risks, supplying seedstock and feed to farmers and buying back fish under contract, which occur in poultry production, likely will not occur with catfish. Although some form of supply-purchase contract between farmer and processor inevitably will develop, it will be flexible enough to allow for the uncertainty of harvest date caused by off-flavor and temperature.

#### Sophistication in Pricing and Quality

Buyers in the United States will become increasingly familiar with farm raised catfish. Per capita consumption of fishery products will continue to increase. Because of favorable price and consumer taste appeal, catfish will comprise a greater percentage of fishery products consumed. Within the next 10 yr, it will become the third most commonly eaten seafood after shrimp and fish sticks.

### Quality Measurement

#### New Measurement Technology

Presence of preharvest off-flavor will be evaluated objectively with specifically designed equipment. Before the fish go to the processing plant, rapid multisample analysis for off-flavor will be conducted in an independent testing laboratory.

#### Mandatory Government Inspection

Processing plants will come under mandatory government inspection, and some form of HACCP program will be implemented. The product will carry a PUFI label. A standardized product identification system also may be developed. Standard identity for products such as fillets, whole fish, nuggets, steaks, frames (backbones with fillets removed), and various value-added products will be established. Grades (A and B), if developed, will be based on appearance, size, and uniformity.

#### Buyer/Processor Sophistication

Standardized products will be marketed. Portion control will be required. Identify standards will enhance movement of products through the market channel by increasing the convenience of filling and placing orders and by boosting the confidence of buyers. The PUFI label will be on all products once catfish processing comes under federal inspection. Because of product uniformity, a grade label will not be as useful to catfish consumers as, for example, to beef consumers.

## Information Dissemination

### Educational Activities

The nutritional value of catfish will be emphasized in advertising and marketing. Through industry choice, if not government mandate, nutrient labeling will become a standard practice with catfish products.

### Branded Products

Branded products will become common, with large companies entering the business (Con Agra, Gold Kist, Delta Pride, etc.).

### Promotion

The Catfish Institute will continue its efforts in promotion. Organizations that once represented seafoods (nonaquaculture fishery products), e.g. the NFI, will expand promotion of aquaculture products.

## Opportunities for Improving Quality

### Economic Incentives

Farmers should be paid better prices for optimally sized fish and for harvest uniformity. Economic analysis of variously sized fish is necessary because different costs and conversion factors are considered for growing-year 2 (0.5 kg) and -year 3 (1.5 kg) fish.

### Grades and Standards

Grades are not of major importance with catfish products; identity standards, however, would be useful to the industry, as discussed.

### Communication

Much more information is available about catfish production than about catfish processing and marketing. Increased government extension and industry participation (workshops, seminars) are needed to ensure quality and safety of processed catfish products.

### Research

One reason for the scarcity of information about processing and distributing catfish products is a limited database. Thus, research is needed to identify critical safety and product quality areas, new processing and distribution technologies, consumer attitudes, and development avenues. The catfish industry has no research and development capacity, but it should work toward developing one. Additional industry check-off funds should go to research. Government sponsored study of product development and product quality is needed. Consumer research, which is quite scant, also is needed to give the industry direction.

### Products

Use of iced, fresh products instead of frozen products would result in a relatively stable product, facilitate market expansion, and improve overall quality. A line of further-processed products also would expand catfish markets.

## Role of Public Policy

### Provide Information about Quality

Although catfish products have a good safety and quality record, they are "unregulated." Government inspection and the PUFI seal, therefore, would ensure the public that catfish products are safe and wholesome. The public should be informed about what the PUFI seal means in terms of the quality of government inspected foods.

### Make Regulations

#### Identity Standards for Catfish Products

Implementation of product standards would enhance product flow through market channels and minimize fraud and deception.

#### Mandatory Federal Inspection

Passage of legislation mandating inspection of all fishery-products processing operations is inevitable and is expected within 2 to 3 yr. Subsequently, the USDA or the USDC (NMFS) probably will develop and administer a HACCP program in the catfish industry. This program will examine production, processing, and distribution.

#### Increase Research Activities and Funding

Recently, the Southern Regional Aquaculture Center, funded by the USDA, initiated a research project entitled "Safety and Quality of Aquaculture Products." The 3-yr, $1.1 million project includes two phases: (1) microbiology and (2) residues. This research should prove quite beneficial to the catfish industry.

#### Public-Private Cooperative Activities

The NMFS has designed a HACCP program for quality and safety improvement in the catfish industry. The service also has assisted the TCI in developing an industry-managed quality-assurance program.

## Role of Private Sector

### Quality Assurance

With the assistance of the USDC, the TCI has developed a quality assurance program in which most catfish-processing plants participate. Products from participating plants indicate on the label that processing takes place under the institute's guidelines.

### Alter the Pricing Strategies

Organizations such as the CBA, whose objective is to establish pond-bank prices for catfish, should take into account both processed product prices and production costs when determining market price of live catfish.

### Support Research

The catfish industry should use its influence to direct research funds to appropriate institutions. States such as Alabama and Mississippi use feed check-off funds for research.

### Industry Research and Development

Some catfish processing operations, or their parent organization, e.g., ConAgra, are large enough to establish R & D programs to investigate new products to improve processing procedures. At present, however, many processors have no R & D programs.

# Glossary

**Albinoism.** White pigmentation in catfish, a reproducible trait; some breeders have albino lines of brood stock.

# 17 Summary and Conclusions

Lowell D. Hill[44]

## Implications for Policy

The preceding description of the production, processing, and marketing of 12 agricultural commodities has provided the information needed for recommending a strategy for policy decisions about grades and standards. The appropriate roles of public policy and private enterprise differ among commodities depending on the size and the geographic distribution of production units, the complexity of market channel, the volume of commodity consumed in each use, the extent of processing before consumption, the economic organization of firms in processing and marketing sectors, and the technology available for measuring quality. Each industry attribute has been discussed in detail in the preceding chapters.

## Definition of *Quality*

*Quality* is an elusive term encompassing measurable characteristics as well as perceptions and preferences. Depending on product and use, as well as on individuals, whose perceptions may differ widely, *quality* means different things to different people. For some buyers, *quality* is almost synonymous with federal grades. At the other extreme, consumers often base quality evaluation on subjective properties of appearance or past experience. The task force adopted the following definition for this report: "*Quality* is the composite of attributes of the product that have economic or aesthetic value to the user."

The *attributes* in this definition are of several types: physical, intrinsic, sanitary and safety, and nutritional. Although these are not mutually exclusive in all cases, the taxonomy provides insight into some of the policies, issues, and concerns analyzed in this report.

Grades provide a technique for combining several quality attributes into a single-valued descriptor. However, personal inspection, labels, brand names, and contract specifications also provide information to buyers and facilitate the process of determining price and communicating information about value. Quality differences (real and perceived) are exploited by sellers through product differentiation, marketing strategy, classification scheme, and allocation among markets under marketing orders. Quality differences expand the choices available to buyers and consumers, but the ability of buyers and sellers to capitalize on these differences depends on the amount of information available to them.

The value of information about quality is increased by widespread adoption of uniform terminology. Especially in bulk commodities, uniformity of quality descriptors facilitates transactions without personal inspection by either buyer or seller. Uniform grades within an industry provide a method for classifying numerous qualities into a few categories. Private labels or brands create product differentiation and form the basis on which consumers can judge if the product conforms to specifications. Grades usually are established by industry groups or government agencies with the objective of uniform description and classification of a commodity for the entire industry. Certification, quality verification, and quality management standards provide further opportunities for characterizing and merchandizing products. Private labels and contract quality specifications usually are firm specific, with the objectives of controlling the characteristics of inbound commodities for processing or for differentiating their product to increase demand or market share.

In addition to their role in assigning values, grades also are used in conjunction with fruit and vegetable marketing orders and agreements to regulate commodity supplies moving to different markets. The USDA–AMS and the secretary of agriculture have the responsibility and authority to enforce the grade regulations of the marketing orders regarding both minimum quality and, occasionally, the allocation of different qualities to different markets. In this way, growers are allowed to receive economic rents. The balance between producer and consumer welfare is

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a frequent source of debate and negotiation.

Although policy debates often are focused on methods for improving quality, maximum quality not always is associated with maximum economic returns. In its report to Congress, the OTA carefully differentiated between *maximum quality* and *optimal quality* (U.S. Congress, 1989). The latter concept focuses attention on economic issues. There is a tradeoff between quality (reflecting value in use) and price. There also is a point at which the cost of quality improvement will offset any possible economic benefits.

The optimal-quality concept implies that market forces must be allowed to influence decisions. Grades, whether enforced by government agencies or voluntarily adopted by marketing firms, describe quality. They neither determine quality nor place values on differing quality characteristics. Legislation or regulation setting limits on "acceptable" or "merchantable" quality characteristics usurps the function of the market to assess value and to negotiate a market-clearing price for all qualities offered for sale.

This important principle must not be compromised by confusing quality concerns with safety and contamination concerns. The government has a role in setting safety standards for agricultural products and in prohibiting sale of commodities unsafe for use. Competitive markets have not been very effective in resolving questions of public health and safety. But the market is efficient in assigning prices to commodities possessing a range of physical, chemical, and psychological characteristics that influence value. Markets also are efficient in allocating commodities of differing characteristics among alternative uses requiring different qualities. To estimate values and to negotiate equitable prices, the market requires uniform descriptive terms, measurement technologies, and objective, unbiased evaluations.

## Alternatives for Describing *Quality*

A review of quality information among agricultural commodities reveals several alternatives in addition to grades for describing quality. Private labels can provide information about the product (primarily at the consumer level), and brand names provide consumers with an estimate of quality based on past experience. Quality specifications in combination with grades are used in purchase contracts to ensure a level of uniformity as well as quality for the characteristics described, but definitions as well as specifications may differ among contracts. Personal inspection and testing of each lot or item are effective methods of determining quality and value but are too labor intensive and expensive for most commodities, except at the retail level. Production contracts are used by many processors to control the process as well as the product from planting to processing. Although such contracts ensure delivery of the desired quality, they add to the cost of marketing because they require additional administrative and supervisory support.

The balance between costs and benefits of uniform grading administered by a public agency differs among commodities and among market stages. When purchase by description is essential to marketing efficiency, grades perform an important economic function. A structured means of quality identification, such as uniform grading, reduces risk associated with estimating value-based price differentials, facilitates equitable payment, provides a basis for uniform market information, and assists in development of market directed incentives.

The primary purpose of grades is to communicate information in verbal and written form to enable buyers to judge the value of the product for storage, transport, resale, or use. Specifically, uniform grades within a commodity market have three functions: (1) to facilitate trading by providing a limited number of homogeneous categories so that lots within each category can be substituted readily at equal values in the market; (2) to facilitate information exchange in the market system, thereby allowing price differentials to influence decisions; and (3) to facilitate establishment of price-value relations among various lots and qualities of products, creating incentives for change.

## Grades and Standards

Grades differ from standards in that *grades* are used to group or to classify commodities into a few categories to facilitate description and sale whereas *standards* provide uniform definitions and measurements of characteristics related to quality. Standards do not classify a product but are necessary for the development of grades. Standards are needed even when buyers purchase on personal inspection or through contracts specifying quality.

Standards are important to buyers as a means of identifying characteristics not determined readily from visual inspection. For example, the percentage of fat allowed in various kinds of ground beef is regulated by a public agency so that consumers can accurately identify content. Likewise, standards of weight, chemical composition, and nutritional information are provided for many retail products.

Standards also are important as means of guaranteeing weights and measures. These standards of quantity and of quality are needed throughout the market channel, and an efficient marketing system must be government supervised to ensure that measurements taken for commercial transactions are as accurate as technology will permit and economics justify.

For example, standards for calibrating grain moisture meters are supervised by a federal agency and implemented by state governments. If every moisture meter manufacturer were free to set calibrations, and every user free to adjust calibrations, then moisture content would provide only limited information about value and could not be used by management to guide decisions about storage and shipping.

Grades and standards obviously are dependent on one another, and the distinction between them is blurred sometimes. For example, accuracy in determining the quantity of grain purchased is achieved by enforcing standards for scales. But buyers also use information about moisture content to adjust the quantity of high-moisture grain. Scale weight is adjusted by multiplying the shrink factor times the percentage points of moisture above market base. Errors in measuring moisture have the same effect on the quantity sold as errors in measuring weight.

# Strategies for Describing Quality

There are several alternatives for providing information about quality to buyers and sellers of commodities. An industry may rely on government grades, private grades, other forms of third-party uniform evaluation, private labels, or personal inspection. Many industries use combinations of these approaches, and the most desirable mix differs among commodities and market-channel stages.

## Differences Among Commodities and Market Stages

Efficient arbitrage over time, form, and space for generic commodities such as grains often requires multiple transactions in which neither buyer nor seller actually sees the physical commodity. Grains are assembled from hundreds of thousands of farms, channelled through thousands of elevators, and sold and resold many times before reaching domestic processors or buyers located in foreign countries thousands of miles from the production area.

The final processor may have had no contact with the producers or the marketing firms that assembled the commodity into uniform lots. Few buyers see the grain at any point in the market channel; even processors may not see the grain until after it has been altered in form and condition. In large volume sophisticated markets such as the international grain trade, grades become an essential marketing tool to facilitate efficient exchange and to reduce marketing cost.

Government grades also are used in describing and classifying fruits and vegetables in the wholesale trade and are essential in implementing marketing orders that allocate different qualities to different uses, effectively segregating markets to increase producer income. In contrast, consumers evaluate fresh fruits and vegetables in retail stores on the basis of appearance and other characteristics that often are quite subjective. Consumers not only examine produce for overall quality but also may select item by item from display counters in the produce sections of supermarkets.

Numerical grading and standard terminology established by government or industry groups are of limited value at the retail level except where they reflect or predict eating satisfaction. Brand labels and visual inspection provide consumers with most of the information that they require. Thus, regulations requiring truth and accuracy in labeling are more important in retail purchases than are grading systems designed to classify products into uniform categories.

The meat and livestock industry also illustrates how the role of grades changes as the commodity moves through the market channel. Live animals are purchased on the basis of description and grades. At this stage, uniform descriptive terms are valuable to processors, who may be separated by one or two additional steps in the market chain from the producer, who can control delivered quality. The processor also is interested in grouping diverse qualities into a few uniform categories to minimize the variability of product delivered to the plant at any one time. The wholesale meat markets, under federal inspection, also rely on grades established by the USDA–AMS. Use of federal grades is voluntary and may be supplemented by additional private grades. However, at the retail stage the consumer may pay little attention to grade but select individual cuts on the basis of inspection at the display counter. USDA Choice, etc. are well known and used by consumers.

Many poultry products are produced under contract with growers, and in such instances, nationally uniform grades have limited value. At the retail level, consumer inspection takes precedence over government grades. Organic certification and nutritional information regarding, for instance the diet fed to layers, may influence consumers to buy a certain brand. A company may gain a competitive advantage by differentiating among eggs with different cholesterol levels. For consumers purchasing eggs, grades are used to indicate size rather than quality. The use of descriptive terms such as *free range* or *low cholesterol* to provide unique information about quality to consumers is a strategy for differentiation—not for standardization.

Processors of some commodities set unique specifications based on the characteristics required given consumer preferences. Conformance to such specifications may or may not be assessed by a third (government or private) party. The quality characteristics of importance in the raw product often depend on the intended use. For example, in the pecan industry, processors using pecans in confections may specify different characteristics than shellers preparing nuts for retail consumption. Nutritional information may be important in assessing quality in some foods but not in others.

## Role of Regulation and Public Policy

Grades are not essential for the quality assessment of many agricultural products. In general, the closer the product is to the final consumer, the more important visual inspection is and the less important nationally uniform grading is. Some commodities and products do not require a grading system for buyers and sellers to determine quality and value. Other commodities may benefit from federal grades but involve so small a volume or so few transactions that the cost of public involvement is unjustified. For example, the small safflowerseed market does not justify the cost of administering grades under the USDA–FGIS even though the commodity meets other criteria for federal grades. In other instances, uses are so diverse and quality for each use so unique that volume in any one use is too small to justify development of grades.

Federal grades are of greatest value for large-volume bulk commodities such as wheat and rice, markets in which inspection of individual units is not physically or economically feasible. Grades for agricultural commodities are more important when transactions involve large volumes with diverse characteristics, direct purchase from producers, and assembly into large volume lots for shipping or processing into a limited number of final products. The closer the commodity is to the final consumer, the less need there is for government involvement in nationally uniform grades. Because consumers select largely on the basis of experience, brand recognition, and visual examination, their reliance on government grades is minimal for commodities such as fresh fruits. Grades have minimal value when producers or processors visually select the products item by item at the point of sale.

When private benefits coincide with private costs, government need neither finance nor administer a public good to achieve economic efficiency. Increased vertical coordination through contract production or ownership control at the production level reduces the need for government to administer grades and standards, because the benefits of quality classification accrue to the private firm.

The trend toward organic certification in cotton, fruits and vegetables, and even specialty uses of corn requires that the contractors agree on quality specifications. The use of production contracts reduces the justification for using federal grades and federal inspection agencies to adjudicate delivered quality. For example, in those processed fruit and vegetable markets where the processor owns the product in the field and standards of quality are set by the contract, federal grades have little influence in creating incentives or setting prices.

Vertical integration also reduces reliance on federal grades. For example, in the broiler industry the producer's primary contribution is labor. The integrating processor-retailer owns the birds and provides other inputs. There is little need for federal inspectors to determine quality even though food safety and other considerations might require that sanitary standards be administered by federal employees. Grades have little economic value in a tightly coordinated vertical system.

## Policy Implications: Commodity Groupings

This report, which includes extensive reviews of production, marketing, and quality determination of 12 different commodity groups, provides insights into the appropriate role of government agencies in quality determination.

The marketing of generic commodities that require additional processing, e.g., grains, oilseeds, fiber crops, milk, and livestock, can be enhanced through nationally uniform grades. National uniformity throughout an industry usually requires government actions, either in the form of grades and inspection or in the form of enabling legislation, empowering an industry group to enforce uniformity. Communication and transaction costs are reduced in domestic and export markets by national and international grades and standards administered by a public agency. Legislation and public funding are required to generate aggregate benefits that cannot be captured by independent actions of individual firms.

Commodities produced under contracts specifying quality characteristics or in vertically integrated systems require no government grades. Buyers can set and enforce quality specifications and derive the benefits of improved quality without assistance from public agencies. Broilers, fish, malting barley, and specialty grains are commodities for which quality control can be maintained efficiently by individual firms.

As raw products move through the stages of processing, reliance on federal grades is reduced. At the retail level, few consumers rely on grades to describe desirable quality attributes except in the case of red meats and poultry. Private brands, descriptive terms, past experience, and visual inspection generally are adequate for commodities such as breakfast cereals, canned vegetables, and fresh fruits. The government's role should be to enforce truth in labeling and to set standards for nutrition and health related characteristics. Nut grades, which may be required to ensure equitable pricing practices at farms, are unnecessary for retail sales of fresh nuts or for foods containing nuts.

In later stages of processing, industry grades can be a substitute for government grades for processed products that are relatively uniform. Sales of oil, meal, and grain by-products are conducted under grades and standards established by industry sponsored associations. Processed meats also are marketed according to quality specifications that supplement or replace government grades.

Marketing orders and agreements provide market power to producers and their cooperatives. The concept of orderly marketing includes control of the supplies provided to different markets. One strategy for allocating supplies has been to direct different qualities or classes into different markets and to charge different prices. The role of government includes enabling legislation and developing grades and standards that are used in prorating supplies among markets with different elasticities of demand.

Forages provide an example of a commodity about which neither private nor government agencies are providing adequate quality information. Federal grades lack uniform measures reflecting nutritional value. Development of measurement technology is needed to enable buyers and sellers to replace or to supplement visual inspection with objective measures of feeding value. Implementation of uniform grades for hay must involve government agencies. The great number of buyers and sellers, the generic nature of commodities, and the need for sophisticated measurement technologies will require government research and development, as well as enforcement of quality descriptions.

## Regulatory Guidelines

The preceding chapters have provided some guidelines to determine whether regulation and legislation are necessary for efficient marketing of a commodity.

1. Price differentials for quality are required to generate incentives. Grades neither create incentives nor determine quality. They merely describe the existing quality characteristics to assist the market in using price differentials to discriminate among qualities and values and allow the reporting of price information on a uniform basis.
2. Accurate and detailed information increases marketing efficiency and ability to allocate each quality of product to its highest-valued use.
3. Developing and enforcing standards of weight and measure including those that reflect quality as well as quantity should be the responsibility of government agencies. Units of weight, calibration of scales, and operation of testing equipment must be uniform throughout the market system to generate the efficiency required in high volume, low margin markets.
4. Measurement technology is advancing rapidly. Research to improve the technology of grading and the dissemination of quality information will increase aggregate benefits, but these benefits may not be recognized by individual firms. Consequently, research on measurement technology and grades is a public good requiring funding and support by government agencies.
5. The role of government agencies should be to serve the entire industry rather than to respond to only one or two sectors of the industry. Uniform federal grades decrease marketing costs primarily through increased communication efficiency and through allocation of various qualities to their highest-valued uses. Those agencies responsible for setting, implementing, and enforcing grades and standards should be viewed as responsive to more than one segment of the industry and should include buyers, sellers, pro-

cessors, and producers in its evaluation of alternatives. The benefits of grades and standards accrue to the aggregate industry, not generally to the individual firm. Product differentiation provides economic benefits to an individual firm even though potentially diminishing total aggregate efficiency of the industry. Regulatory agencies and legislative bodies therefore must evaluate their role in setting grades and standards on the basis of aggregate benefits. The regulating agency may need to override the objections of individual firms for whom uniformity and standardization reduce monopoly or monopsony profits and preclude collection of excess economic rents.

6. Attempts to allocate costs of standardization and national uniformity only to those firms using grades and standards directly are self defeating. User fees that include costs of research and standardization will result in higher charges by the federal inspector than by private employees, whose costs do not include national uniformity. Firms will avoid grading costs when possible and, by substituting private (and therefore nonuniform) grades, will rely less and less on national uniform grades. This reduces the efficiency of using economic signals to communicate across the various sectors of an industry. With fewer firms using any one grading system, the value of information about quality will be diminished. Private grades require that every buyer become familiar with every seller to evaluate and to judge the adequacy and the credibility of quality information.
7. For certain commodities and at certain stages in the market channel, government grades are unnecessary. Personal inspection, private labels, vertical integration, and production contracts provide adequate protection and constitute an efficient system of quality identification for many agricultural commodities. Legislation and government regulation should be instituted only when industry structure, marketing channel, pricing practice, and commodity volume demonstrate a need for uniform grades and standards that cannot be met in the private sector.
8. Government and private grades should describe the full range of qualities and allow the market to determine which quality is acceptable for a particular use.

## Recommendations for Policy Action

1. The USDA–AMS and the USDA–FGIS under the auspices of the USDA–Joint Quality Committee (JQC) should review grades and standards for all commodities. Using the criteria established, the JQC should determine the extent to which current grades and standards are adequate for each of the commodities under the jurisdiction of the two agencies. It should decide which commodities should rely on private or industry quality determinations and which should be retained as the responsibility of a government agency.
2. The secretary of agriculture, in consultation with the USDA–AMS and the USDA–FGIS, should appoint a small task force for each commodity with members representing the USDA, industry, and academia. The task force should be given the charge to develop an ideal system of grades and standards for each of the commodities that they have determined needs government administered grades and standards. The task force also should develop a strategy for implementing required changes (if needed) to move industry toward the ideal, with minimal market disruption.
3. Congress should review current legislation to ensure that policy guidelines and regulatory authorizations are in place to enable the USDA–AMS and the USDA–FGIS to develop grades and standards best meeting the needs of the whole industry. Legislation should not restrict individuals in the market from determining optimal qualities or from determining prices for each quality offered without legislative restrictions on grade or on grade limits in transactions.
4. State and national government should continue to evaluate policy alternatives to provide producers and marketing firms with tools to enhance orderly marketing, marketing efficiency, and returns on resources. These objectives must be balanced against costs and consumer welfare.
5. Because of limited cost effectiveness, requirements for an economic impact study for each proposal to change a factor definition or factor limit should be eliminated. No one factor is essential to a system of grades and standards. Benefits are derived from the collection of factors and factor limits providing accurate descriptions of quality and value. Congress should authorize a simple study to demonstrate the costs and the benefits of uniform grades and standards for commodities for which mandated uniform grades are needed.

6. Legislative actions should be limited to providing regulatory agencies with the authority to revise and implement grades, and setting policy guidelines. Legislation should not attempt to "micro manage" the industry by prohibiting or requiring certain levels of quality, by restricting handling technologies or strategies, or by establishing mandatory price-quality relations.

The appropriate role of government in setting and in enforcing grades in a market economy depends on the agricultural commodity, the structure of the producing and marketing industries, and the stage in the market channel at which quality is being measured. Voluntary grades and federal standards facilitate the operation of marketing orders and collective action by producers. Producers, through cooperative marketing groups, can control and improve quality, segregating and directing the flow of qualities into their highest valued use. Without uniform measures of quality it would be difficult for each cooperative to establish grades and quality specifications. Government grades are essential to ensure efficiency and equity in some industries; grades may interfere with efficiency and increase cost and complexity in others. These distinctions must be recognized before regulatory policies are established.

# Glossary

**Attributes.** Physical, intrinsic, sanitary and safety, and nutritional characteristics of a product.

**Grades.** Designation used to group or to classify commodities into a few categories to facilitate description and sale.

**Quality.** Composite of product attributes with economic or aesthetic value to the user.

**Standards.** Uniform definitions and measurements of characteristics related to quality do not classify a product but are necessary for the development of grades. Needed even when buyers purchase on personal inspection or through contracts specifying quality.

# Literature Cited

U.S. Congress, Office of Technology Assessment. February 1989. *Enhancing the quality of U.S. grain for international trade.* OTA–F–399. U.S. Government Printing Office, Washington, D.C.

# Appendix A: Grades and Standards for Oilseed Products

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## Soybean Oil

*Crude soybean oil* is recovered from the beans by expulsion, pressure, or solvent extraction, or by a combination of these methods. The Trading Rules used most frequently in the United States, those of the NOPA (Anonymous, 1989a), specify that crude soybean oil shall conform to the specifications in Table A-1.

Moisture and volatile matter are important because excess moisture in a crude oil can lead to hydrolysis and increased FFA, both of which increase refining losses.

Oils with refined and bleached colors rated 6.0 red on the Lovibond scale or higher are unacceptably dark when processed into finished products.

*Degummed soybean oil* is crude oil with the major portion of the gums removed by means of hydration and physical separation. Quality specifications are listed in Table A-1.

*Once refined soybean oil* has essentially all FFA and nonoil substances removed by chemical treatment and physical separation. Specifications are listed in Table A-1.

*Fully refined soybean oil* (export) is produced from pure soybean oil from which all FFA and nonoil substances have been removed by means of chemical treatments and physical separation. This oil is used for salad dressing, food preparation, and cooking and thus should be bland in flavor, relatively free from color, and reasonably stable during use. Specifications are listed in Table A-1.

Standard measurement techniques based on AOCS Methods (Anonymous, 1989b) developed and tested by subcommittees of the AOCS Uniform Methods Committee are being updated and improved continually. And new techniques are being developed, tested, and introduced into the Methods in an ongoing program. Other organizations such as the American Association of Cereal Chemists, the AOAC, the Codex Alimentarius, the ASTM, the IUPAC, and many other foreign groups also sponsor programs to develop methods and list analytical methods used around the world.

## Soybean Meal

Most soybean meal is sold on the basis of 44% protein content. Thus, the important quality attributes are those describing levels of nutritional attributes. The minimum protein level of 44% is the most important feature. Feed formulators and others using the material base all feed formula calculations on this protein level and rely on the minimum level of 0.5% fat and the maximum levels of 7.0% fiber and 12.0% moisture as well. Fat level is important because it indicates whether the ration's energy requirement can be met. If the fiber level is too high, the digestible carbohydrate level will be too low. Moisture level controls component level but also affects storability. If moisture is excessive, meal will ferment and heat.

Penalties are assessed for excess moisture or fiber and for nonstandard protein content. According to NOPA rules, the penalty for excess moisture is two times the delivered invoice bulk price from 12 to 13% moisture and 2.5 times delivered price for moisture exceeding 13%. When fiber exceeds 7.5% for the 44% protein meal (based on an official sample adjusted to 12% moisture), the shipment will be discounted 1% out of the delivered invoice price for each 0.1% fiber in excess of 7%. Protein deficiency more than 0.5% below the specification (basis is an official sample at 12% moisture) will be settled on the basis of two times the delivered invoice bulk price/unit of protein below specification. There are certain limitations on the claims for fiber and protein on the high-protein (48%) meal, in that they cannot exceed 100 to 150% of the market spread between the 44 and 48% products, depending on whether the buyer was informed of the substandard shipment. Additionally, if total fiber and protein claim exceeds 15% of invoice price for 44% protein meal, the shipment is rejectable with freight to be paid by the seller.

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The NOPA standards (Anonymous, 1990) describe six types of soybean meals:

1. *Soybean cakes or chips* are the products remaining after oil is removed from soybeans by means of pressure or solvent. The process used and the protein content will be part of the name.
2. *Soybean meal* is ground soybean cake. The process used and the protein content will be part of the name.
3. *Soybean mill feed* is a by-product of the manufacture of soy flour or grits and is composed of soybean hulls and offal from the mill's tail. Typical analysis is 13% CP, 32% crude fiber, and 13% moisture.
4. *Soybean mill run* results from the manufacture of dehulled soybean meal and is composed of hulls and adhering meats. Typical analysis is 11% CP, 35% crude fiber, and 13% moisture.
5. *Soybean hulls* consist primarily of the outer covering of soybeans. They contain 13% moisture.
6. *Solvent extracted soybean flakes*, obtained by ex-

**Table A–1. Trading rule specifications for soybean oils (Anonymous, 1989a; 1989b)**

| Soybean oil Specification | Method | Amount |
|---|---|---|
| Crude | | |
| Not more than 0.5% moisture and volatile matter | — | — |
| A green color lighter than Standard B | — | — |
| A refined and bleached color not darker than 6.0 red | — | — |
| A neutral oil loss not exceeding 7.5% | — | — |
| Not more than 1.5% unsaponifiable material (exclusive of moisture and insoluble impurities) | — | — |
| A flash point | — | 250°F minimum |
| Degummed | | |
| Unsaponifiable matter | — | 1.5% maximum |
| Free fatty acids, as oleic | — | 0.75% maximum |
| Moisture, volatiles, and insolubles | — | 0.3% maximum |
| Flash point | — | 250°F minimum |
| Phosphorus | — | 0.02% maximum |
| Discounts from the contract price are allowed in ranges up to 1.25% FFA | — | — |
| Discounts are allowed in ranges up to 0.25% phosphorus | — | — |
| Once refined | | |
| Clear and brilliant at 70–85°F | — | — |
| Free from settlings at 70–85°F | — | — |
| 0.10% maximum moisture with discounts allowed up to 0.15% | — | — |
| 0.10% maximum FFA with discounts allowed up to 0.15% | — | — |
| Bleached color < 3.5 red and not predominantly green | AOCS method Ce 83–63 | — |
| Flash point | — | 250°F minimum |
| Unsaponifiables | — | 1.5% maximum |
| Fully refined | | |
| Flavor shall be bland | — | — |
| Color (Lovibond) 20Y/2.OR | AOCS method Cc 13b–45 | maximum |
| Free fatty acids | AOCS method Ca 5a–40 | 0.05% maximum |
| Clear and brilliant at 70 to 85°F | — | — |
| Cold test | AOCS method Cc 11–53 | 5.5 hours minimum |
| Moisture and volatiles | — | 0.1% maximum |
| Unsaponifiables | — | 1.5% maximum |
| Peroxide value < 2.0 meq/kg | — | 1.5% maximum |
| AOM stability 35 meq/kg | — | 8 hr minimum |
| GRAS preservatives permitted | — | — |
| Negative for fish and marine animal oils | — | — |
| Free from rancid, painty, musty, fishy, metallic, beany, and other foreign or undesirable odors | — | — |

traction of part of the oil from soybeans by means of hexane or related solvents, are designated and sold according to protein content.

Most meal sold throughout the world is either 44 or 48% protein. The specifications for these products are as illustrated in Table A-2.

# Cottonseed Oil

## Color

Followed closely by flavor, odor, and refining loss, color probably is the most important quality attribute of cottonseed oil. Color undoubtedly gained prominence because of the difficulties occurring as poor quality seed is processed. Crude oils have five grades indicating color and refining loss. If the crude oils have poor colors, they are difficult to refine and to bleach to an acceptable edible product. Often, dark, odoriferous oils contain FFAs, phospholipids, sterols, tocopherols, metals, pigments, and other nonsaponifiable materials. The miller sells refiners the oil on the basis of grade. If the oil is of an unacceptable grade for refining, the mill will dispose of it in non-edible use channels or in animal feed (Anonymous, 1989c).

## Flavor and Odor

Flavor and odor are related attributes connected to quality of the original seed. If the seed has deteriorated, flavor and odor often are objectionable, and it is difficult to process the oil to an acceptable end product.

**Table A–2. Specifications for soybean flakes and meal (Anonymous, 1990d)**

| Product[a] | Specification | Amount |
|---|---|---|
| Soybean flakes and 44% protein soybean meal | Protein | 44% minimum |
| | Fat | 0.5% minimum |
| | Fiber | 7.0% maximum |
| | Moisture | 12% maximum |
| Soybean flakes and high protein or solvent extracted soybean meal | Protein | 47.5 to 49.0% minimum[b] |
| | Fat | 0.5% minimum |
| | Fiber | 3.3 to 3.5% maximum[b] |
| | Moisture | 12.0% maximum |

[a]Any of the above products may contain an inert, nontoxic conditioning agent at 0.5% to reduce caking and improve flowability. The name of the agent must be shown as an added ingredient.

[b]Protein and fiber to be determined by buyer and seller at time of sale.

## Refining Loss

*Refining loss* is a measure of crude oil deterioration occurring because of seed quality. Enzymes in the seed catalyze oil hydrolysis, and FFA builds up. Thus, when the oil is alkali refined, there is much loss as soaps. Additionally, oils with high FFA levels are difficult to refine.

## Grades and Standards

Grades and standards for cottonseed oil are some of the oldest in the U.S. fats and oils industry. The 1989–1990 NCPA Trading Rules (Anonymous, 1989c) are given in Table A-3. These rules contain a chapter entitled "Methods of Chemical Analysis," which describes methods based on those of the AOCS, which have been undergoing refinement for the last 80 yr. Many techniques were developed for use in small QCLs attached to oil mills and refineries. Thus, many were relatively simple chemical and physical techniques using equipment available to the respective laboratories. Newer techniques involving state-of-the-art analytical instrumentation are being studied but have not been adopted even though many of the smallest laboratories have access to them.

# Cottonseed Cake and Meal

Cottonseed cake is designated Prime Quality if firm but not flinty in texture, free of sour, burnt, or musty odor and mold, and capable of producing Prime cottonseed meal when ground. Cottonseed cake is designated and sold according to protein or nitrogen content. If containing 36% protein or 5.76% nitrogen, it is designated 36% protein cottonseed cake, or Prime Quality. If the cake meets none of these requirements, it is graded Off-Quality. The rules describe many physical sizes and shapes of this product, but all must meet the requirements for Prime Quality cake.

*Cottonseed meal* is composed mainly of the cottonseed kernel, with such portions of hull, fiber, and oil as remain after manufacture. Prime Quality meal is ground finely but not bolted. It has no musty, sour, or burnt odor; is free of excess lint; and contains not less than 36% protein or 5.76% nitrogen. Cottonseed meal that has a sour, musty, or burnt odor or that is infested with weevils is graded Off-Quality and sold according to protein or nitrogen content.

**Table A–3. The 1989–1990 National Cottonseed Products Association Trading Rules for cottonseed oil grades and standards (Anonymous, 1989a)**

| Rule | Cottonseed oil | Specification |
|---|---|---|
| 144 | Crude | Crude cottonseed oil means the oil as produced from cottonseed only, by either the hydraulic, expeller, or screw press, prepress solvent, or solvent extraction system. |
| 145 | Prime crude | Prime crude cottonseed oil shall be prime in flavor and odor, as determined by Rule 201, and must refine, as required by these rules, to a color no higher than AOCS 7.6 and with a loss in weight not exceeding 12.0%. Combined moisture and insoluble impurities shall not exceed 1.0% as determined by AOCS test methods. Settlement on refining loss shall be made in accordance with Rule 201. |
| 146 | Basis prime crude | To be tenderable on a "basis prime" contract, crude cottonseed oil must refine, as require by these rules, to a color no higher than AOCS 12 and with a loss in weight not exceeding 20%. Combined moisture and insoluble impurities shall not exceed 1.0% as determined by AOCS test methods. Settlement shall be made in accordance with Rule 201. |
| 147 | Off crude | Under an "off-crude" contract, oil must refine, as required by these rules, to a color no higher than AOCS 20, with a loss in weight not exceeding 25%. Settlement shall be made in accordance with Rule 201. |
| 148 | Reddish off crude | Under a "reddish off-crude" contract, oil must refine, as required by these rules, to a color no higher than AOC30, with a loss in weight not exceeding 40%. Settlement shall be made in accordance with Rule 201. |
| 149 | Low grade crude | Crude cottonseed oil not coming up to the specifications set forth in Rules 147 and 148 shall be sold either by sample or as "lowgrade" cottonseed oil. |
| 155 | Choice summer yellow (refined) | Choice summer yellow cottonseed oil must be reasonably free from visible foreign matter, clear and brilliant at temperatures sufficient to melt the stearine, sweet in flavor and odor, of a color no higher than AOCS 7.6 and shall contain not more than 0.125% FFA nor in excess of 0.10% moisture and volatile matter. |
| 156 | Prime summer yellow (refined) | Prime summer yellow cottonseed oil must be reasonably free from visible foreign material, clear at temperatures sufficient to melt the stearine, sweet in flavor and odor, of a color no higher than AOCS 7.6, and shall contain not more than 0.25% FFA nor in excess of 0.10% moisture and volatile matter. |
| 157 | Prime winter yellow (refined) | Prime winter yellow cottonseed oil must be reasonably free from foreign material, sweet in flavor and odor, of a color no higher than AOCS 7.6, and must stand a cold test as prescribed in these rules, and shall not contain more than 0.25 FFA nor in excess of 0.10% moisture and volatile matter. |
| 158 | Good off summer yellow (refined) | Good off summer cottonseed oil may be off in flavor and odor, must be reasonably free from visible foreign material, of a color no higher than AOCS 7.6, and shall contain not more than 0.25% FFA nor in excess of a 0.10% moisture and volatile matter. |
| 159 | Summer yellow (refined) | Summer yellow cottonseed oil must be reasonably free from visible foreign material, sweet in flavor and odor, of a color no higher than AOCS 12, and shall contain not more than 0.25% FFA nor in excess of 0.10% moisture and volatile matter. |
| 160 | Off summer yellow (refined) | Off summer yellow cottonseed oil may be off in flavor and odor, must be reasonably free from visible foreign material, of a color no higher than AOCS 12, and shall contain not more than 0.50% FFA nor in excess of 0.10% moisture and volatile matter. |
| 161 | Reddish off summer yellow (refined) | Reddish off summer yellow cottonseed oil may be off in flavor and odor, must be reasonably free from visible foreign material, of a color no higher than AOCS 20, and shall contain not more than 0.75% FFA nor in excess of 0.10% moisture and volatile matter. |
| 162 | Prime bleachable summer yellow (refined) | Prime bleachable summer yellow (PBSY) cottonseed oil must be reasonably free from visible foreign material, temperatures sufficiently high to melt the stearine, sweet in flavor and odor, and when bleached as provided in these rules shall be of a color no higher than AOCS 2.5, and shall contain not more than 0.25% FFA nor in excess of 0.10% moisture and volatile matter. |
| 163 | Prime summer white cottonseed (refined) | Prime summer white cottonseed oil must be reasonably free from visible foreign material, clear at temperatures sufficient to melt the stearine, sweet in flavor and odor other than an earthy flavor, of a color no higher than AOCS 2.5, and shall contain not more than 0.25% FFA nor in excess of 0.10% moisture and volatile matter. |
| 164 | Prime winter white (refined) | Prime winter white cottonseed oil must be reasonably free from visible foreign material, sweet in flavor and odor other than an earthy flavor, of a color no higher than AOCS 2.5, must stand the cold test as prescribed in these rules, and shall contain not more than 0.25% FFA nor in excess of 0.10% moisture and volatile matter. |
| 165 | Stearine | Sec. 1. Prime bleachable cottonseed oil stearine must be only the residue after the removal of prime winter cottonseed oil, must be free from visible foreign material, clear at a temperature 10–15 degrees Centigrade above the melting point of the stearine, sweet in flavor and odor and when bleached as provided in these rules shall be of a color no higher than AOCS 2.5, shall contain not more than 0.25% FFA nor in an excess of 0.10% moisture and volatile matter and shall have a maximum iodine value of 98<br>Sec. 2. Cottonseed oil stearine other than bleachable conforms to all or the specifications of Sec. 1 of this rule with the exception of the bleach color, which shall be subject to agreement between buyer and seller. |

Prime quality solvent-extracted meal must meet the same standards but also must be labeled *solvent extracted*.

*Low-gossypol meal* contains not more than 0.04% free gossypol and is so labeled. It must meet the foregoing standards for Prime cottonseed meal.

## Whole Pressed Cottonseed

There also are grades for whole pressed cottonseed, which contains the entire cottonseed less oil and linters. The products of whole pressed cotton contain less than 22% protein and are sold according to protein content. If they fail to meet the other requirements for Prime cottonseed meals, they are graded Off-Quality.

## Cottonseed Hulls

Cottonseed hulls graded Prime must be sound, free of mustiness, and reasonably free of foreign material. Additionally, no lint should have been removed unless through the usual milling process. Hulls not meeting these standards, produced from Off-Grade, heated, bolly, or trashy seeds, or heated or damaged are graded Off-Quality.

## Sunflower Oil

Sunflower oil grades and standards also are found in the NCPA rules and in the American Fats and Oils Association rules, as well as in other international trading manuals. These rules are straightforward, and requirements apply for most crude oils, with a few exceptions unique to sunflower oils. The association's typical grades and standards for sunflowerseed oil (Anonymous, 1991) are presented in Table A-4.

The price-quality relations of seeds for which discounts and/or premiums were provided when outside the standards were outlined.

Discounts and premiums described by the NCPA rules for crude oils (Anonymous, 1989c) are typical:

1. Buyer shall credit seller at the rate of 0.1% of the contract price for each 0.1% of FFA below 2%; seller shall pay buyer at the same rate for each 0.1% above 2% but not exceeding 3% FFA.
2. Buyer shall pay seller for loss at the rate of 1% of the contract price for each 1% loss under 5%, and seller shall pay buyer at a rate of 1% above 5%. Losses shall be calculated fractionally.
3. When refined and bleached color is in excess of 2.5 R, the oil is rejectable and settlement may be negotiated.

**Table A–4. American Fats and Oils Association (AFOA) grades and standards for sunflowerseed oil (Anonymous, 1991)[a]**

| Specification | Method | Amount |
|---|---|---|
| Flash point | AOCS Cc 9b–55 | 250°F minimum |
| Halphen test | — | Negative |
| Saponification value | — | 188–194 |
| Unsaponifiable | — | 1.3% maximum |
| Free fatty acid (as oleic) | — | Basis 2%; 3% maximum; 1 for 1 allowance over 2 |
| Moisture and volatile | AOCS Ca 2d–25 | 0.5% maximum |
| Insoluble impurities | AOCS Ca 3–46 | 0.3% maximum |
| Color 4 1/4 tube | AOCS Cc 13b–45 | — |
| bleached | AOCS Cc 8g–52 | — |
| after refining | AOCS Ca 9a–53 | 2.5 R maximum |
| Linolenic | — | 1.0% maximum |

[a]Note that almost each method specified is that of the American Oil Chemists' Society (AOCS) and where they are not specified there are AOCS methods that are applicable.

## Glossary

**Cottonseed meal.** Composed mainly of the cottonseed kernel, with such portions of hull, fiber, and oil as remain after manufacture.

**Crude soybean oil.** Recovered from the beans by expulsion, by pressure, or by solvent extraction, or by a combination of these methods.

**Degummed soybean oil.** Crude oil with the major portion of the gums removed by means of hydration and physical separation.

**Fully refined soybean oil.** Oil produced from pure soybean oil from which all free fatty acids (FFA) and nonoil substances have been removed by means of chemical treatment and physical separation.

**Gossypol.** Poisonous yellow pigment found in cottonseed plant gland.

**Low-gossypol meal.** Meal containing not more than 0.04% free gossypol, so labeled, and meeting the standards for Prime cottonseed meal.

**Once refined soybean oil.** Oil having essentially all FFA and nonoil substances removed by means of chemical treatment and physical separation.

**Refining loss.** Measure of crude oil deterioration occurring because of seed quality. Enzymes in the seed catalyze oil hydrolysis and FFA builds up.

**Solvent extracted soybean flakes.** Products obtained by extraction of part of the oil from soybeans by means of hexane or related solvents. Designated and sold according to protein content.

**Soybean cakes or chips.** Products remaining after oil is removed from soybeans by means of pressure or solvent.

**Soybean hulls.** Matter consisting primarily of the outer covering of soybeans; containing 13% moisture.

**Soybean meal.** Ground soybean cake.

**Soybean mill feed.** By-product of the manufacture of soy flour or grits and composed of soybean hulls and offal from the mill's tail.

Typically, 13% crude protein, 32% crude fiber, and 13% moisture.

**Soybean mill run.** Results from the manufacture of dehulled soybean meal; composed of hulls and adhering meats. Typically, 11% crude protein, 35% crude fiber, and 13% moisture.

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# Appendix B: Abbreviations, Acronyms, and Symbols

## Abbreviations and Acronyms

| | |
|---|---|
| AAA | Agricultural Adjustment Act |
| ABC | Almond Board of California |
| ACSH | American Council of Science and Health |
| ADF | acid detergent fiber |
| AFGC | American Forage and Grassland Council |
| AMA | Agricultural Marketing Act |
| AMS | Agricultural Marketing Service |
| AOAC | Association of Official Analytical Chemists |
| AOCS | American Oil Chemists' Society |
| APHIS | Animal and Plant Health Inspection Service |
| ARP | Acreage Reduction Program |
| ASA | American Soybean Association |
| ASPCA | American Sheep Producers' Council of America |
| ASTM | American Society for Testing and Materials |
| ATLAS | automatic tester for length and strength |
| BCFM | broken corn and foreign material; a grade factor for corn |
| BKFM | broken kernels and foreign material; a grade factor for grain sorghum |
| BPOC | Beef Promotion Operating Committee |
| BPRB | Beef Promotion and Research Board |
| BST | bovine somatotropin |
| CAB | California Almond Board |
| CARDS | computer assisted retail decision support |
| CASS | California Agricultural Statistics Service |
| CAST | Council for Agricultural Science and Technology |
| CAT | computerized axial tomography |
| CBA | Catfish Bargaining Association |
| CBOT | Chicago Board of Trade |
| CCC | Commodity Credit Corporation |
| CDC | Centers for Disease Control and Prevention |
| CES | Cooperative Extension Service |
| CI | Cotton Incorporated |
| CMS | California Macadamia Society |
| CFA | Cotton Futures Act |
| CP | crude protein |
| CPA | California Pistachio Association |
| CPC | California Pistachio Commission |
| CPI | California Pistachio Industry |
| CWC | California Walnut Commission |
| DDM | digestible dry matter |
| DDT | dichlorodiphenyltrichloroethane |
| DFA | Dry Fruit Association |
| DFD | dark, firm, and dry (pork) |
| DM | dry matter |
| DMI | dry matter intake |
| EC | European Community |
| EEC | European Economic Community |
| ELISA | enzyme-linked immunosorbent assays |
| ELS | extra-long staple |
| EPA | U.S. Environmental Protection Agency |
| ERS | Economic Research Service |
| FACT 1990 | Food, Agriculture, Conservation, and Trade Act of 1990 |
| FAS | Foreign Agricultural Service |
| FB | farm bill |
| FDA | U.S. Food and Drug Administration |
| FFA | free fatty acid |
| FGIS | Federal Grain Inspection Service |
| FMI | Food Marketing Institute |
| FOB | Free-on-Board |
| FSA | Food Security Act |
| FSIP | Federal-State Inspection Program |
| GATT | General Agreement on Tariffs and Trade |
| GQIA | Grain Quality Improvement Act |
| GRAS | generally-recognized-as-safe |
| GSA | Grain Standards Act |
| HACCP | Hazard Analysis Critical Control Point |
| HDA | Hawaii Department of Agriculture |
| HMB | Hazelnut Marketing Board |
| HMNA | Hawaiian Macadamia Nut Association |
| HVI | high-volume instrument |
| ICCA | Interstate Cottonseed Crushers Association |
| IFT | Institute of Food Technologists |
| IP | identity preserved |
| IWTO | International Wool Textile Organization |
| JQC | Joint Quality Committee |
| LSD | Livestock and Seed Division |
| M-W | Minnesota-Wisconsin |
| ML | mean length |
| MPP | Market Promotion Program |
| NAC | National Advisory Committee |
| NAFTA | North American Free Trade Agreement |
| NAHQC | National Alfalfa Hay Quality Committee |

| | |
|---|---|
| NAHTA | National Alfalfa Hay Testing Association |
| NASS | National Agricultural Statistics Service |
| NBQA | National Beef Quality Audit |
| NCA | National Cattlemen's Association |
| NCPA | National Cottonseed Products Association |
| NDF | neutral detergent fiber |
| NDPRB | National Dairy Promotion and Research Board |
| NFTA | National Forage Testing Association |
| NHA | National Hay Association |
| NHQC | National Hay Quality Committee |
| NIH | National Institutes of Health |
| NIOP | National Institute of Oilseed Processors |
| NIR | Near-Infrared |
| NLMB | National Live Stock and Meat Board |
| NMFS | National Marine Fisheries Service |
| NMR | nuclear magnetic resonance |
| NOPA | National Oilseed Processors' Association |
| NPCA | National Peanut Council of America |
| NPPC | National Pork Producers' Council |
| NPSA | National Pecan Shellers' Association |
| NRDC | Natural Resources Defense Council |
| NRRB | National Rice Research Board |
| NSA | National Sunflower Association |
| NYCE | New York Cotton Exchange |
| OKS | Oregon Kernel Standard |
| OTA | Office of Technology Assessment |
| PAC | Peanut Administrative Committee |
| PMO | Pasteurized Milk Ordinance |
| PSE | pale, soft, exudative (pork) |
| PSF | percentage short fiber |
| PUFI | processed under federal inspection |
| QCL | Quality Control Laboratories |
| R-to-C | resistance to compression |
| R & D | Research and Development |
| RCMD | Rice Council for Market Development |
| RFV | relative feed value |
| RMA | Rice Millers' Association |
| S-D | Smith-Doxey |
| SCPA | Society of Cotton Products Analysts |
| TCI | The Catfish Institute |
| TDN | total digestible nutrients |
| TEA | Targeted Export Assistance |
| TOBEC | Total body electric conductivity |
| UHM | upper-half mean |
| UHT | ultra-high temperature |
| UI | Uniformity Index |
| UR | Uniformity Ratio |
| USCA | U.S. Canola Association |
| USDA | U.S. Department of Agriculture |
| USDC | U.S. Department of Commerce |
| USMEF | U.S. Meat Export Federation |
| USWA | U.S. Wheat Associates |
| WMB | Walnut Marketing Board |
| WQC | Wheat Quality Council |

## Symbols

| | |
|---|---|
| +b | yellowness |
| a. | acre |
| bu | bushel |
| cm | centimeter |
| cwt | hundredweight |
| d | day |
| g/tex | 1/8" gauge |
| ha | hectare |
| hr | hour |
| in. | inch |
| kg | kilogram |
| kPa | kiloPascal |
| ktex | linear density of clean wool |
| lb | pound |
| ml | milliliter |
| mo | month |
| Mt | million metric tons |
| ppb | parts per billion |
| t | metric ton |
| yr | year |

# Index

## C

P

## Q



## R

Y

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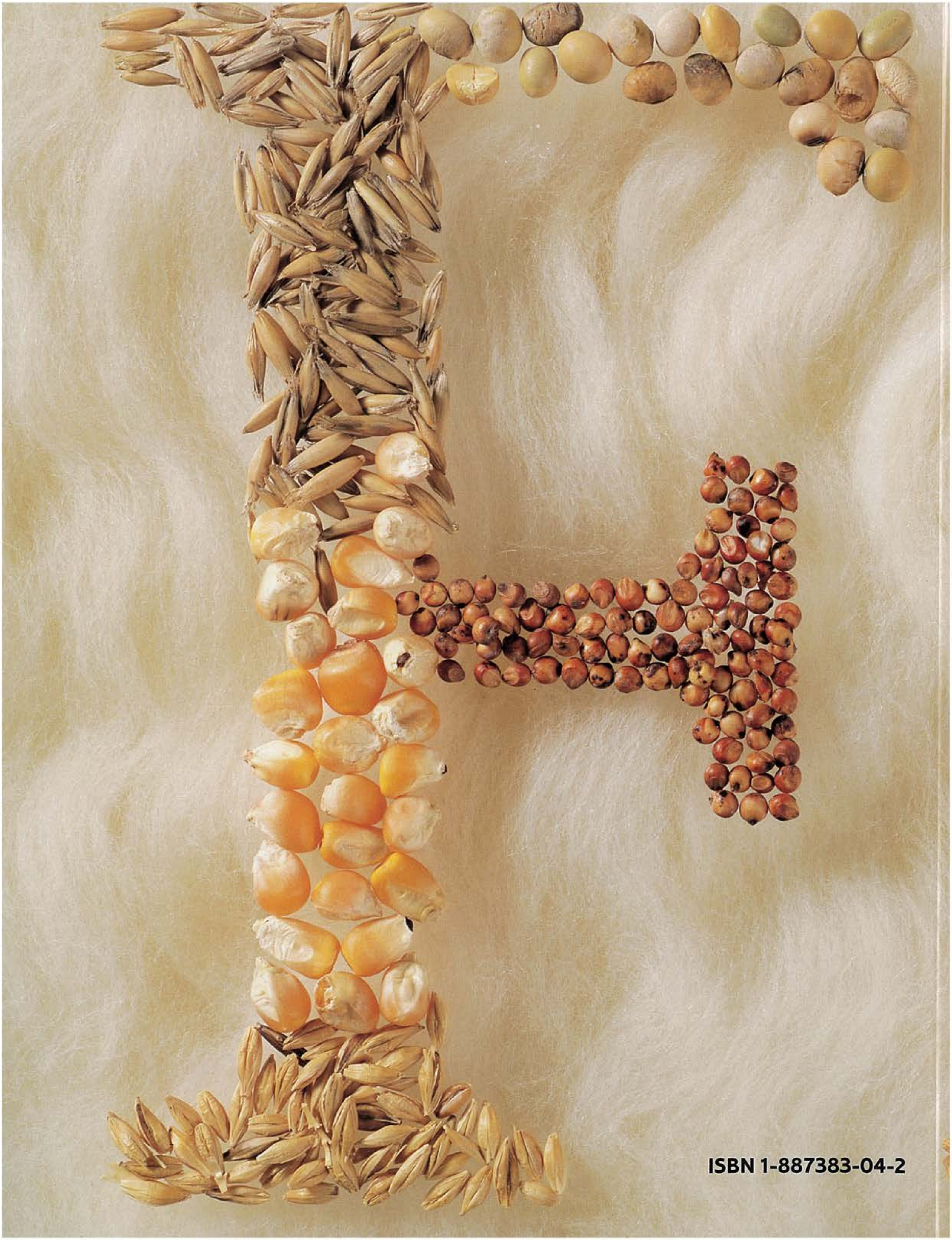

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