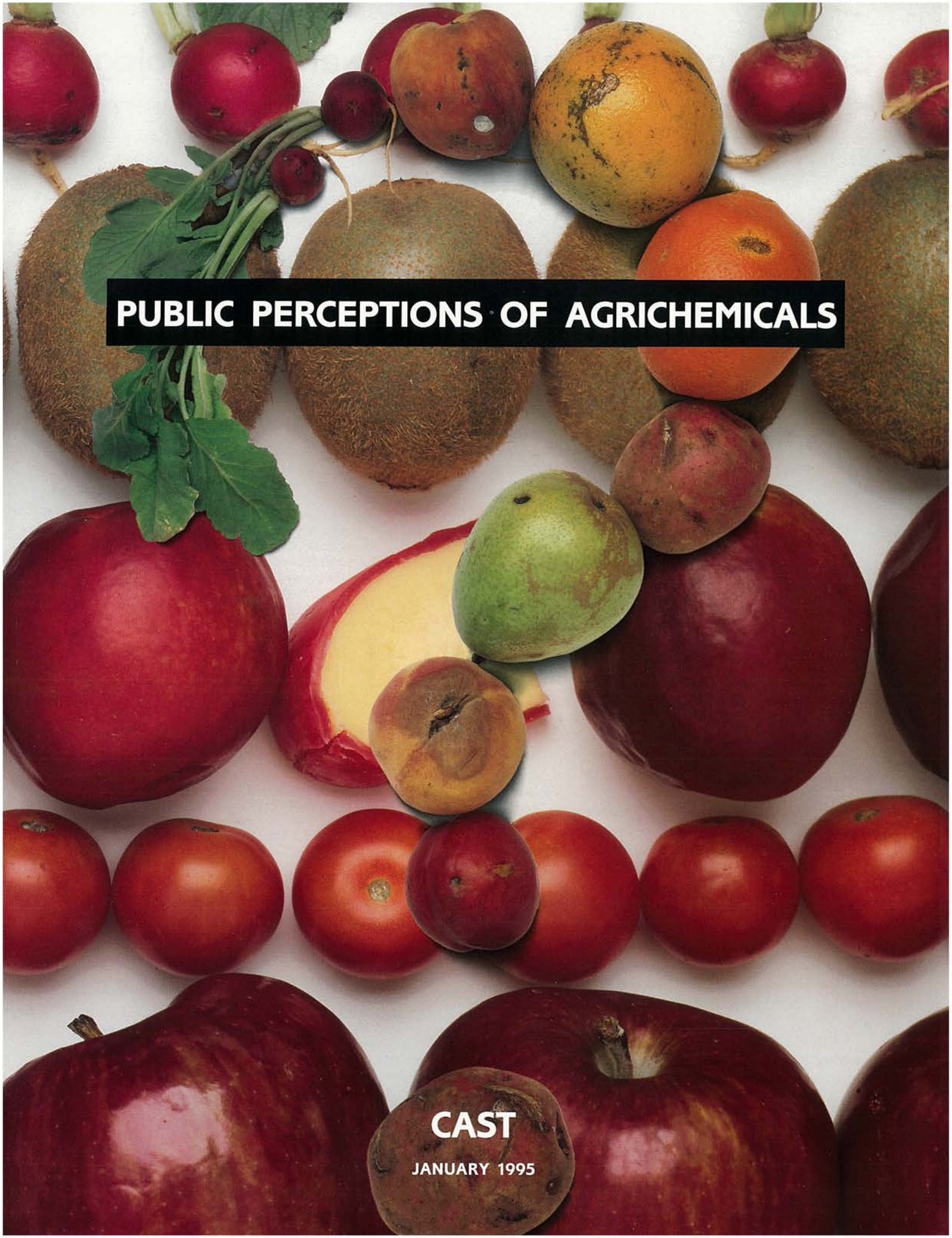

PUBLIC PERCEPTIONS OF AGRICHEMICALS

CAST

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4420 West Lincoln Way, Ames, Iowa 50014-3447 • Phone: (515) 292-2125 • Fax: (515) 292-4512
www.cast-science.org E-mail: cast@cast-science.org

Council for Agricultural Science and Technology

4420 West Lincoln Way, Ames, IA 50014-3447 • (515) 292-2125 • Fax: (515) 292-4512 • Internet: b1cast@exnet.iastate.edu

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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 30 scientific societies and many individual, student, company, nonprofit, and associate society members. CAST's Board of Directors is composed of 47 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.

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Council for Agricultural Science and Technology

Author

Eileen O. van Ravenswaay, Department of Agricultural Economics, Michigan State University, East Lansing

Reviewers

Charles R. Curtis, Department of Plant Pathology, The Ohio State University, Columbus

Thomas J. Hoban, Department of Sociology and Anthropology, North Carolina State University, Raleigh

Jean L. Kinsey, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul

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Foreword

Following a recommendation by the CAST National Concerns Committee, the CAST Board of Directors authorized preparation of a report addressing public perceptions of agrichemicals.

Dr. Eileen O. van Ravenswaay, professor, Department of Agricultural Economics, Michigan State University, East Lansing authored the report. A highly qualified group of scientists was chosen to serve as reviewers and includes persons with expertise in agricultural and applied economics, plant pathology, public risk perception, and sociology.

The author prepared an initial draft of the report. The author and reviewers revised all drafts 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 author and reviewers are responsible for all scientific content in the report.

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

This report is being distributed to members of Congress, the U.S. Department of Agriculture, the Food Safety Inspection Service, 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, Office of Technology Assessment, Office of Management and Budget, media personnel, and to institutional members of CAST. Individual members of CAST may receive a complimentary copy upon request for a $3.00 postage and handling charge.

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Eileen O. van Ravenswaay
Department of Agricultural Economics
Michigan State University

Interpretive Summary

Public Perceptions of Agrichemicals

Public perceptions of the risks and the benefits of agrichemicals can influence government and business decisions regarding use and development. A growing body of research is improving scientific understanding of these perceptions and their impact on food purchases. This Council for Agricultural Science and Technology report reviews relevant research findings and develops recommendations for policy and for future research.

Risk Perceptions

Contrary to popular belief, perceptions of risks from residues of agrichemicals in food differ greatly among members of the public. Approximately one-fourth perceives a great chance of harm from pesticide residues in food whereas approximately the same percentage perceives very little or no chance. The differences observed imply that there are very different information needs and policy preferences among different segments of the public.

The public perceives a range of health effects broader than the cancer risks typically addressed by the government: for example, some are concerned about allergies and nervous system disorders. Furthermore, concern regarding agrichemicals is not limited to food and food safety but extends to concerns about the environment and agricultural workers. These latter concerns may be reflected in public attitudes about residues in foods. Risk communicators need to address a wider range of concerns than just the potential carcinogenicity of agrichemicals or just the risks from residues in food.

Trust in government and industry may be a more important influence on risk perception than is the inherent safety or the danger of an agrichemical. The majority of the public does not trust government to set or to enforce safety standards, or farmers to ensure that the foods they sell are safe. Restoring public trust should be a high priority.

Pesticide Use

The public generally believes that insects, diseases, and other pests need to be controlled but also believes that there are effective alternatives to pesticides. Because about half of the public does not believe that these alternatives are costlier, much of the public perceives little or no benefits from pesticide use.

There is evidence that the public is willing to pay more for tougher pesticide residue standards and their intensified enforcement. Whether public willingness to pay can offset the cost of eliminating agrichemical use is unknown. In some cases, it may not be possible to produce acceptable foods without agrichemical use.

Consumers differ greatly in terms of their willingness to purchase foods labeled *pesticide free*. Consequently, one pesticide-residue standard is unlikely to please all consumers. Extensive research is needed before definitive conclusions about the potential success of labeling efforts can be made.

New Animal Drugs

Public reaction to new animal drugs depends on public awareness of their use in agriculture. This awareness evidently is quite limited and dependent on media coverage; in fact, much of the public feels it lacks the information needed to develop an opinion about their use. Survey results suggest that thorough scrutiny by the broader scientific community is important to public confidence in claims about the safety of new animal drugs.

Lower prices and decreased fat content, two benefits of animal drug use, also affect public reaction. Both of these benefits are highly desired by consumers, but perceptions of these benefits may not offset perceptions of risks in all cases for all consumers. For example, public furor over bovine somatotropin (BST) may reflect a perception of insufficient benefits compared to potential risks.

Research Needs

There is very little research available on public perception of agrichemicals. The conclusions reported here are derived from a small number of studies that have not been replicated. In short, this area of research is in its infancy, and more research is needed to develop valid and reliable theories, methods, and conclusions about public perceptions of agrichemicals and other agricultural technologies.

Perceptions of the risks and the benefits of agrichemicals seem to influence public reaction, but there is little consensus regarding how to measure these perceptions. Consequently, it is very difficult to compare results from different studies. Research is needed to develop appropriate methods and to generate data for comparative research.

Purchase of food seems affected by perception of agrichemicals, but methods used to link perception with purchase often are indirect or inadequate. Research is needed to improve methods and to apply them to a broadened range of foods.

Although studies of public perceptions of agrichemicals inform policy, marketing, and communication decision makers, the research required in each area is unique. When this fact is recognized, research validity and analysis will improve.

Introduction

Public attitudes can influence government and business decisions regarding the use of agrichemicals. Yet the public often is uninformed, misinformed, or distrustful of scientific judgments about the risks and benefits of agrichemical use. Although public opinion is essential to democracy and free enterprise, scientific opinion is essential to the development of useful technologies. How can responsible government and business decisions result when public and scientific opinions clash?

One step in the direction of harmonious social decision-making would be understanding how the general public perceives the risks and the benefits of agrichemical use. Such understanding would help government and business anticipate and respond to public concerns in a timely manner.

This Council for Agricultural Science and Technology (CAST) report presents key findings from a new and growing area of research on public perceptions of and reactions to agrichemicals. Chapter 1 examines what must be learned about public perceptions if understanding of public concerns is to improve. Chapter 2 discusses data from surveys of public perceptions of the risks of pesticides and animal drugs. Chapter 3 discusses studies of (1) public perceptions of pesticide benefits and (2) public willingness to pay for lowered pesticide residue level in food. Chapter 4 examines how the public reacts to the introduction of animal drugs, and Chapter 5 summarizes major findings and conclusions regarding public perceptions of agrichemicals.

1 Understanding Public Perceptions

Agrichemicals are controversial because they are both beneficial and potentially risky. They increase food quality and affordability, but excessive amounts or the wrong kinds can cause human health and environmental problems. Substantial public and private resources are expended to ensure that agrichemicals are used safely, but no technology is perfectly safe. Accidents occur, and scientists are not able to predict all risks. When accidents occur or scientific risk assessments change, people may begin to question whether a technology's benefits are worth the risks.

During the last three decades, accidents and changes in scientific risk assessments have fueled controversy over the use of agrichemicals. Several incidents in which food has been contaminated accidentally with residues of banned or restricted agrichemicals, e.g., heptachlor, aldicarb, and diethylstilbestrol (DES), have been reported. And several widely used agrichemicals, e.g., ethylene dibromide (EDB), Alar, and sulfamethazine, have been reported to pose previously unknown health risks. These cases of accidental food contamination and changes in scientific risk assessment have been covered intensively by the media, thus raising public concerns about the risks of agrichemicals.

Valid and reliable information about public concern regarding agrichemicals is needed by those who create public policy, make food marketing decisions, and develop communication strategies. Policy makers need to know to what extent public policy on agrichemicals reflects consumer preference. Food producers need to be able to predict which products consumers will buy. Educators and communication specialists need to know how, when, and what to communicate about the risks and the benefits of agrichemicals.

Research appropriate to evaluate public policy may not be appropriate to evaluate marketing and communication strategies. A key issue in determining whether public policy reflects consumer preference is whether consumer preference is *informed*. For example, when consumers understand the risks and the benefits of foods produced with and without agrichemicals, which foods do they prefer? In contrast, a key issue in determining what products consumers will buy or how effective a communication strategy will be is what *actual* consumers likely will do. For example, if a new agrichemical was used by farmers, would consumers become aware of it, and if so would their awareness influence food purchases?

Learning what informed consumers think about agrichemicals obviously is difficult, for most consumers are informed neither of the existence of such substances nor of the risks and benefits they experience because of them. Policy research examines which risk-benefit tradeoffs consumers perceive to be associated with different types of food and the tradeoffs that they prefer given their perceptions. This information can be used to infer the choices that consumers would make if informed fully of tradeoffs.

Accurate prediction of which food products consumers will buy requires a different kind of investigation: specifically, an investigation into the actual conditions, even if less than ideal, under which consumers are likely to make purchase decisions. For example, some consumers completely unaware of agrichemicals make food purchase decisions, others are misinformed, others are informed accurately. The goal of marketing research is to identify the possible information states of consumers, to estimate the percentage of consumers in each information state, and to examine how purchase decision depends on the consumer's information state.

Assessing how the public perceives the risks and the benefits of agrichemicals requires development of valid and reliable measures of perception. Assessing why the public perceives risks and benefits as it does necessitates the examination of how personal circumstances affect perception, as well as how message and messenger do. For example, do access to, understanding of, and trust in scientific sources of information about the risks and the benefits of agrichemicals increase with educational level? The goal of communication research is to describe what perceptions the public has, how they differ, and how they change in response to information.[1]

The distinctions among policy, marketing, and communication research on public perceptions of ag-

richemicals must be made if studies reviewed in this report are to be interpreted appropriately. *Policy research* seeks improved understanding of the tradeoffs that informed consumers prefer. *Marketing research* seeks improved understanding of the tradeoffs that consumers actually make under prevailing market conditions. *Communication research* seeks improved understanding of the tradeoffs perceived by the public and why. Although the three types of research overlap notably, valid conclusions about answers to questions in one area cannot always be drawn using research from another.

Defining *Risks* and *Benefits*

The goals of policy, marketing, and communication research are distinct, yet each type of research can examine public perceptions of the risks and the benefits of agrichemicals. Policy research requires examination of the risk-benefit tradeoffs that consumers perceive themselves to be making. Marketing research examines whether consumer perceptions of risks and benefits affect food purchases. Communication research examines how communication strategies affect perceptions of risks and benefits.

This section defines *risks* and *benefits* as they are meant to be understood throughout the report. By *risk* is meant usually the health hazard constituted by exposure to agrichemical residues in food or water. But the public also may perceive and be concerned about risks to farm workers, wildlife, and the environment. Each type of public perception of risk has been studied, but most data concern consumer perceptions of health risk from agrichemical residues in food. A more commonly accepted definition of *risk* is the chance of harm in a given context (Fischhoff et al., 1981; Krimsky and Golden, 1992; National Research Council, 1989; Rescher, 1983). *Chance* refers to a specified population and time; *harm*, to type, severity, painfulness, reversibility, duration, immediacy, lifecycle timing, and mitigation cost. *Context* refers to the set of circumstances resulting in a particular level of hazard exposure and population susceptibility to harm.

Each of the elements of risk—*chance, harm, and context*—may be defined in numerous ways. Different populations, time periods, harms, exposures, and susceptibilities may be perceived as relevant to risk assessment, and uncertainty about each element may exist. Obviously, people will perceive risk differently if they disagree on which definition of its elements is appropriate or on how much uncertainty exists.

For example, because their diets or living environments differ, members of the public may define *chance*, *harm*, or *context* differently. Some may believe that washing and cooking virtually eliminate risk, but others may believe that only the elimination of agrichemical use will. Perhaps individuals have reason to believe that their household is susceptible to certain health problems or at greater risk of pesticide exposure. Another possible reason for differences in risk definition is that households care about different populations. Some may care only about their immediate selves. Others may care about their friends and neighbors or about the public at large. Some also may have concerns about the environment, livestock, or survival of family farming. Yet another possible reason for differences in risk definition and perception is that households either possess different amounts or types of information or process it differently.

To clarify the public perception of risk associated with agrichemicals, the next chapters will examine what is known about how the public defines the dimensions of such risk. The report will describe certain harms that people associate with pesticides and animal drugs. It also will examine public perceptions of the conditions that determine expectations about hazard exposure, including perceptions of the extent and the efficacy of current risk-management strategies.

In some instances, the report will examine how likely respondents believe harm to be when they are given certain definitions of *chance*, *harm*, and *context*; correct interpretation of these data depends on the provision of clear definitions. The studies being reviewed often asked respondents to react to very different contexts, thus making it impracticable to compare studies or to interpret how results apply to real-world contexts in which the public reacts to agrichemicals.

Benefits in this report generally refers to the advantages that consumers gain from the use of agrichemicals in food production. These benefits depend on the extent to which consumers value the foods and food attributes produced and on how much costlier it would be to produce these foods or food attributes

[1]This report reviews communication research focused on agrichemicals. There is, however, a large body of communication research literature involving a wide range of technologies such as nuclear power and solid waste incineration. This body of work provides general lessons about communicating with the public about technology's risks and benefits. (See recent reviews by Casamayou, 1993; Kasperson and Stallen, 1991; and Krimsky and Golden, 1992.)

without agrichemicals. For example, consumers value the elimination of pest damage on the fruits and vegetables that they buy. Because it costs less to use agrichemicals to produce undamaged fruits and vegetables than to use other methods, the cost of purchasing undamaged fruits and vegetables is reduced. Similarly, because it is possible to use animal drugs to lower the level of fat in meat, consumers who value both a low-fat diet and the taste of meat can benefit from the use of such drugs.

To clarify public perception of the benefits of agrichemicals, the next chapters will examine what is known about (1) the values the public places on food attributes produced with agrichemicals and (2) the extent to which the public believes that use of agrichemicals lowers food prices. Not all food attributes resulting from the use of chemicals have been examined, but how much consumers value pest damage control on fruits and vegetables and how much they value fat reduction in meat have been studied. This report also will examine studies of why consumers may or may not believe that they benefit from the use of agrichemicals. For example, it will examine whether the public considers pest control necessary and whether the public believes cost-effective alternatives to agrichemicals are available.

Study of how the public perceives the risks and the benefits of agrichemicals should clarify which tradeoffs the public perceives, but it does not identify the tradeoffs that the public prefers, or likely will make in the marketplace. For example, two individuals may perceive the same risks and benefits but disagree about whether benefits sufficiently compensate for risks. Individuals have different views about risk acceptability.

By examining willingness to pay for diminished risk from agrichemical use, social scientists have addressed the questions of which tradeoffs the public prefers and under which conditions. The basic objective of such research is to obtain an estimate of consumer willingness to trade income or product quality for specific guarantees of reduced residues. This type of information is useful in the evaluation of public policy. But if the information is to be used for marketing purposes, the industry must determine which trade-offs consumers actually are making, rather than which they prefer when informed fully. The next chapters will examine what is known about how the public views such trade-offs, which it prefers, how aware it is of them, and how consumers might respond in the marketplace.

Because interest in public perceptions of agrichemicals has developed only in the last decade or so, most studies reviewed in this report describe research as yet unreplicated. Inasmuch as theoretical approaches differ greatly among studies, consensus regarding the key variables to be measured has not been reached. Methodological approaches are not standardized, so measurement of variables is inconsistent across studies. Both the theoretical and methodological variations make it difficult to compare results across studies. Most studies do not represent the U.S. population as a whole because samples are drawn from regional or state populations. Some of the studies reviewed are exploratory studies; their results are based on small, often unrepresentative samples.

Because the reliability and the validity of existing studies of public perceptions of agrichemicals are limited, conclusions drawn using these data must be viewed cautiously. Nonetheless, this report attempts to develop as many conclusions as possible for the benefit of policy makers, marketers, risk communicators, and future researchers. The conclusions drawn are really hypotheses because definitive studies have not been conducted. It is hoped that readers, while remaining skeptical of conclusions presented in the report, will be stimulated by its attempts to understand public perceptions of agrichemicals.

2 Risk Perception and the Public

Much of the evidence regarding public perception of risk from agrichemicals comes from opinion polls conducted on behalf of businesses and government agencies interested in public concerns about food safety. The results of these surveys provide a picture of change over time; readers may find these results familiar because they have been quoted widely in the press. Possible interpretations of results will be explored.

One of the earliest nationwide surveys to inquire into public attitudes toward food safety was conducted in 1980 for the Food and Drug Administration (FDA) (Heimbach, 1981). Respondents stating that they were concerned about certain problems (28%) or generally very worried about food safety (10%) were asked an open-ended question about the source of their doubts. Sources most frequently mentioned were nutrients, additives, chemicals, preservatives, over-processing, artificial colors, and freshness. Only 1% of respondents mentioned pesticides. None mentioned animal drugs.

For almost two decades, the Food Marketing Institute (FMI) has assessed opinions on a variety of topics related to food and supermarkets by conducting annual telephone surveys of 1,000 randomly selected U.S. households. When the FMI asks respondents about their *nutritional* concerns, a wide variety are reported but pesticides or animal drugs are not among them (Table 2.1).

Beginning in 1989, FMI has asked respondents opinions about the greatest threats to food safety. "Spoilage or germs" tops the list, followed by "pesticides, residues, insecticides, or herbicides" (Table 2.2). However, neither of these two categories is mentioned by the majority of respondents. Less than one-fifth mentioned pesticides, and animal drug residues were seldom mentioned. The FMI results indicate that concerns about spoilage have increased steadily since 1990, but concerns about pesticides and chemicals declined slightly (Table 2.2).

Importance of Survey Question Design

A very different picture of public perception of agrichemicals is drawn when respondents are asked to rate the seriousness of the hazard posed by pesticide

Table 2.1. Partial results (in percentages) from Food Marketing Institute (FMI) national telephone surveys asking the open-ended question "What is it about the nutritional content of what you eat that concerns you and your family the most?"[a] (Food Marketing Institute, 1994; Hammonds, 1985)

	Year									
Nutritional content	1983[b]	1986	1987	1988	1989	1990	1991	1992	1993	1994
Fat content/low fat	9	17	16	27	29	46	42	50	54	59
Cholesterol levels	5	13	14	22	38	44	37	30	23	21
Salt content/less salt	18	20	22	26	25	30	22	21	26	18
Sugar content/less sugar	21	18	16	20	15	16	12	13	18	14
Preservatives	22	15	14	16	9	7	8	11	8	10
Chemical additives	27	16	10	12	7	4	8	9	6	8
Vitamin/mineral content	24	22	21	21	21	14	15	8	10	6
Food/nutritional value	10	11	13	14	8	6	8	5	10	4
Balanced diet	10	14	14	11	10	4	5	4	4	2
Chemicals	0	0	0	4	3	3	4	4	2	3

[a]Annual sample sizes vary, but consist of approximately 1,000 U.S. households/yr.
[b]Data from 1983 is provided as a reference point. The remaining years cover 1986 through 1994.

Table 2.2. Partial results (in percentages) from Food Marketing Institute national telephone surveys asking the open-ended question "What, if anything, do you feel are the greatest threats to the safety of the food you eat?"[a] (Food Marketing Institute, 1990, 1994)

	Year				
Threats	1990	1991	1992	1993	1994
Spoilage or germs	29	27	36	46	41
Pesticides, residues, insecticides, or herbicides	19	20	18	13	14
Improper packaging or canning	16	17	10	13	5
Chemicals	16	15	13	8	12
Tampering	14	8	8	7	4
Unsanitary handling by supermarket employees	11	3	6	4	3
Preservatives	8	7	6	6	7
Additives	6	6	5	4	5
Environmental pollutants	4	3	3	2	3
Antibiotics	2	2	—[b]	1	1
Radiation	1	1	1	—[b]	—[b]
None	6	3	3	3	3
Not sure	12	19	15	14	14

[a]Annual sample sizes vary, but consist of approximately 1,000 U.S. households/yr.
[b]— = less than 0.5%.

residues, animal drugs, and other chemicals (Table 2.3)[2]. When survey questions are asked this way, we find that the majority of respondents rate agrichemicals as serious hazards. They also appear to rate pesticides as a more serious hazard than bacteria (Table 2.4). The same results are obtained in other studies as well. For example, a 1990 telephone survey of 437 households in Idaho, Oregon, and Washington found that 72% agreed that pesticide residues in food are a big health risk (Dunlap and Beus, 1992). A 1990 survey of 1,065 households in the Delmarva Peninsula found high levels of concern about pesticide residues (Byrne et al., 1991).

[2]The FMI has obtained roughly similar results since 1984, when it began asking these questions.

Table 2.4. Partial results (in percentages) from a telephone survey of 600 Michigan households that were asked whether respondents believed each item listed was a serious health hazard, somewhat of a hazard, or not a hazard at all (Atkin, 1990)

	Health hazard			
	Serious	Somewhat	Not	Don't know
Pesticide residues	68	25	5	1
Antibiotics and hormones in poultry and livestock	53	33	10	5
Additives and preservatives	23	57	13	3
Natural toxins and bacteria	50	36	11	3
Product tampering	71	17	11	1

Responses to these closed-ended survey questions suggest conclusions that conflict with responses to the aforementioned open-ended questions. When asked a closed-ended question, nearly 80% of respondents perceived pesticide residues and 60% perceived animal drugs as serious hazards. When asked an open-ended question in the same year, only one-fifth of respondents mentioned pesticides, and almost none mentioned animal drugs. The relative ranking of different types of concerns also seems to change.

One plausible explanation for this discrepancy is that the two different types of questions asked respondents to evaluate different sets of circumstances or contexts. The open-ended type asked respondents to

Table 2.3. Results (in percentages) from a Food Marketing Institute national telephone survey asking the closed-end question, "I'm going to read a list of food items that may or may not constitute a health hazard. For each one, please tell me if you believe it is a serious health hazard, somewhat a hazard, or not a hazard at all?"[a] (Food Marketing Institute, 1994)

	Serious hazard (%)						1994			
	Jan. 1988	Jan. 1989	Jan. 1990	Jan. 1991	Jan. 1992	Jan. 1993	Serious hazard	Something of a hazard	Not a hazard at all	Not sure
Residues such as pesticides and herbicides	75	82	80	80	76	79	72	23	3	1
Antibiotics and hormones in poulltry and livestock	61	61	56	56	53	56	50	37	8	6
Nitrites in food	44	44	37	41	40	35	34	43	7	16
Irradiated foods	36	42	42	42	35	35	38	30	13	20
Additives and preservatives	29	30	26	29	26	23	25	62	12	2
Artificial coloring	21	28	21	24	21	19	22	49	25	4

[a]Annual sample sizes vary, but consist of approximately 1,000 U.S. households/yr.

name a current food-safety problem. The closed-ended type in essence asked how serious the hazard was when residues or bacteria were present. Additionally, the closed-ended questions specified neither how much residue nor which pesticide or animal drug was to be evaluated. Because it is common knowledge that pesticides and drugs are potentially dangerous if too much or the wrong kind is used, it is reasonable that respondents rated both serious hazards. Similarly, it is reasonable that bacteria, whose potential toxicities often but not always are much less, were rated much less serious hazards. If the questions had specified what foods were involved, where they were purchased, or that residues were below federal limits, respondents might have responded quite differently.

Another possible explanation is that respondents defined the population at risk differently in the closed-ended and the open-ended questions. For example, a respondent asked about the seriousness of the hazard posed by pesticide residues might have visualized hazards to the environment and to farm workers during food production, as well as to food consumers. In contrast, the open-ended questions supplied a more specific context by asking respondents to report on their own food safety and nutrition concerns. As shown later, environmental concerns about agrichemicals may be as great as food safety concerns.

The above points about question design are illustrated by two studies on perceptions of animal drugs. Kinsey et al. (1993) examined consumer perceptions of a wide variety of meat attributes in a survey of 515 randomly selected households in the Twin Cities metro area in 1993. Respondents were asked whether "meat from animals that have been given antibiotics at FDA approved levels" was safe (= 1) or not safe (= 2). Forty percent said they did not know. The average response for the rest of the sample was 1.375, which means that they believed meat generally was safe in this case. Respondents also were asked whether "meat from animals that have been given hormones at FDA approved levels" was safe. Forty-four percent said they did not know. The average response for the rest of the sample was 1.532, meaning that meat was generally perceived as unsafe in this case.

Kaiser et al (1992) found a high level of respondent uncertainty when they asked about antibiotics and milk safety. In this study, 716 randomly selected New York households were surveyed in 1990. Respondents were asked their level of agreement (1 = strong agreement, 3 = don't know, 5 = strong disagreement) with the statement that "milk is safe to drink even though farmers use antibiotics." The average response was 2.92. Few respondents strongly agreed (4.2%) or strongly disagreed (4.6%). These results indicate a high level of uncertainty about safety in this case.

Whatever the explanation for the discrepancy between results from closed- and open-ended questions, a clear understanding of what specific survey questions are designed to measure is required to properly interpret the survey data. Survey questions must be designed according to an explicit theory of risk perception. Variables defining risk perception must be incorporated into question design and either held constant or varied, depending on the feasibility of doing so and the hypothesis to be tested. Yet many surveys and opinion polls such as those described are not designed in this manner. Critical variables may be left unspecified or unmeasured, and respondents may make broadly ranging, unknown assumptions. Clearly, the results of surveys without an explicit theoretical and methodological approach must be interpreted cautiously.

Complexity of Public Risk Perceptions

Survey evidence from scholarly research suggests that perceptions of the chance of harm from pesticide residues differ greatly among consumers. A random nationwide sample of more than 900 households surveyed by van Ravenswaay and Hoehn (1991b; 1991c) was asked what they thought "the chances are that someone in your household will have health problems someday because of the current level of pesticide residues in their food." Table 2.5 shows that about one-

Table 2.5. Partial results (in percentages) of a 1990 national mail survey of 906 U.S. households that were asked "What do YOU think the chances are that someone in your household will have health problems someday because of the current level of pesticide residues in their food?" (van Ravenswaay and Hoehn, 1991b)

Probability	Respondents
No chance	4.1
1 in a million	19.5
1 in 100,000	16.4
1 in 10,000	13.4
1 in 1,000	15.6
1 in 100	12.1
1 in 10	5.1
1 in 5	3.2
1 in 2	1.0
Certain to happen	4.4
No answer	5.2

quarter believed the chance very small (1 in 1,000,000 or less), about 45% believed the chance moderate (between 1 in 100,000 and 1 in 1,000), and about one-fourth believed the chance very great (1 in 100 and greater). Similar results were obtained in response to a comparable question asked of 1,003 randomly selected Michigan households (van Ravenswaay et al., 1992). In this latter study, these quantitative measures of risk perception were found to be highly correlated with qualitative measures obtained from the same respondents.

One explanation of risk perception differences among consumers is that they experience or perceive that they experience different risk contexts. *Risk context* is the set of conditions resulting in exposure to a hazard and in susceptibility to harm from exposure. Thus, one reason for the differences in consumer perceptions of risk from pesticide residues is that some households may perceive themselves to be more exposed to agrichemicals or to be more susceptible to harm from them compared to other households.

An indicator of perceived differences in exposure to pesticide residue is fruit and vegetable consumption, because consumers associate high residue levels with these foods. An indicator of perceived differences in susceptibility to harm would be the presence of children in the household. A survey of consumers in Seattle, Washington and in Kobe, Japan reported that the consumption of vegetables and the presence of children in the household both are correlated positively with the perception of risk from pesticide residues (Jussaume and Judson, 1992).

Another explanation of risk perception differences among consumers is that their access to accurate information about risk differs. Income is one indicator of the amount of accurate information about risk that a household is likely to have: households with higher incomes can afford to purchase more accurate information about their health. Another indicator of access to accurate information is education; more educated consumers should be better able to evaluate the accuracy of information and to understand complex information. Thus, we should expect that more educated households earning higher incomes would perceive different risks from pesticide residues in food than other households would.

As expected, some researchers have found that concern about pesticide residues is related inversely to income (Byrne et al., 1991; Dunlap and Beus, 1992; Jussaume and Judson, 1992). Inconsistent results have been reported regarding the effect of education, however (Halbrendt et al., 1991). Some studies support the hypothesis that concern about pesticides is related inversely to education (Bryne et al. 1991; Misra et al., 1991); others find little or no association (Dunlap and Beus, 1992); and others find the contrary (Jussaume and Judson, 1992).

Variations in consumer perceptions of risk have led researchers to examine whether there are unique consumer segments purchasing foods with either low pesticide residue levels or other food-safety attributes. For example, McGuirk et al. (1990) determined by means of annual survey data collected by the FMI whether there were distinct consumer segments with respect to preference for food safety. These researchers found three distinct groups but few demographic distinctions among them. Baker and Crosbie (1993), who conducted a market simulation with 160 customers at two supermarkets in San José, California, also identified three distinct consumer segments.

Variation in consumer risk perceptions also has been found in terms of the types of harm that people associate with pesticides. Hammitt (1986), Rae (1987), van Ravenswaay and Hoehn (1991b; 1991c), and van Ravenswaay et al. (1992) found that consumers associate a broad spectrum of health problems with pesticide residues in food. Cancer is cited most frequently, but not by everyone. For example, only 55% of respondents mentioned cancer when asked an open-ended question about the health effects of pesticide residues in food (van Ravenswaay et al., 1992). Allergies, heart disease, nervous system disorder, and impaired immune function also were cited but were perceived as much less likely to occur than cancer. On average, respondents believed that residues posed very low levels of risk of impairing child development or of causing birth defect or mental illness.

An important implication of these findings is that consumers perceive a much wider range of potential health problems than typically is addressed by the scientific community. Toxicologists, for example, commonly present data on cancer to the public to show that current levels of pesticide residue are no cause for concern. Evidently they need to be informing the public about other potential health problems, especially allergies.

People who buy organic food seem to perceive pesticide residues as substantially greater risks than others do (Goldman and Clancy, 1991; Hammitt, 1986; Rae, 1987). Hammitt (1986) conducted focus groups with conventional-food and organic-food consumers and found that the median organic-food consumer's estimate of the annual risk of dying from consuming pesticide residues on conventional fresh produce was three orders of magnitude greater than

the conventional-food consumer's estimate.[3] Rae asked customers at four Boston-area organic-food stores what they thought that their chances of getting cancer would be if they ate only organically grown food and if they ate only conventionally grown food. The average risk perception for the only-organic scenario was 25.8%, or a roughly 1-in-4 chance; the average risk perception for the conventional-only scenario was 45.6%. Goldman and Clancy's survey of shoppers at an organic food cooperative in upstate New York also found that concern about pesticide residues was associated with the decision to purchase organic foods.

Perceptions of risk from pesticides have increased substantially since the 1960s. In 1965 and in 1984, a random sample of Pennsylvania households was asked how much danger they felt there was to a person who eats fruits and vegetables, drinks milk, or eats "chicken raised around pesticides" (Bealer and Willits, 1968; Blair and Sachs, 1986; Sachs et al., 1987). As Table 2.6 shows, the percentage answering "a great deal" or "some" was greater in 1984 than in 1965. A significant decline in Pennsylvanian's belief in the adequacy of government regulation also was observed: the percentage of respondents agreeing or strongly agreeing with the statement that "government adequately regulates chemical use in or on food" was 94% in 1965 but 48.9% in 1984.

An important implication of these studies is that public concerns about pesticide residues have been growing while confidence in government regulation has been declining. At the same time, consumer perceptions of chance and type of harm differ. Some see great risk; others see very little. Some associate many types of health problems with pesticides; others associate few or none. Because their perceptions of the risks posed by pesticide residues in food are so divergent, consumers as a whole are unlikely to be satisfied by one safety standard.

Perceptions of Residues in Food

Have perceptions of risks from pesticide residues changed or grown because new concerns about health effects have arisen or because the public believes that there is more residue in food now than in the past? Survey evidence suggests that the public believes there is more residue today, and so both factors probably account for increasing public concerns.

In a nationwide survey conducted by the U.S. Department of Agriculture (USDA) in 1974, respondents were asked about pesticides (Jones and Weimer, 1977). The survey consisted of personal interviews with homemakers in 2,503 households. Its main object was to assess homemakers' attitudes and practices concerning foodborne disease. Respondents were asked "Which of the types of food listed, if any, do you believe could carry traces of chemicals that kill insects and other pests?" Results are presented in Table 2.7.

Consumers have become somewhat more likely than they were to report that foods could contain pesticide residue. In a nationwide survey conducted in the fall of 1990, van Ravenswaay and Hoehn (1991b) asked respondents, "What do you think the chances are that there are *any* pesticide residues in each of the following types of food that you might buy when

[3]Respondents were given a scale called a "risk ladder" showing various causes of death and their associated annual mortality rates per 100,000 individuals. Consumers of organic foods ranked the annual mortality risk from pesticides on conventional food as 8.5×10^{-4}; conventional consumers ranked it 8×10^{-7}.

Table 2.6. Partial results (in percentages) of surveys of Pennsylvania households in 1965 and 1984 that were asked how much danger they felt there was from the listed actions (Bealer and Willits, 1968; Blair and Sachs, 1986; Sachs et al., 1987)

	Perceived danger			
	Great deal		Some	
Action	1965[a]	1984[b]	1965[a]	1984[b]
Eating fruits and vegetables sprayed or dusted with pesticides	11	30	29	42
Drinking pasteurized milk from farms where pesticides were used around cows and on their feed	1	14	11	39
Eating chicken from farms where pesticides were used	3	17	16	45

[a]Interviews with 1,075 Pennsylvania households.

[b]Telephone interviews of 605 Pennsylvania households.

grocery shopping?" Because almost no respondents believed that the chance was zero, this study differed from the 1974 USDA survey. The studies were similar, however, in that both found perception differences across food groups (Table 2.8). For example, on average, respondents thought that there was a 60% chance that fresh fruits and vegetables would have residues, whereas they thought that the chance was about 40% for frozen or canned fruits and vegetables.

How close to reality are public perceptions of residue levels? The FDA samples foods and reports the percentage with detectable levels of residues and the percentage with residue levels above tolerance (U.S. Food and Drug Administration, 1987)[4]. Data regarding the percentage of food samples with detectable levels of residues are available for 10 of the 12 food items examined in the van Ravenswaay and Hoehn study (1991b). For 6 of these 10 items, i.e., apples, lettuce, oranges, fish, cereals, and baked goods, the FDA found somewhat larger percentages of samples with detectable residues than were perceived on average by respondents. For 2 of the 10 items, i.e., fresh produce and dairy products, the average respondent perceived a percentage chance of residues similar to that which the FDA found in its samples. For 2 of the 10 food items (tomatoes and juices), the FDA's percentages were much smaller than respondents'. It seems then that on average the public perceives no more foods as having detectable residues than scientists do.

Public and scientific perceptions differ sharply, however, about whether the detectable pesticide residues on food are within federal standards. The FDA reports that less than 5% of the food samples it tests contains residues above federal standards. Yet only 51% of Michigan households agreed that all the food they buy meets federal standards (van Ravenswaay et al., 1992).

Environmental Concerns About Agrichemicals

The few studies investigating public perception of the environmental consequences of agrichemical use suggest that these concerns may be as large as food safety concerns. Dunlap and Beus (1992) asked households in the Pacific Northwest how safe pesticides are for the environment when they are used according to approved directions. Sixty-five percent said that pesticides were somewhat or very unsafe for the environment. In interviews with customers at three retail grocery locations in State College, Pennsylvania, respondents agreed or strongly agreed with the statement that they were concerned that pesticide use harms ground water (91%), wildlife (88%), the environment (85%), farmworkers (80%), and their own health (80%) (Weaver et al., 1992). Similarly, in a telephone survey of a random sample of Pennsylvanians, Sachs et al. (1987) found that respondents believed pesticide use is harmful to wildlife (81%), farmworkers (79%), and consumer health (71%). Sev-

[4]More recent data on residues are available. Only data on residues reported *before* the time people's perceptions are measured, however, can influence those perceptions or what was reported in the news media.

Table 2.7. Results (in percentages) of a 1974 nationwide in-person interview survey in which homemakers in 2,503 U.S. households were asked "Which of the types of foods listed, if any, do you believe could carry traces of chemicals to kill insects and other pests?" (Jones and Weimer, 1977)

Food	Respondents
Fresh fruits and vegetables	88
Dried foods such as flour, cereals, and rice	46
Meat and poultry	41
Frozen fruits and vegetables	32
Canned fruits and vegetables	28
None of these	5
No answer	1

Table 2.8. Results of a 1990 national mail survey of 906 U.S. households that were asked: "What do YOU think the chances are that there are *any* pesticide residues in each of the following types of food that you *might* buy when you do the grocery shopping?" (van Ravenswaay and Hoehn, 1991b)

Item	Average score[a]
Fresh fruits and vegetables	5.8
Apples	5.5
Lettuce	5.4
Tomatoes	5.2
Oranges	4.8
Fresh fish (fresh or salt water)	4.3
Fresh meats (beef, chicken, pork)	4.2
Frozen or canned fruits and vegetables	4.1
Fruit juices or vegetable juices	4.1
Cereals, flour, or uncooked grains	3.8
Dairy products	3.1
Bread and baked goods	2.9

[a]Respondents were asked to assign scores ranging from 0 (0% chance) to 10 (91–100% chance).

eral studies reviewed in Goldman and Clancy (1991) suggest that organic-food consumers perceive pesticide use as dangerous to wildlife and to drinking water supplies. Focus groups with consumers indicate four types of concerns about pesticides: food safety, worker safety, environmental safety, and pesticide use in foreign countries (Auld et al., 1994).

Again, results must be regarded cautiously. Like certain closed-ended survey questions about hazards associated with pesticide and animal drug residues, questions about the environmental effects of pesticide use may reflect public attitudes toward *potential* effects. What is learned from responses is the types of problems that concern the public, a significant segment of which clearly perceives several environmental problems as the potential results of pesticide use. To what extent the public believes that these problems currently exist and are associated with pesticides is not learned from such surveys, however.

Public Trust

One of the emerging themes in risk perception research is the importance of trust. The key idea is that risk perception is not just a perception of the inherent dangers of technology; actions taken by the humans who use and regulate a technology also ultimately determine risk. For example, if consumers do not trust the ability of people who use a technology to do so safely and without accidents or if they distrust the people regulating the technology to develop and to enforce safety standards, consumers likely will perceive greater risk.

Several studies have begun to investigate public trust in the government regulation of agrichemicals, and great differences exist among consumers. In a 1992 survey of Michigan residents, about half trusted the federal government to set the same standards that they themselves would set in limiting pesticide residue in food (van Ravenswaay et al., 1992). About half said that they trusted that once federal standards were set, the food they bought would meet those standards.

Focus groups with consumers find that some have great trust in government regulation of pesticide use whereas others have little (Auld et al., 1994). That the government frequently has revised its risk assessments for pesticides is one reason cited for erosion of confidence. These findings have potentially important implications for food purchases. A survey of Washington state residents found, for example, that individuals with limited trust in pesticide regulations were more likely than others to seek foods with reduced pesticide-residue levels (Dittus and Hillers, 1993).

Trust in farmers also varies among consumers. In a survey of residents of the Delmarva Peninsula, 45% agreed that farmers ensure that the foods they sell are safe (Byrne et al., 1991). This finding suggests that some consumers are likely to put greater emphasis on the need for government regulation than others are.

Several studies have examined the credibility of various risk communicators. The Delmarva Peninsula survey found that the news media and health-food store owners were less likely to be believed as sources of information about risk from pesticide residues than university scientists were (Byrne, et al., 1991). But the 1992 Michigan survey found that only half of respondents felt that the scientific community could be trusted to be truthful regarding what it knows about health risks from pesticide residues (van Ravenswaay et al., 1992). Focus groups have found mixed attitudes toward news media coverage of pesticides because, although they are seen as providing needed warnings, they also are seen as having a tendency to sensationalize (Auld, et al., 1994).

Why might the public lack trust in the users and the regulators of agrichemicals? One reason is evidence of error such as accidental food-contamination episodes or risk assessment revisions. For example, there have been highly publicized incidences of banned agrichemicals found in food as well as reports of previously unsuspected risks from widely used pesticides and animal drugs. A second reason is evidence of dishonesty. There have been intensively reported incidences both of scientific fraud in the case of pesticides and of government ineffectiveness in the case of meat inspection. These cases may diminish public trust in the safe use and regulation of any technology, including agrichemicals.

Much additional work is needed to clarify the nature of and reasons for public trust in food producers and government regulators and the impact of trust on perception of risk from agrichemicals. Survey results suggest two important hypotheses. The first is that trust in people is as important if not more so than belief in inherent technological safety: even if the public believes that agrichemicals can be used safely, it may not think that they will be. Yet when scientific risk assessments are done, assumptions about how agrichemicals will be used are not always clearly linked to prevailing public views about the expected behavior of users and regulators. A second hypothesis is that restoring trust may require action that scientific risk assessment may not warrant. At

present, risk managers rank priorities on the basis of risk, not on the basis of lack of either public trust or consumer confidence. Yet both food producers and consumers might benefit from actions taken to improve consumer confidence. What such actions may be, what they may cost, or how great a benefit they may have are questions that should be explored.

3 Risk Acceptability and Pesticides

Some people may perceive risk, but consider it acceptable. Some risks, for example, may be acceptable if accompanied by great benefits. But if benefits are negligible, people may forego them to avoid risk. This section examines both public perception of the benefits of agrichemical use and consumer willingness to pay for reduced use.

Perceptions of Pesticide Benefits

Key benefits of agrichemical use include lowered price, increased seasonal availability, and improved quality of food. Studies suggest, however, that much of the public believes these benefits are obtainable without the use of agrichemicals. Although the majority of the public seems to believe that there is a need to control insects, disease, and other pests, a large segment also believes that pesticides are not necessarily the only effective or the least expensive means of doing so.

In a 1992 survey of 1,003 Michigan households (van Ravenswaay et al., 1992), over 70% of respondents believed that food prices would increase and food quality and supplies decrease if plants and animals were not protected in any way from insects, diseases, or other pests (Table 3.1). Similarly, in a 1990 survey of 437 residents of Idaho, Oregon, and Washington, 74% of respondents agreed with the idea that it is necessary to protect food from damage by insects or plant disease while it is being grown (Dunlap and Beus, 1992).

Although the majority of the public appears to recognize the need to control pests, many individuals think that chemical pesticides need not be used. Three-fourths of Michigan households said that pesticides were not the only effective means of controlling pests (van Ravenswaay et al., 1992). Eighty-four percent of households in Idaho, Oregon, and Washington said that food should be grown with fewer pesticides, and only 55% agreed that pesticides were necessary to grow food (Dunlap and Beus, 1992). Of 390 Kansas households surveyed in 1983 (Penner et al., 1985), only 34% said that pesticide use improved food quality. (See Table 3.2.)[5]

Even though the majority of the public seems to believe that there are effective alternatives to pesti-

[5]This latter result may reflect respondent uncertainty about the meanings of *quality* and *food* in the survey's context. For example, the word *food* may have conjured up images of prepared entrees whose quality likely would be judged by their ingredients, not by the use of pesticides.

Table 3.1. Partial results (in percentages) of a 1992 telephone survey of 1,003 Michigan households asking respondents the extent to which they agreed with the following statements about pest control in food production (van Ravenswaay et al., 1992)

Statement	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree	Don't know/ no opinion/ refused
If plants and animals were not protected in any way from insects, diseases, or other pests,					
. . . the supply of food available to me would decrease.	36.5	44.3	12.6	5.4	1.3
. . . the food available to me would not look as good as it does now.	36.5	39.7	15.8	8.1	1.0
. . . the price of food available to me would increase.	39.8	29.3	18.6	10.5	1.8
There are many equally effective ways other than using pesticides to protect plants and animals from insects, diseases, or other pests.	32.7	43.9	12.3	5.0	6.2
It is more expensive to use other ways of protecting plants and animals from pests than it is to use pesticides.	20.8	36.0	19.6	14.4	9.2

cides, some may perceive pesticides as less costly to use than these alternatives. For example, 57% of respondents in the Michigan study believed that alternative pest control methods were costlier than pesticides (van Ravenswaay et al., 1992). But only 19% of Kansas respondents believed that pesticide use decreased food prices while 58% believed that pesticide use increased food prices. (See Table 3.2.)[6]

Although too limited to permit firm conclusions to be drawn, survey evidence suggests that the public may perceive little benefit from using synthetic chemical pesticides. This conclusion does not mean that the public does not value control of pest damage on food. In fact, as a later section will demonstrate, the reverse is true. This conclusion reflects the findings that one segment of the public perceives no need to control pests, that another thinks there are effective alternatives to pesticides, and that a smaller segment considers pesticides the least costly means of controlling pests. But obviously if the public perceives few or no benefits from pesticides, it is unlikely to support their use even if it perceives them as not being very risky.

Willingness to Pay for Decreased Pesticide Use

Although the public may believe that there are equally effective, albeit more expensive, alternatives to agrichemicals, it may be unwilling to pay to decrease pesticide use. Because a large segment of the public perceives little health risk from agrichemical use, paying for lowered pesticide-residue levels may not seem worthwhile. A smaller but still significant portion of the public perceives much greater health risks, but because these respondents also may believe that it would cost no extra to stop using pesticides, they too might be unwilling to pay extra. This section reviews studies relevant to the public's willingness to pay for curtailing pesticide use.

As study results are interpreted, it is important to distinguish between policy research and marketing research. Although both study how much consumers are willing to pay for lowered pesticide-residue levels, the type of purchasing scenario that consumers are asked to evaluate differs. Policy research asks consumers to evaluate purchasing scenarios relevant to the evaluation of relevant policy alternatives, e.g., the establishment of tougher federal standards regarding pesticide residues, the intensified enforcement of existing standards, or a labeling policy that permits foods to meet different standards so long as they are labeled. An example of the former is requiring either no detectable residue or zero residues on all foods. An example of the second is requiring all foods to be tested and certified to meet federal standards. In these two policies, *all* foods would have to meet the same standards. Therefore, the correct purchasing scenario would present consumers with only one standard or one level of certified enforcement. Consumers would not be able to choose between foods meeting different standards or between foods certified and those not. If the policy-relevant option is to allow labeling of pesticide residues on foods, different standards would be labeled and more than one standard would exist. In this case, the correct purchasing scenario presents consumers with the choice among different standards.

In contrast, the goal of marketing research is to find out how a product meeting more stringent standards would compete with all other available products. In other words, marketing research asks consumers to evaluate purchasing scenarios in which they can choose between a new product meeting tougher standards and other products already on the market. To predict how many consumers ultimately would purchase a certain product, however, marketing research also would need to predict consumer awareness of the new item, and how awareness depends on media coverage, marketing, and advertising effort. This contrasts with the policy research that is not concerned with product awareness levels. Furthermore, marketing research would need to account for likely responses of competitors.

Table 3.2. Partial results (in percentages) of a 1983 mail survey of 390 Kansas households that were asked what effect pesticide use has on food price, quality, and safety (Penner et al., 1985; van Ravenswaay, 1988)

Effect	Price	Quality	Safety
Decreasing impact	19	22	43
No impact	9	22	6
Increasing impact	58	34	31
Don't know	15	22	21

[6]This latter result may have reflected respondent uncertainty about the situation being evaluated. Some respondents may have reasoned that it is more costly to use pesticides than to use none at all, so their use must increase price. Some may have reasoned that more can be charged for food not damaged by pests. Because most of the public is unfamiliar with food production methods, it is difficult to design questions that will be interpreted consistently and as intended.

In both policy and marketing research, willingness to pay for reduced pesticide residues may be estimated from market data or survey data. Both have serious limitations as well as advantages. Market data has the advantage of being based on actual behavior, but the limitation that market conditions often are very different from the policy and marketing scenarios we wish to evaluate. Survey data allows us to incorporate these conditions into scenarios presented to respondents, but can only elicit people's stated intentions. Even when conditions that are close to the scenario later materialize, people may act quite differently than they said they would. Research to understand and better control for this phenomenon is far from complete. The survey data reported here reflect this limitation.

Policy Research on Willingness to Pay for Lowered Pesticide-Residue Level

Policy research indicates that much of the public is willing to pay for a single tougher standard regarding pesticide residue level. But this is not to say that people would buy products with lowered residue levels if they were on the market. Rather, it is to say that if a tougher standard were in place and people were aware of them, they would judge these standards as beneficial. Whether perceived benefits outweighed costs would remain an open question, however, and it would remain unproven that the public wanted tougher standards.

To estimate the economic value of tougher standards to consumers, van Ravenswaay and Hoehn (1991a) estimated the premium that consumers would have been willing to pay for earlier removal of Alar from the market during the Alar scare. Using actual market data from the New York metropolitan area, they estimated that New York consumers would have been willing to pay more than an additional 30% per lb for fresh apples in 1989 to avoid the risks of Alar. On an annual basis, the average person would have been willing to pay a total of about $2.35 to avoid perceived risk from Alar.

Van Ravenswaay and Hoehn (1991b; 1991c) conducted a national survey of households to estimate what consumers would be willing to pay if *all* apples were *tested* and *certified* (1) to have no pesticide residues above federal limits, (2) to have no detectable pesticide residues, and (3) to have no pesticide residues. Respondents were presented with apple photos and a range of prices and were asked about their purchase intentions on a typical shopping occasion in the fall. The researchers estimated that consumers were willing to pay an average of $.24 more per lb for apples that normally cost $.79 per lb if all apples, but no other fruits, were certified and tested as having no residues exceeding federal limits. No statistically significant difference in terms of the added willingness to pay was found between the federal-limit apples and the no-detectable-residue apples. But it was estimated that consumers were willing to pay an average of $.38 more per lb for the no-pesticide-residue apples. This is $.14 more than the premium for the other two residue standards. The estimates of willingness to pay for reduced residue that are obtained from this survey data are comparable to those obtained in the study of consumer reaction to Alar (van Ravenswaay and Hoehn, 1991a).

A surprising finding is that willingness to pay for tougher pesticide-residue standards was not limited to people perceiving great risk. Whereas for all respondents perception of risk from pesticide residues was a statistically significant factor in explaining willingness to pay, those who perceived high risks were willing to pay only a penny more for the tougher standard than those were who perceived little risk. This finding has two implications: (1) The public considers very low risk unacceptable and (2) risk perception may not be the only factor accounting for willingness to pay for lowered pesticide-residue level.

Marketing Research On Willingness to Pay for Lowered Pesticide-Residue Level

Marketing research suggests potential for fresh produce specially tested and certified to meet tightened pesticide-residue standards. As yet, this research has addressed neither the consumer awareness level likely resulting if certified produce was offered for sale nor the effect of product presentation and marketing on purchase. So the studies reviewed in this report assume implicitly that (1) *all* consumers are aware of the availability of the new certified product and (2) the new certified product is presented and marketed in a way *identical* to the marketing of existing fresh produce. Obviously, the extent to which these conditions diverge from actuality will affect the validity of conclusions drawn from the studies about the potential market success of a new product. Results therefore should be thought of as providing upper-bound estimates of consumer willingness to pay for lowered pesticide-residue levels.

Baker and Crosbie (1993) examined whether there were distinct consumer segments in regards to the acceptability of pesticide residue in fresh produce. These researchers asked 160 shoppers at two supermarkets in San José, California to evaluate photographs of fresh apples, some of which were labeled as having been tested for pesticide residues by a government or private laboratory. Apples also were described as meeting one of three types of pesticide residue standards: (1) current, (2) 35% less residue, and (3) carcinogenic pesticide residue free. Apples varied in price and extent of pest damage. Three distinct consumer segments were identifiable in terms of willingness to pay for apples certified to meet more stringent standards. All three segments were willing to pay more but differed in terms of how much. The segment willing to pay the least (29% of the sample) was willing to pay an estimated $.22/lb extra for the government to certify that apples met existing standards. More than 70% of the sample preferred no carcinogenic pesticides, a reduced quantity of all other pesticides, and a label certifying this. More than 70% preferred government testing to private laboratory testing. The authors concluded that a single residue standard would not satisfy all three groups and that, therefore, labeling pesticide residues might be a better policy option.

Three other surveys have investigated potential consumer interest in pesticide-free foods. Two Georgia surveys asked whether respondents would be willing to pay more for certified pesticide-free fresh produce (Misra et al., 1991; Ott, 1990; Ott et al., 1991; Ott and Maligaya, 1989). A Michigan survey asked whether respondents would be willing to pay for food products grown without the use of pesticides and/or chemicals (Atkin, 1990). Responses are presented in Table 3.3.

Response differences among the three surveys may reflect differences between Georgia and Michigan or among questions asked. The Michigan survey gave respondents the opportunity to indicate several levels of percentages. The Georgia surveys offered fewer response categories, which may have created end-point bias.[7]

Although survey results differed, responses suggested that many consumers might be willing to pay for certified fresh produce but unwilling to pay either at levels approaching the typical premium for organic foods or at levels reported by consumers of organic food in studies to be described. Responses also suggest a wide range of consumer preferences. Between one-quarter and one-third of respondents were un-

[7]*End-point bias* occurs when answer categories given to respondents change their answers.

Table 3.3. Results (in percentages) from three surveys about the average consumer's willingness to pay for pesticide-free fresh foods

Willingness to pay	313 Atlanta suburban supermarket shoppers (1988)[a]: WTP[b] for pesticide-free fresh produce	389 members of the Georgia Consumer Panel by mail (1989)[c]: WTP for certified pesticide-free fresh produce	600 Michigan households by telephone (1990)[d]: WTP for food products grown without the use of pesticides and/or chemicals
No	34	26	29
Yes	66	45	66
Don't know	0	29	5
Yes:			
Pay 5% more	56	24	23
Pay 10% more	10	15	21
Pay > 10%	NA[e]	6	17[f]
Don't know	NA	NA	5

[a]Ott, 1990; Ott and Maligaya, 1989.

[b]WTP = willing to pay.

[c]Ott et al., 1991.

[d]Atkin, 1990.

[e]NA = not applicable to survey.

[f]10% were willing to pay 15% or 20% more. 7% were willing to pay 25% or 30% or more.

willing to pay a premium for pesticide-free fresh foods. At least 10% and perhaps as many as 40% of respondents were willing to pay a 10% premium or higher.

As a percentage of total food spending, these premiums would require consumers to increase annual food expenditures substantially. According to recent figures of the U.S. Department of Labor (1989; 1990), annual average expenditures per household in 1987 was $263 for fresh fruits and vegetables and $2,472 for all food eaten at home (in 1990 dollars). Thus, if higher prices did not reduce total quantities purchased, spending 10% more on fresh produce would cost the average household about $26 per year, and spending 5% more on all food would cost about $250 more per year.

One might expect that differences in risk perception would help explain differences in willingness to pay. Only the 1989 Georgia survey evaluated this hypothesis and Huang et al. (1990) found that the level of concern about pesticides helped explain willingness to pay.

Willingness to Accept Pest Damage

Inasmuch as lower pesticide-residue level can mean poorer quality and higher price, whether consumers will accept more damage for lower residue level is an important question addressed by both policy and marketing research.

In their policy study, van Ravenswaay and Hoehn (1991b, 1991c) asked a national sample of households to evaluate color photographs of apples with varying levels of pest damage and offered for sale at a range of different prices. They estimated that consumers were willing to accept damage of 7.5% of the visible area on the photo in return for guarantees that residues were below federal limits and that price did not change. Damage acceptance was 12% of the visible surface of the photo for guarantees that there were no residues and that price did not change.

In another marketing study, Baker and Crosbie (1993) asked San José shoppers to evaluate photographs of apples showing damage of 0, 1.6, and 3.4% of the visible surface area and priced at $.39, $.79, and $1.19/lb. Some apples were labeled as certified and tested to meet a variety of residue standards. Accounting for approximately 40% of preference rankings, damage on apples was the most important factor determining respondent preference for the apples presented to respondents. Price and certification labels accounted for 20% each. Distinct consumer segments existed, however. The largest segment (55%) placed a high value on avoiding damage whereas a smaller segment (16%) was comparatively unconcerned.

In 1988, Bunn et al. (1990) interviewed 229 shoppers in 12 supermarkets in Los Angeles and San Francisco. The researchers presented respondents with three photographs of oranges—one perfect orange, one with 10% surface scarring from thrips, and one with 20% scarring. Note that these surface areas were measured in terms of the percentage of damage on one side of a two-dimensionally photographed orange: that is, on a real orange, the total surface area would be larger, so the percentage of damaged area would be smaller. Respondents were asked how much more or less willing they would be to buy each of the scarred oranges than the perfect one, and most respondents (78% and 88% for each of the damaged oranges, respectively) were *less willing* to buy. But when respondents were told that the scarred oranges were grown with 50% less pesticide and asked again about their willingness to buy, most respondents (63% and 58%, respectively) reported that they would be *more willing* to buy the scarred oranges than the perfect orange. Only 25% and 34%, respectively, reported being less willing.

Ott and Maligaya (1989) asked Atlanta shoppers whether they would accept cosmetic damage to obtain pesticide-free fresh produce. Most (61.5%) would not. When asked whether they would accept insect damage, even more respondents (88.4%) would not.

All studies of willingness to accept pest damage indicate that consumers place a high value on avoiding damage although some value avoidance more than others do. There appears to be a segment of consumers who will accept some damage in return for reduced residue level, but acceptable damage level is low and likely dependent on type of fruit or vegetable. Generalizing therefore is unwise. For example, although perhaps unwilling to accept much damage on fruits and vegetables served fresh, especially to children, consumers may consider damage on foods used primarily in cooking more acceptable. Studies of a variety of foods are needed to determine consumer preferences.

Willingness to Pay for Organic Foods

Although organic foods are not necessarily produced without pesticides, many people believe that

they are. A survey of 1,003 Michigan households (van Ravenswaay et al., 1992) found that 29.3% strongly agreed and 41.5% somewhat agreed with the statement that food labeled *organic* was grown without pesticides.

To approximate willingness to pay for lowered pesticide-residue levels in food, several researchers have estimated price premiums for organic foods. For example, by estimating price premiums from weekly prices recorded for 27 organic and conventionally grown produce items at two food cooperatives, one health food supermarket, and two supermarkets in West Los Angeles and Santa Monica over a ten-week period in the spring of 1985, Hammitt (1986) sought to estimate consumer willingness to pay for lowered pesticide residue levels.

Premiums depend on produce type. For example, estimated organic price premium per pound was $.02 for potatoes, $.37 for apples, and $.62 for broccoli. On average, organic price premiums were about 45% of the conventional price. Thus, if the hypothesis is accepted that organic produce and conventional produce differ only in terms of organic attribute, conventional potato purchasers were unwilling to pay $.02 more per lb for the organic attribute.

To examine consumer views of organic food, Hammitt also conducted a pilot study with organic-food and conventional-food consumers. A brief questionnaire was administered to assess both willingness to pay for organic produce and risk perceptions; 45 usable responses resulted. Reported willingness to pay for organic food differed between the two groups. The median response of conventional-food consumers was that they would be willing to increase their fresh produce expenditures by 5% to purchase the safer produce (almost always the organic version). The median response for organic consumers was 50%, which is close to the median organic price premium of 45% estimated by means of market data.

Hammitt's (1986) focus groups also revealed that consumers did perceive significant differences in risk among different types of produce. Some, however, thought that peeling or cooking might lower residue level. Both groups thought that conventional produce was more attractive cosmetically. Consumers of organic food stated that the main reason they bought it was their own family's health; others did so for political, ecological, nutritional, or taste reasons.

Like Hammitt, Rae (1987) sought to characterize organic-food consumers' willingness to pay for organic food. In April 1987, Rae conducted a survey at four Bread and Circus stores, which sell both organic and conventional foods in the Boston area. Rae sampled 400 customers, who were given $10 in free food for completing the survey.

The average customer spent an estimated $12 to $13 per month extra for organic foods. The additional travel costs of organic food customers were estimated to be between $15 and $18 per month. Combining the organic premium and the travel costs, it was estimated that the average organic food customer incurred expenditures of between $27 and $31 extra per month. Using a 5% discount rate, the present value of 40 years worth of these expenditures was estimated to represent a lifetime willingness to pay for organic food of at least $5,850 to $6,700. This is a low estimate, for consumers of organic food may be willing to pay more than they currently are paying, and the real discount rate may be substantially less than 5%.

To estimate maximum willingness to pay, the survey asked respondents whether they would support a referendum requiring the EPA to eliminate most pesticide use if the agency knew it would increase the cost of food by a certain percentage. Different respondents were given different percentages, i.e., 20, 40, 50, 60, and 80%, and if they did not support the referendum, they were asked to report the percentage that they would be willing to pay. On average, respondents said they were willing to pay at least 38% more. After adjusting for the fact that some supporting the referendum may have been willing to pay even more than they were asked, the researchers estimated an average willingness to pay of 49%, or $115 more per month. Discounted at 5% over 40 years, this yielded a lifetime willingness to pay of about $24,000. Once design differences between the two studies are accounted for, Rae's (1987) estimates of consumers' willingness to pay for organic food are comparable to the estimates of Hammitt (1986) (van Ravenswaay, 1992).

Three surveys conducted in 1989 and in 1990 sought estimates of the percentage of households purchasing organic food, but data conflicted. One survey is the 1989 version of a national telephone survey conducted annually by the trade publication *The Packer*. The second is a mail survey conducted by Jolly et al. (1989) of households in three California counties. The third is a Michigan telephone survey conducted by Atkin in 1990 for the MDA. Data from the surveys are summarized in Table 3.4.

No more than 10%, and possibly less than 5%, of consumers should be described as frequent purchasers of organic food. Thus, although the Hammitt (1986) and Rae (1987) studies provide lower-bound estimates of what organic-food consumers are will-

ing to pay, little in fact is known about what the majority of shoppers are willing to pay for pesticide-free food.

Jolly (1989), who used survey data from three counties in California, also sought to estimate organic-food consumers' willingness to pay premiums for organic apples and peaches. (See also Jolly, 1991.) Only responses from the portion of the sample that had reported buying organic foods in the prior three months were used although the subsample size was not reported. Jolly estimated that organic consumers were willing to pay, on average, 37% more for organic apples if the conventional price was $.68/lb, and 69% more for organic peaches if the conventional price was $.49/lb. Average premiums, then, were $.25 and $.34, respectively.

These organic premiums, which should represent the average organic consumer's maximum willingness to pay for organic fruits, are lower than the corresponding market price premiums estimated by Hammitt, i.e., $.37 for apples and $.67 for peaches. Potential organic consumers therefore may be unwilling to pay the prevailing prices for organic fruits.

There are several reasons that results from studies of organic-food consumers should be used cautiously to reach either policy or marketing conclusions. First, although organic price premiums may be higher than most consumers are willing to pay for lowered pesticide-residue levels, consumers are not necessarily unwilling to pay nothing at all. Second, because organic-food price premiums reflect all the reasons for which consumers purchase organic food—not just reduced residues, the price premiums for organic foods should be higher than those for certified produce. Third, organic foods look different and are marketed and distributed differently from conventionally produced foods, and not all consumers are aware of or have easy access to organic foods. These factors constitute a few of the nonprice reasons that organic foods are not purchased by conventional consumers. Fourth, not all consumers think that organic foods are produced without pesticides. When these consumers do not purchase organic foods, their actions may belie a willingness to pay for lowered pesticide-residue level.

Table 3.4. Results (in percentages) from three surveys estimating the percentage of households purchasing organic food

Response	1,260 households nationally, October 1989 for *Fresh Trends* mail survey[a]: Seek and buy organically grown produce in previous 12 months	946 households in 3 California counties[b] for University of California mail survey[c]: Purchase organically grown products	600 households in Michigan for MDA/MSU telephone interview[d]: Ever purchase organically grown foods; how often?
No	89	38	48
Yes	11	62	45
Don't know	0	0	7
16–30 times/month[e] Very often[f]	—	2[e]	7[f]
5–15 times/month[e]	—	9[e]	—
1–4 times/month[e] Occasionally[f]	—	23[e]	23[f]
Less than once/month[e] Seldom[f]	—	28[e]	15[f]

[a]Jones and Zind, 1990.

[b]Marin, Sacramento, and San Diego counties.

[c]Jolly et al., 1989.

[d]Atkin, 1990.

[e, f]Survey data correspond to appropriate superscript [e] or [f] in response column.

4 Consumer Reactions to Animal Drugs

Few studies specifically have addressed consumer reaction to existing animal drugs, perhaps because there has been less controversy about them compared to pesticides.[8] Nonetheless, the potential for controversy over the introduction of two new animal drugs—bovine somatotropin (BST) and porcine somatotropin (PST)—has stimulated research on potential consumer reaction.

The main reason that consumer reaction has been studied is that these drugs are produced by means of biotechnology. But from the consumer's perspective, the main source of controversy is not how these drugs are produced, but whether their use in livestock production might adversely affect human health. The intent of this chapter, therefore, is to use prospective and retrospective studies of consumer reaction to BST and PST to understand consumer concerns about animal drugs—not public concerns about biotechnology.[9]

Bovine Somatotropin[10]

Public reaction to the introduction of BST depends on public awareness of its use. Bovine somatotropin is a naturally occurring protein regulating milk output in dairy cows. Obviously, if the substance was used in dairy production and the public was not aware of its use, public reaction would be minimal because consumer awareness depends on information. Awareness would increase if BST was the subject of numerous news reports or if milk was labeled regarding its use.

Studies conducted in states or at times when BST was not controversial have reported low levels of consumer awareness. For example, in a 1989 survey of 605 randomly selected Virginia households, only 20% had heard of BST (McGuirk et al., 1992; Preston et al., 1991); in a 1990 survey of 716 randomly selected New York households, 26.7% had; in a 1990 survey of 219 Missouri households, 42% had (Slusher, 1990). In contrast, a survey of 1,056 households in Wisconsin, where BST had become quite controversial, reported an awareness level of 90% (Douthitt, 1990).

In November 1993, the FDA approved BST use in dairy cows. After approval, the major television networks covered consumer protests. To determine awareness levels after media coverage, Hoban (1994) surveyed 1,004 randomly selected households nationwide. Only 4% of individuals surveyed had read or heard a lot about BST; 15% had heard something; and 62% had heard nothing at all. Evidently, awareness levels remained low after FDA approval.

A key factor affecting response of consumers who were aware of BST was the perception of health risk. Hoban's (1994) national survey asked respondents this question: "The federal Food and Drug Administration has ruled that milk from cows that receive BST is unchanged, safe, and nutritionally the same as milk currently on grocery store shelves. Given this information, would you personally have any concerns about the milk?" Sixty percent said that they would not be concerned whereas 38% would. When asked what concerns they would have, most respondents mentioned concerns related to their risk perceptions. Half of respondents mentioned human health effects; 23%, inadequate research or testing; 15%, distrust of government. But 11% mentioned adverse effects on cows, and 4% mentioned the economy.

When Hoban's study is compared with studies of consumer perceptions of BST risks before FDA approval, approval had a positive effect on consumer confidence. In the Virginia (McGuirk et al., 1992; Preston et al., 1991) and New York (Kaiser et al.,

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[8]Only two studies were found on consumer reaction to an existing animal drug: Kaiser et al. (1991) who examined consumer reaction to antibiotics in milk as well as to bovine somatotropin (BST) and Kinsey et al. (1993) who examined consumer reaction to a variety of safety issues on meat.

[9]Public concern about biotechnology in agriculture is an important issue. The most contentious issues are likely to be about the genetic manipulation of food plants and animals and the genetic engineering of organisms to produce food plants and animals. For consumer research on this subject, see Hoban and Kendall (1993).

[10]Studies described in this section used the term *BST* in their surveys. The terminology used here reflects that used in the studies rather than more technically correct references such as rBST.

1992) studies, respondents were given both a brief description of BST as a naturally occurring protein hormone and a summary of scientific conclusions about its safety and were told that the FDA soon might approve its use. Virginia respondents were asked whether they agreed that "approval of BST will make milk *unsafe* to drink." Forty-four percent of respondents disagreed, 19% agreed, 37% did not know. New York respondents were asked whether they agreed that "milk will be safe to drink if the FDA approves BST." On a scale with *1* representing *strong agreement*, *3* representing *don't know*, and *5* representing *strong disagreement*, average response was 3.05. The authors concluded that most respondents did not know enough about BST to judge its safety. In fact, 40.6% of the New York sample selected "don't know."

Different results were obtained in Missouri and Wisconsin, however. In a Missouri study in which respondents were given no information about BST or its safety but were asked whether they would be concerned to learn "that the FDA approved milk produced with BST, a growth hormone, as safe for human consumption," 49% said that they would probably or definitely be concerned. Thirty-nine percent said that they probably or definitely would not (Slusher, 1990). The much smaller percentage of respondents choosing the "don't know" response than in the Virginia and the New York surveys might have been due to differences in interpretation of the question in the Missouri study. For example, respondents might have believed that the question asked about how concerned they would be if the FDA approved BST at that point in time before the scientific studies regarding its safety had been completed.

In Wisconsin, much greater concern about the safety of BST produced milk was observed (Douthitt, 1990). Seventy-one percent of Wisconsin households believed, FDA assurances notwithstanding, that future studies might implicate BST as harmful to human health. This greater concern may reflect greater awareness of and greater controversy about BST in Wisconsin. As mentioned, other studies have linked awareness level to safety concerns (Preston et al., 1991).

Another factor affecting public perception of risk and thus reaction to BST is trust in government. Preston et al. (1991) found a large percentage of Virginians skeptical about government's role in guaranteeing milk safety. Thirty-four percent disagreed with the statement that "government will make sure that milk supplies are safe to drink"; 54% agreed, and 12% did not know. Similarly, 51% of Missouri respondents agreed that "if the government, such as the Food and Drug Administration and the U.S. Department of Agriculture, says a production process is safe then it is okay to eat foods produced that way"; 31% disagreed, and 18% were neutral.

Given consumer uncertainty about BST safety and their skepticism about the government's regulation of food safety, it is not surprising that some studies found consumer preference for BST labeling. Eighty-five percent of Virginia respondents thought that "milk from BST-treated cows should be labeled" (Preston et al., 1991). Only 68% of Wisconsin respondents supported labeling (Douthitt, 1990), but this fact may reflect limited support for any use of BST.

The potential impact of BST approval on milk purchases was examined in the New York (Kaiser et al., 1992) and the Virginia (McGuirk et al., 1992; Preston et al. 1991) studies, which provided upper-bound estimates by examining how much purchases would fall if *all consumers became aware of BST use and the price of milk remained unchanged.* In both states, 82% of respondents indicated that they would not change their purchase of milk if prices did not fall. Thus, the upper-bound estimate of the expected decline in milk purchases after BST approval therefore was approximately 15% in New York and 14% in Virginia. The study also examined how this estimate would be affected if milk prices fell $.10 and $.40/gal. As expected, the predicted decline in milk purchases was not as large, but lower milk prices did not completely offset the decline associated with BST use. The Virginia study predicted a decline in milk purchases of 12.2% if prices fell $.10 per gal. and a decline of 9% if they fell $.40. Again, these predictions concerned the effect on purchases if 100% of consumers became aware of BST approval.

But because all consumers probably would not become aware of approval, Kaiser et al. (1992) adjusted their upper-bound estimate of the decrease in milk consumption in the New York sample. Only 26.7% of New York respondents were aware of BST, and the researchers assumed that only aware consumers would reduce purchases. The awareness-adjusted estimate indicated a 5.5% decline in milk purchases if BST was approved and milk prices (and all other factors) remained unchanged.

This awareness-adjusted estimate of the decrease in New York consumption is larger than what appears to have occurred nationally. Hoban's (1994) national study after FDA approval of BST asked, "Thinking about the amount of milk you and your family consume, would you say that your family's milk consumption has gone up, gone down, or stayed the same

during the last two months?" Nine percent of respondents indicated a decrease in consumption. Only 10 of the 1,004 respondents reported reducing their consumption of milk as a result of BST use (Hoban, pers. com., 1995). Obviously, decreased milk consumption by less than 1% of consumers would not account for a predicted 5.5% decrease in milk consumption.[11]

The discrepancy between what seems to have occurred and what was predicted to occur raises doubts about the validity of the methods used to predict the impact of BST approval. The possibility of decreases in the price of milk following FDA approval of BST, however, could account for the discrepancy. Also a discrepancy between predicted and actual purchases in fact was to be expected because the Virginia and the New York studies presented consumers with a scenario at a time when the FDA approval of BST was still uncertain and scientific controversy over the safety of BST was a distinct possibility. Additionally, BST awareness levels seemed somewhat less after FDA approval than predicted. Almost two-thirds (62%) of respondents in Hoban's study had not heard or read anything about BST.

Ultimately, the FDA decreased the chance of scientific controversy by publishing the evaluation of BST safety before approving its use, thus providing a forum in which scientific consensus could develop. Such steps probably were important in decreasing public controversy over BST. Research such as Hoban's (1994) indicates that scientific scrutiny of the safety of BST is an important factor determining consumer acceptance.

Research indicates that consumers may prefer labeled to unlabeled milk. To estimate the market potential for BST labeling, Douthitt (1990) asked Wisconsin respondents whether they would prefer to purchase milk labeled as being from untreated herds, as long as there was no difference in price. Seventy-seven percent stated this preference. Of this group, 87% (or 67% of all respondents) stated that they would be willing to pay at least $.05 more per half-gallon for labeled milk. The average premium that respondents were willing to pay for BST-free milk was $.22 per half-gallon, or 20% of current milk prices. Because the consumer sample was universally aware of BST and of the availability of labeled milk, these results should be treated as upper-bound estimates of the market potential for labeled milk. As demonstrated, consumers outside of Wisconsin are much less aware of BST. Moreover, awareness of the availability of labeled milk depends on marketing and advertising efforts to promote it, and market prices depend on supply as well as demand. Although it will take several years before we know how consumers actually react to the recent FDA approval of rBST, there is anecdotal evidence of a developing market in BST-labeled milk. For example, Land O'Lakes is selling milk labeled "BST-free" in some areas, and organically certified milk companies report increased sales.

Research on consumer reaction to BST has provided useful insights into how to communicate the risks associated with agricultural technology. Hoban (1994) found that consumer acceptance of BST increased significantly when respondents were informed that "the National Institutes of Health, the American Medical Association, and several other independent medical groups have found milk from cows that receive BST is unchanged, safe, and nutritionally the same as milk currently on grocery shelves." Additionally, Hoban found that, among scientific organizations, the American Medical Association was the most credible source of information about safety of BST. The National Institutes of Health, the FDA, the American Dietetic Association, and state university and agriculture department scientists also were considered fairly credible. The least credible sources were packaged-food manufacturers, chefs, activist groups, and grocery stores.

Porcine Somatotropin

Porcine somatotropin is a naturally occurring growth protein causing hogs to produce more lean muscle and less fat. Because of the increasing demand for low-fat foods, PST use in hog production could increase pork consumption. On the other hand, public concern about chemicals in food could limit consumer acceptance of PST. For this to happen, consumers would need to become aware of the chemical and to develop concerns about potential health risks. Studies of consumer reaction to PST, however, have examined neither consumer awareness nor consumer risk-perception, but instead whether consumption would be affected *if* all consumers were aware of PST use. Because it is very unlikely that even *most* consumers ever would be aware of PST, estimates of the extent to which PST awareness would affect pork consumption must be interpreted, again, as upper bound.

In 1988, Halbrendt et al. (1990) surveyed 1,106

[11]Hoban's (1994) study found that 14% increased milk consumption. In contrast, McGuirk et al. (1992) reported that more than 10% of respondents would have increased milk consumption if prices decreased by $.40 per gallon.

randomly selected households in five metropolitan areas: Atlanta, Chicago, Los Angeles, New York, and Philadelphia. Respondents were provided with several brief alternative descriptions of PST and asked whether they would "eat less pork due to the use of PST in its production." Sixty-seven percent of respondents stated that they would not change their consumption of pork; 33% would.

Assuming that pork would be cheaper if PST was used, 44% of respondents stated that they would increase consumption. If pork produced with PST was leaner, 46% would eat more pork and 48% would be willing to pay a premium. The study did not report how much cheaper or leaner pork would have to be to offset consumer concerns about safety. These results suggest that study of tradeoffs between benefits and risks is important in predictions of consumer acceptance of new technology.

Additional results of this PST survey have been reported for a sample of 495 Atlanta households (Florkowski et al., 1989). In the Atlanta survey, PST was called TROPIN and respondents were told that its use in production would lead to leaner, faster growing, cheaper hogs. More than one-quarter of respondents stated that they would be likely to increase consumption of pork produced with TROPIN because it would be leaner; 12.6% of respondents said they would not eat pork unless it was produced with TROPIN. Thirty-two percent said they would pay $.05 to $.10 more per lb for pork produced with TROPIN. Nearly 40%, however, said they would not increase consumption of pork if produced with TROPIN; 47% would not pay more for such meat.

Additional results have been reported for the sample of 400 New York/Philadelphia households (Halbrendt et al., 1989). In this survey, respondents were given different descriptions of PST, i.e., growth promotant, somatotropin, growth hormone, and repartitioning agent. In New York and Philadelphia, 32% stated that they likely would increase consumption of pork produced with PST because it would be leaner; 46%, that they would not change consumption if PST produced pork were leaner, and 22%, that they would be "less likely to eat more." About half of respondents said they would be willing to pay a premium for PST produced pork if it was leaner. More than 20% said they would be likely to eat less pork if produced with PST.

The Atlanta, New York, and Philadelphia surveys also asked respondents about their belief in safety claims. Results were similar regardless of PST description. More than 80% of Atlanta respondents said that they would be inclined to believe public health officials' claims that the substance was safe, and more than 75% said they would believe the safety statements of federal agencies. In New York and Philadelphia, 75% of respondents said they would believe federal agencies and 87% said they would believe university scientists. The levels of belief in safety statements reported in these studies are higher than those found in the BST studies. There is no apparent reason for this difference, but question wording could be a cause.

These findings should be interpreted cautiously because survey design issues still are unresolved and the estimates may have a large range of error. However, a few general conclusions seem warranted. The studies of consumer reactions to PST contrast with those on BST. A larger percentage of consumers report willingness to purchase pork produced with PST compared to milk produced with BST. Apparently, consumers place a very high value on leanness, and for about a third of consumers, this value appears to more than offset concerns about safety. This finding may help to explain why BST has been so much more controversial than PST. Nonetheless, for about a quarter of consumers, safety concerns appear to outweigh the benefits of lower price and greater leanness. We are reminded once again that consumer preferences are diverse.

5 Summary and Conclusions

Public perceptions of the risks and the benefits of agricultural technologies can influence government and business decisions to use them or to invest in their development. Consequently, what the public perceives and why, as well as how its perceptions affect food purchases and public policy, are important. Yet research on these complex topics is in its infancy, and theoretical concepts and measurement instruments needed to produce accurate knowledge are being developed. Conclusions presented in this report should be regarded as tentative and deserving scrutiny.

One reason for not taking existing survey results at face value is the very discrepant findings regarding perception of risk from agrichemicals. When asked directly about their perceptions of potential hazards from these compounds, most subjects responded that there was a serious hazard. But when asked what food safety problems they were worried about or what they believed their personal risks to be from food, a much smaller number mentioned agrichemicals. In general, public awareness of specific compounds is minimal. When asked whether specific foods are safe when FDA-approved compounds are used, many consumers say they don't know.

Contrary to popular belief, great differences in public perceptions of risk from pesticides exist. Approximately one-quarter of the public perceived a very great chance of harm from pesticide residues in food; approximately the same fraction perceived very little or no chance. These differences in risk perception as yet are unexplained. They may be due partly to differences in consumer access to or understanding of risk information. For example, there is some evidence that consumers with higher income and education levels perceive less risk from pesticides than other consumers did. Another possible explanation is that consumers experience or perceive different risk contexts. That is, some consumers may have reason to believe they experience higher or lower exposure to pesticide residues than the average consumer does. Some may have reason to believe they are more or less susceptible to harm from exposure to residues.

Because considerable differences in risk perceptions exist among members of the public, it is unwise to make blanket statements about what the public believes about agrichemicals. Moreover, these differences imply that there are very different food safety and environmental policy preferences among different public segments.

Although most respondents seemed to perceive little risk from pesticide residues in food, there was less evidence about their perceptions of risks from animal drugs. Although the evidence suggests that a larger percentage of the public perceived risks from pesticide residues than from animal drugs, additional data are necessary. The limited data on perceptions of risks from animal drugs suggest there is a great deal of uncertainty among the public. This finding may reflect lack of information or differences in survey question design.

Survey results also suggest that not all consumers disagree with scientists' views about the health risks associated with agrichemicals. Most respondents also seemed in surprisingly close agreement with regulators in terms of their assessments of the proportion of foods with detectable levels of pesticide residues. Most respondents believed, however, that the pesticide residue level in food exceeds federal safety standards. In contrast, the FDA reports that more than 95% of the foods that it samples have residue levels well below federal standards.

Most respondents seemed to perceive a broader range of health effects than the cancer risks typically addressed by government officials and scientists. Indeed, a large segment of consumers do not mention cancer when asked what health problems they associate with pesticide residues in food. This finding has important implications for risk communication. Most scientists and risk communicators have focused on the potential carcinogenicity of agrichemicals, and this focus likely has been too narrow.

The public has agrichemical concerns in addition to the potential harm to consumers. Most of the public is concerned about the harmful effects of pesticides on the environment, especially on wildlife and groundwater. They also are concerned about the im-

pacts of pesticides on farmworkers. These concerns may be as important as or more important than concerns about consumer health in determining public reaction to agrichemicals, but additional research is needed to verify this.

But trust in people may be as important as, if not more important than, perceptions of the inherent safety of agrichemicals. The majority of the public does not trust the government to set appropriate safety standards or to enforce them. There is public skepticism about whether farmers ensure their products' safety. Public opinion is split over whether the scientific community truthfully represents the health risks from pesticides. The public sees the news media as tending to sensationalize as well as providing timely warnings. Finally, public-policy makers tend to rank priorities on the basis of relative risks—not on the basis of public trust or confidence. For all these reasons, the importance of restoring trust and confidence during the setting of policy priorities needs reconsideration and reaffirmation.

Willingness to Pay for Decreased Pesticide Use

Although it seemed that most respondents perceived small health risks from pesticide residues, these risks may not have been acceptable. The few existing studies indicate that most consumers believe that insects, diseases, and other pests can be controlled effectively without pesticides. Although more than half of respondents recognize that it may cost more to use alternative controls, many do not and thus perceive no benefits from pesticide use.

The implication of studies of consumer willingness to pay for lowered pesticide-residue levels depends on whether the studies were conducted for policy or marketing purposes. Policy research estimates the value to reasonably informed consumers of changing pesticide residue policy. Marketing research estimates the likelihood that consumers will actually purchase foods with lowered pesticide-residue levels.

Policy research suggests that the public is willing to pay for tougher pesticide-residue standards. But because their cost has not been estimated, whether it would be outweighed by benefits is unknown.

The results of marketing research on consumer willingness to pay for products with lowered pesticide-residue levels are upper-bound estimates. Purchase depends on whether consumers are aware of the new product, how presentation and marketing of it compares to established products, and the response of competitors. Because current marketing research has not studied all these factors, estimates of consumer willingness to pay are based on the assumptions that (1) all consumers are aware of the new reduced-residue product, (2) an identical process is used to market it and the conventionally produced product, and (3) the availability of substitutes remains unchanged. Obviously, estimates of consumer willingness to pay under actual market conditions would be much lower.

Marketing research suggests that most consumers might be willing to pay as much as 5% more for guarantees of reduced risks from pesticide residues. About one-quarter to one-third of consumers seemed unwilling to pay to avoid pesticide residues. At the very most, 5 to 10% of consumers now purchase some organic foods and, to avoid pesticide residues, seem willing to pay premiums as high as 50% over the price of some conventional foods. Such great differences suggest that a single policy regarding risk from pesticide residues in food is unlikely to please all consumers, many of whom may prefer an array of choices.

There is some evidence that minor levels of pest damage are acceptable if consumers believe that pesticide-residue levels are lowered. Without this guarantee, pest damage may be unacceptable, for most consumers value its avoidance.

Both policy and marketing research indicate that most consumers place a high value on current government standards limiting pesticide risks. In other words, most consumers seem to believe that government residue standards provide them significant health protection. The data also suggest that many consumers, however, would be willing to pay to ensure that foods actually meet government standards. Thus, consumers have doubts about enforcement.

Differences in the perceived level of risk rather than in the perceived value of avoiding adverse health outcomes may account for some of the differences in willingness to pay to avoid pesticide residues. Most organic-food consumers perceive very great risk from pesticide residues in conventional foods. Most other consumers perceive some small risks. Such great differences suggest that consumers either consult widely different sources of information about health and diet or regard as authoritative very different sources. Consumers also may have unique dietary patterns that increase their exposure to pesticides or may recognize unique health conditions or age factors that make them more susceptible to harm.

Studies of organic-food consumers provide additional evidence about the willingness to pay for low-

ered pesticide-residue levels. This evidence should be used cautiously, however, because price premiums for organic foods derive from several sources—not just from lowered pesticide-residue levels. Additionally, organic foods are marketed differently from conventional foods and can look different from them.

Public Reaction to Animal Drugs

Consumer awareness of animal drugs is quite limited and depends on the controversy surrounding them and on their coverage in the media. For example, less than 20% of consumers were aware of BST after it was approved by the FDA. If consumers are unaware of the use of a new animal drug in food, they cannot alter purchase patterns as a result. Because most studies of the effect of animal drugs on food purchases predict for cases in which 100% of consumers are aware, predictions usually are upper-bound estimates of likely impact.

Since the FDA approved BST for use, it is possible to compare how consumer purchases actually changed with how they were predicted to change. Although market data have not been analyzed yet, a consumer survey conducted after FDA approval found that less than 0.5% of consumers reported having decreased milk purchases as a result. Studies conducted several years before FDA approval predicted that consumer purchases would decrease by as much as 15% if 100% of consumers became aware of BST approval and if the price of milk remained the same. If the price fell $.40 per gal., purchases were predicted to decline by only 9%.

The discrepancy between what seemed to have occurred and what had been predicted likely was due to several factors. First, predictions were based on the assumption that 100% of consumers would be aware of BST, but awareness level turned out to be only about 20%. Second, it is unknown to what extent milk prices were affected after BST approval. Third, predictions may have influenced how the BST approval process was conducted and, consequently, the extent of controversy ultimately reported in the press.

Studies of the impact of PST also assume 100% consumer awareness. They suggest that as many as one-third of consumers would decrease pork consumption if price and leanness remained unchanged after approval. Lower prices and leaner meats were very attractive to consumers, however, about one-third might have been willing to buy more pork if it was leaner and cost approximately $.05 more per lb.

The studies of BST and of PST arrive at different results regarding the effect of government approval on consumer beliefs about safety. The BST studies report widespread consumer skepticism about whether the government would ensure milk safety. They also report a great deal of consumer interest in milk labeling. In contrast, the PST studies report that three-fourths of consumers believed government safety claims. Both sets of studies, however, indicate that thorough scientific scrutiny is important in earning public trust.

How consumers ultimately react to foods produced with new animal drugs depends on many factors. Public awareness is critical, as are the extent of controversy over safety and the subsequent coverage by news media. Government and industry can affect controversy level by ensuring that scientific scrutiny is thorough and broadly inclusive so that scientific consensus develops and includes scientific bodies that the public considers highly credible. If controversy over the safety of animal drugs in food is substantial, however, consumers likely will react quite negatively.

Improving Understanding of Public Perceptions

Several steps need to be taken to improve the reliability and the validity of research on public perceptions of agricultural technologies.

1. Specific needs for research on the public perceptions of agrichemicals differ depending on whether research is meant to inform public policy, marketing, or communication strategy. Identifying the knowledge lacking in each area will improve the usefulness of data and the interpretation of results.
2. Numerous perceptions probably play a role in public reaction to agricultural technologies, and perceptions of personal health risks likely is only one factor. Perceptions of the health risks to wildlife and environmental systems, farm animals, farm workers, and farm owners are other likely factors, as are perceptions of cost and efficacy of alternative methods for managing crops and livestock and for protecting them from pests. Each factor affecting consumer choice needs to be examined to provide a theoretical foundation for future research.
3. Valid and reliable methods to measure the various dimensions of public perceptions are needed. Underlying concepts need to be developed, alternative methods for measuring these concepts

need to be tested, and their reliabilities need to be assessed before empirical results can be generated and replicated. As outlined in Chapter 2, risk perception clearly is a multidimensional concept; what these dimensions are and how best to measure them are open to debate, however. Although much progress has been made in the past decade, additional work is needed to make reliable methods available for measuring risk perception and related concepts such as trust in government. The same observations apply to perceptions both of potential harms to the environment and to farmers and of viable technological alternatives and their costs.

4. Methods for empirically linking perceptions to relevant behaviors such as purchasing food must be improved. So far, most methods have been indirect. For example, studies of consumer reaction to food scares are based on aggregate market data rather than on household data. Thus, the extent to which behavior varies with perceptions and with household characteristics cannot be examined. Survey methods permit the linking of perceptions to behaviors, but designing scenarios to represent actual market conditions—especially to account for awareness level in the prediction of change in purchasing behavior—remains difficult.
5. Research is needed to clarify the differences among individual perceptions of agricultural technologies. For example, why do some individuals perceive very high risk from pesticide residues whereas others perceive very low risk? Models of how perceptions are formed and why they change are needed so that valid and reliable empirical research can be conducted.
6. Additional empirical research is needed on the public perception of agricultural technologies. The number of studies completed so far has been small, and many have been exploratory, i.e., based on small sample sizes and on low response rates. Few have used similar underlying concepts or measurement methods, and so comparing studies has been difficult.

Because agricultural technology continues to change and because science continues to reveal new information about the role of food in health, public perceptions of agricultural technologies likely will continue to be a subject of great interest to businesspeople, educators, government personnel, and members of trade associations and public interest groups. The basic research outlined in this CAST report will help facilitate the collection of accurate data about these perceptions and about their influences on public reaction.

Appendix A: Abbreviations, Acronyms, and Symbols

BST	bovine somatotropin
DES	diethylstilbestrol
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
FMI	Food Marketing Institute
gal.	gallon
lb	pound
MDA	Michigan Department of Agriculture
NRC	National Research Council
PST	porcine somatotropin
rBST	recombinant bovine somatotropin

Appendix B: Glossary

Agrichemicals. Synthetic chemicals used for pest control and growth regulation in the production of agricultural products. As used in this report, the term includes pharmaceuticals as well as fungicides, herbicides, insecticides, rodenticides, animal and plant hormones, and fertilizers among others.

Benefits. The advantages that a consumer gains from agrichemical use in food production. These depend on the extent to which the consumer values the foods and food attributes produced and on how much costlier it would be to produce them without agrichemicals.

Chance. The likelihood that something will occur to individuals in a specified population and time.

Communication research. Research seeking improved understanding of effective communication strategies.

Context. The set of circumstances resulting in a particular level of hazard exposure and population susceptibility to harm.

End-point bias. Bias occurring when answer categories given to respondents change their answers.

Harm. A negative health or environmental outcome characterized by its type, severity, painfulness, reversibility, duration, immediacy, lifecycle timing, and mitigation cost.

Marketing research. Research seeking improved understanding of the product purchases that consumers actually make under prevailing market conditions.

Policy research. Research seeking improved understanding of the tradeoffs between costs and benefits that reasonably informed consumers prefer for various policies such as risk reduction or information provision.

Risk. The chance of harm in a given context; specifically, the health hazard constituted by exposure to agrichemical residues in food or water.

Risk context. The set of conditions resulting in exposure to a particular level of hazard exposure and in population susceptibility to harm from it.

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