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# Staff Paper

**FOOD SAFETY ISSUES AND ECONOMIC ANALYSIS**

by
**Eileen van Ravenswaay**
**Tanya Roberts**

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# FOOD SAFETY ISSUES AND ECONOMIC ANALYSIS

by

**Eileen van Ravenswaay and Tanya Roberts**[1]

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# FOOD SAFETY ISSUES AND ECONOMIC ANALYSIS

by

Eileen van Ravenswaay and Tanya Roberts

The sustainable agriculture movement has emerged from several types of concerns about modern agriculture. One concern is the impact of current farming methods on the future productivity of agriculture--especially impacts on soil erosion and irrigation water supplies. A second concern is the impact of agriculture on the environment--especially losses of wildlife habitats and ecological services provided by wetlands and forests. Yet another concern is the effect of modern agriculture on the human safety of drinking water and food.

This paper examines food safety policy issues related to production agriculture. In the past, most food safety issues concerned problems with how foods are processed, handled, packaged or prepared, not how they are grown. Thus, relatively little attention has been given to food safety issues associated with production agriculture. The paper seeks to clarify the policy issues, identify the ones likely to be most important to the future of a sustainable agriculture, and the need for research by agricultural economists. The paper focusses primarily on policy developments in the U.S. However, it is hoped that the paper will stimulate discussion of related concerns in other countries and international food safety issues.

First, the paper shows how historical developments in the science of risk assessment and the organization of the food sector have affected the type of food safety issues that have occurred in the U.S. over time. Next, it examines the economic rationale for government intervention into private markets with respect to food safety and the range of policy alternatives that might be and have been used. Several sections examine food safety problems associated with three types of food contaminants: microbial pathogens, pesticides, and animal drugs. The final section

addresses future policy issues and economic research needs, including implications for sustainable agriculture.

## HISTORICAL DEVELOPMENT OF FOOD SAFETY POLICY ISSUES

Public concerns about food safety date back to ancient times. For example, Hippocrates (circa 460 B.C.) warned of harms from food and drugs. Cato (234-149 B.C.) developed methods for curing meats and removing odors from wine. Roman law included rules about the sale of spoiled food.

The types of food contaminants of concern have changed over time reflecting changes in scientific knowledge about food contaminants and changes in the way food is produced. Potential food contaminants of concern today fall into two broad classes: microbial contaminants (disease-causing bacteria, parasites, viruses, and fungi) and chemical contaminants (pesticides, animal drugs, environmental contaminants, and food additives).

Methods for detecting the presence of potential contaminants in food and assessing their toxicity evolved slowly over the centuries paralleling the developments of modern science and medicine. The first chemical tests for detecting food contaminants were developed by Robert Boyle and his contemporaries in the 1600s. These and other chemical tests were developed over two centuries culminating in the first major treatise on food poisons and contaminants published by Accum in 1820 (Hutt and Hutt).

The sensitivity of the methods used to detect the presence of food contaminants has vastly improved over the past several decades. It is now often possible to detect levels of chemical contaminants in parts per billion, and in some cases, in parts per trillion or quadrillion. The speed of these testing methods has also greatly increased over the past decade and is likely to

improve even more with the advent of biotechnology. For example, some tests for the presence of food contaminants that used to take weeks now take days.

Until this century, most knowledge of the toxicity of food contaminants was limited to observation of acute health effects in humans. At the turn of this century, 12 human subjects--all employees of the U.S. Department of Agriculture--were used to test the safety of boric acid, sulfites, benzoates, formaldehyde, and other food additives. Called the "poison squad," these human guinea pigs became the subject of intense public interest throughout the U.S. (Hutt and Hutt). Today, human testing continues for microbes which cause only minor foodborne disease or which have been altered to be less virulent.

Modern methods for establishing toxicity employing laboratory animals are a very recent development. The basic biology of rats, mice, and other mammals had first to be understood before they could be employed as "animal models" of mammalian response to microbial and chemical toxins. Not until after World War II were large colonies of these laboratory animals bred for experimental work. Thus, animal experiments are now used to test the potency of chemicals and the virulence of microbial contaminants likely to occur in food.

While much has been learned about the presence and toxicity of food contaminants in the past several decades, there are literally thousands of chemicals and microbial contaminants whose acute and chronic toxicity remains to be established. As new data on the toxicity of these contaminants and peoples' exposure to them becomes known, new food safety issues arise--sometimes triggering immense public concerns as we learn more about the harms we could face and what we can do to control them.

While science has changed, so have the technologies used to produce foods. Most modern concerns about food safety date back to the emergence of national and international food

markets. For example, in the U.S., foods began to be mass produced and marketed nationwide in the 1860s following the Civil War. This led to a number of food safety concerns related to the way foods were handled, processed, and packaged (Okun). For example, milk pasteurization was hotly debated in the early 1900s--"less contaminated" pasteurized milk had a longer shelf-life, could be shipped greater distances into new markets, and the economies of scale for the pasteurizer forced the smallest, local milk sellers out of business.

At the same time, growing national and international markets stimulated the demand for large and stable supplies of commodities. Wide scale use of synthetic chemicals in agriculture began after World War II triggering concerns about their effects on the environment and food consumers.

Increased international trade in commodities since World War II led to conflicts in how different countries addressed food safety issues. To harmonize divergent food safety standards, the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) jointly established the Codex Alimentarius Commission in 1962. The Codex establishes international food safety standards. Under the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) negotiations, harmonization of international food safety standards has been recognized as a basic principle furthering the GATT objective of reducing nontariff barriers to trade (GATT secretariat). Thus, international trade considerations are becoming increasingly important in the development of food safety policy in the U.S.

Food consumption patterns have also changed, reflecting more food being prepared and/or eaten away from home, faster cooking technologies, and new concerns about nutrition. These changes in food consumption patterns have produced new food safety problems, and, thus, new policy issues in the U.S.

Concerns about food risks associated with how food commodities are grown has intensified during the past decade. Around the beginning of the 1980s, national opinion polls in the U.S. began to reveal public concerns about whether agricultural chemicals might make food unsafe. Many of these concerns were shared by citizens in other countries and triggered international controversies. For example, the EEC proposed to ban hormones used in livestock production and threatened to halt imports of beef produced in the U.S. Likewise, Japan--the largest importer of U.S. pork--threatened to stop importing U.S. pork because of residues of sulfa drugs. These and other food safety issues have become the focus of debate in the GATT negotiations, the Codex Alimentarius Commission, and international scientific forums.

Most scientists agree that the most serious food safety problems are a result of microbial contamination. However, there has been more public controversy and consumer concern in the U.S. about chemical contaminants than there has been about microorganisms. There are many domestic and international issues about both types of contaminants, and policy issues about both are examined below.

## FOOD SAFETY PROBLEMS AND POLICIES

Food safety problems arise from a number of sources. Some potentially hazardous substances may enter the food chain because they lower the costs of producing food (e.g., pesticides and animal drugs), because avoiding their presence in food increases the cost of producing that food (e.g., microbial and environmental contaminants), or because they impart desirable qualities to food (e.g., food additives that enhance taste, texture, visual appeal and shelf life).

The human health risks from food contaminants depend on their toxic potency and human exposure. Human exposure to a food contaminant depends on how much of the substance is in

particular foods and how much of those particular foods are consumed. Many common and useful substances can become harmful if large enough quantities are eaten.

An unregulated food market will not generate sufficient information about the toxicity and presence of food contaminants to protect consumers. To understand why, it is helpful to ask what level of safety we could expect if there were no food safety regulations. This means examining the safety outcomes that would result in unregulated food markets where only general liability and negligence laws prevail.

## Food Safety in the Unregulated Market

Consumers affect their exposure to risky substances in food when making choices among available products. For consumers to be able to make informed decisions about tradeoffs among price, safety, and other dimensions of quality, they need to know what contaminants are in particular foods and how those contaminants may affect their health. The first kind of information is exposure information; the second is toxicity information.

Acquiring and processing toxicity information is extremely costly, particularly if done independently by each consumer. Many scientific tests may need to be done to learn what types of health effects a substance may cause and at different "doses." But once those tests have been done, there is no need for another person to reproduce them. The information can be shared at little additional cost.

Exposure information is also difficult and costly for a consumer to determine. In many cases, it is not only necessary to know what substances a food producer may be using, but to use expensive and complex chemical tests to double check.

In an unregulated market, sellers have little incentive to produce toxicity or exposure information about contaminants in their products let alone to provide it to buyers. One reason is

the high cost to buyers of verifying safety claims. If buyers throughout the food chain cannot easily establish the validity of safety claims, they will be reluctant to pay a higher price for "safer" food unless a reliable third party will guarantee the safety claim. If sellers cannot recoup the extra costs of producing a safer product, it will not be produced.

For sellers to be willing to provide a safety guarantee, they will require that they can pass on the cost of the guarantee to buyers. Since the cost of testing for toxic or other undesirable substances in foods is very high, third party guarantees generally will not exist in the unregulated market. Furthermore, for third party guarantees to be reliable, there would have to be some penalty for providing a false guarantee. This condition holds only if liability laws are effective.

Unfortunately, liability rules are not effective for most food safety cases. It can be very difficult for a consumer to know whether a particular illness is due to eating a particular food and, in some cases, ill effects are substantially delayed. Even if a consumer can trace the cause, proof may not exist because the food has been eaten or thrown out. In other cases, damages suffered by individuals may not be large enough to justify the enormous time and expense of litigation. In such instances, class action suits are very difficult to organize unless there is a single, identifiable source of the contamination. Due to the lack of recourse for false guarantees, there is little incentive to provide any guarantee.

## Regulatory Remedies

There are a range of government policies that could be used to remedy the different types of market failures outlined above. Since the nature of these market failures is somewhat different for the different types of food contaminants, it is not surprising that different methods have been used for each.

It was pointed out above that the market fails to produce both toxicity and exposure information, however the reason why is different for each type of information. Toxicity information suffers from the public good problem. Exposure information suffers from the problem of information asymmetry.

In the case of the provision of toxicity information, the public good problem is greater for naturally-occurring contaminants than for man-made ones. The primary reason why is that a single responsible party cannot be identified in the case of a man-made toxin, thus, making cost-sharing rules arbitrary. Consequently, two methods have been used to ensure the supply of toxicity information: government-required private research and publicly sponsored research. In the case of man-made contaminants (e.g., pesticides, animal drugs, environmental contaminants, and food additives), the private party that manufactures the potential food contaminant is required to produce the toxicity information before introducing the substance into the food supply. However, for "naturally occurring" toxins produced by bacteria or fungi, there is no one responsible party. Thus, publicly provided research is necessary.

In the case of the provision of exposure information, the information asymmetry problem is greater for toxins that are more difficult and costly to detect. For example, contaminants that are added in known amounts to food--such as food additives--require little new information to determine their presence, and, thus, their presence in food can be labeled with relatively little cost. Contaminants that are more randomly occurring would require expensive testing to determine their presence, thus making labeling much more costly. In this case, it may be much less costly to restrict their occurrence in the food system. This can be done by specifying food production practices (e.g., sanitary measures and rules for use of chemicals) or establishing allowable levels of contaminants in foods. The latter alternative allows producers a greater range

of choice of production methods, whereas the former may in some cases be less costly to enforce. (The cost depends on how easy it is to observe a particular production practice.)

Even in those cases where exposure can be labeled with relatively little cost, a consumer would still require some type of toxicity information. This kind of information would not only mean that many foods would have to be accompanied by a booklet, it would also mean that consumers would have to be very sophisticated in their scientific training. However, the consumers' costs of processing this information are reduced if the government pre-screens the information to determine a safe level of exposure.

Current Federal regulations in the U.S. require safety testing of man-made substances added to food or used in food production. This requirement produces the toxicity information needed to decide if there is a safe level of exposure, and, if so, what that level is given food consumption patterns.

Exposure to these substances is mainly controlled by limiting how much and what substances are in foods rather than influencing food consumption choices through risk labelling. To label every food product for microbial and chemical contaminants, each food item would have to be tested for literally hundreds of substances at several points in the production process. This still would not indicate contamination at the site of final preparation. Testing methods are nonexistent for many contaminants, and few tests are rapid enough for results to be available before food spoils. Even if tests were available and affordable so that each consumer could test foods just prior to consumption, the tasks of determining safe levels of each of the substances and communicating them to consumers remains. Finally, the enormous number of decisions made by consumers in a supermarket is likely to cause information overload and consumers may prefer to have regulators make safety decisions for them.

The regulatory tools most often used by the U.S. Food and Drug Administration (FDA), the USDA's Food Safety and Inspection Service (FSIS), and the Environmental Protection Agency (EPA) are "tolerances," food manufacturing process standards, and registrations for food technologies such as pesticides and animal drugs. "Tolerances" are legal limits on the amount of a substance that will be tolerated or allowed in a commercially sold food. Food manufacturing process standards include sanitation and construction requirements for packing plants, food processing establishments, groceries, and restaurants. Registrations state how, when, and where a substance such as a pesticide or animal drug may be used in food production.

Today, the establishment of tolerances, process standards, and registrations is very lengthy. For example, a new animal drug may have to undergo years of very specific types of safety testing. Field studies for demonstrating residues under prescribed conditions of use must be conducted. Further tests are needed to determine what happens to residues of compounds during food processing.

Once safety standards are set, some mechanism for enforcing them is needed. This requires an inspection system for testing foods and observing the premises of food producing establishments, and a penalty when violations are detected. Because inspection is extremely costly, it is usually done on a sampling basis with some kind of penalty for noncompliance. The sampling rate determines the probability of being caught in noncompliance. This probability, coupled with the penalty imposed for noncompliance, creates an expected cost for violating the law. The higher the expected cost of violating, the more violations that are deterred.

An exception to the reliance on policies which seek only to influence the amount of substances in food occurs when substances are added to foods in known amounts. This is the case for colors, flavors, preservatives, artificial sweeteners, and other "food additives." In this

instance, the presence of additives can be indicated accurately on the label, and consumers can make their own choices about consuming them. However, government still plays an important role in ensuring that what is added is safe or, at least, poses small health risks, and that the label is informative. Another notable exception is telling consumers to cook pork well, rather than inspecting for the parasite that causes trichinosis.

The next three sections take an indepth look at the policy issues surrounding the three important food safety concerns associated with agricultural production. These issues have to do with microbial contamination, pesticides, and animal drugs.

## MICROBIAL CONTAMINATION

Foodborne disease caused by microorganisms is an increasingly recognized problem in the U.S. Reported cases have increased for some common diseases, such as salmonellosis, partly because of greater diligence by public health agencies and because foodborne disease appears to be increasing in the U.S. and overseas. A joint study by the Centers for Disease Control (CDC) and the Carter Center at Emory University estimates that 6.5 million Americans become ill with foodborne disease annually (Bennett, et al.). The World Health Organization (WHO), in 1990, urged its member nations to cooperate more closely in the field of microbial food safety monitoring and research "in view of the massive rise in foodborne diseases."

### Foodborne Disease Risks from Microbes

Foodborne disease can be caused by bacteria, parasites, viruses, and fungi. Typically it occurs because the raw food is contaminated and inadequate cooking or other food preservation technique allows the pathogen to survive. In the U.S., foodborne disease is primarily associated with animal protein products, rather than cereals, fruits, or vegetables (Centers for Disease Control).

Some bacteria (Salmonella, Campylbacter, and Listeria monocytogenes) and parasites (Trichinella spiralis and Toxoplasma gondii) are common contaminants of food animals on the farm. Other bacteria (Shigella and Staphylococcus aureus) are more likely to be introduced by food handlers during processing. Viruses, for example, Hepatitis, are more likely to enter food processing plants through contaminated water or infected food handlers. Bacteria and fungi can multiply during food storage, whereas parasites and viruses do not increase in numbers.

The conventional wisdom used to be that foodborne disease of microbial origin would only cause mild, brief illness (primarily diarrhea and vomiting for a day or two). But, foodborne disease severity is enormously variable. Under some circumstances even healthy adults in the prime of life die from normally minor foodborne diseases, such as campylobacteriosis (Blasser). Parameters affecting the infective dose include: virulence of the organism, food composition and use of anti-acids, and host susceptibility which varies with age, underlying disease, pregnancy, medications, nutritional status, and immunity (Cohen). The CDC/Carter Center study estimates 9,100 Americans die each year from foodborne disease.

The four most important bacterial contaminants, Campylobacter, Salmonella, Staphylococcus, and miscellaneous enteric organisms, each cause over 1,000 estimated deaths annually in the U.S. In addition, chronic diseases can occasionally result from common bacterial and parasitic diseases (Archer). Central nervous system disorders, heart complications, blood poisoning, or kidney disease are other low-probability outcomes for many bacterial and parasitic infections transmitted by foods (Mossell). Some parasitic and viral diseases of foodborne origin can cause suppression of the immune system. While these are low-probability events, the life-long implications are serious. Archer and Kvenberg suggest that 2-3 percent of foodborne disease cases have some kind of short-term or long-term recurring after-effects.

Foodborne disease comes from food consumed at and away from home (Jones and Weimer; Center for Disease Control Outbreak Data). While more cases occur away-from-home, a smaller percentage of meals are eaten out indicating the relative risk may be lower from a home-cooked meal.

Food processors have typically relied on multiple devices to control foodborne disease microorganisms including high acidity, high sugar content, low water content, high salt or nitrite content, and temperature control. We now know that these traditional barriers are not foolproof; some important pathogenic microorganisms survive.

New convenience foods such as precooked entrees for reheating at home or in restaurants pose new food safety problems. Vacuum packaging hinders the growth of spoilage bacteria but may permit the growth of Clostridia botulinum at temperatures found in most commercial and home refrigerators. Also, precooked foods may be minimally heated which eliminates the traditional last line of defense--thorough cooking immediately before eating. The widespread use of microwave ovens exacerbates this problem since they often have cold spots where bacterial pathogens and parasites may not be killed. The increasing diversity of the American diet, with food imported from many countries with different microbial contaminants, also adds to the potential for microbial contamination.

Consumers tend to underestimate the risk of foodborne disease from specific causes. While USDA surveys of chicken over two decades have consistently shown that 35 percent are contaminated with Salmonella when they leave the slaughterhouse, only 12 percent of homeowners indicated that they thought contamination was very likely (Jones and Weimer). Although pork, beef, and seafood are less likely to be contaminated with Salmonella, they are more likely to contain other contaminants causing foodborne disease (CDC, 1990).

## The Cost of Foodborne Diseases

The costs of foodborne disease fall upon the individuals who become ill, their families and co-workers, their employers, the food industries, and the public health sector. Individuals' costs include medical bills, time lost from work, pain and inconvenience, loss of leisure time while ill, and increased health insurance premiums. Food industry costs include the possibility of product recalls, plant closings and cleanup, product liability insurance, and reduced product demand in a highly publicized foodborne disease outbreak (Smith, van Ravenswaay, and Thompson; Todd). Public costs also include the public health sector, costs of maintaining a disease surveillance system, investigating outbreaks, and helping to cleanup outbreaks.

Medical costs and time lost from work for individuals in the U.S. are estimated at around $1 billion annually for salmonellosis, a common intestinal disease with "flu-like" symptoms (Roberts, 1988). Campylobacteriosis, a similar intestinal disease, also has medical and productivity costs of around $1 billion annually (Roberts, 1987). A third disease, congenital toxoplasmosis, causes mental retardation in fetuses and is estimated to have costs of $368 million to $8.8 billion annually (Roberts and Frenkel). These partial estimates leave out many of the foodborne diseases. Clearly individuals' medical costs and productivity losses for foodborne disease are several billion dollars in the U.S. each year (Roberts, 1989).

## Alternatives for Controlling Microbial Contaminants

Farm level control options exist for most microbial contaminants, such as pasteurizing feed, keeping rodents/cats/birds out of animal feed and pens, removing dead animals from pens, and chlorinating the water supply. It may be most cost effective to eliminate microbial contamination of meat and poultry at the farm level, but more research is needed to confirm this.

Processing control alternatives for reducing microbial contaminants also exist. For example, irradiation permits the possibility of "pasteurization" of raw meat, seafood, and poultry to reduce microbial contamination. The public health benefits of irradiating U.S. pork and chicken have been estimated to be 2 to 4 times greater than the cost of irradiation (Roberts, 1985). FDA and FSIS have approved irradiation of pork to kill Trichinae. FDA has approved irradiation of chicken for Salmonella, and FSIS is considering approval. The first commercial U.S. food irradiation plant is being built in Florida and plans to treat poultry and strawberries in the summer of 1991. The market test is about to begin--are the public health protections and shelf-life extension benefits large enough to overcome documented consumer fears of irradiation (Zellner and Degner; Malone)?

A method for determining where contaminants come into the food chain and for monitoring their levels, the Hazard Analysis Critical Control Point (HACCP) program, is being considered by the Codex Alimentarius Commission as well as U.S. food firms and regulators (NRC, 1985). Decisions involved with implementing HACCP are 1) identifying the human health risks associated with specific foods; 2) deciding how to define health risks--for example, cases of disease, number of deaths, or economic losses (medical costs and lost productivity); and 3) minimizing the economic costs to industry and regulators of enforcing, monitoring, and complying with HACCP.

Use of time/temperature integrators could affect both the handling of consumer packages of food during retailing and shipping as well as enable consumers to alter their purchase decsions based on knowledge about how the food has been handled. The integrators change color if proper temperature control and storage times are violated. The integrators cost about 2 cents apiece and are most likely to be used on high-risk foods, such as ready-to-eat foods in air tight

packages which need strict temperature and shelf-life control to avoid botulism. Consumer demand for such integrators depends on consumer awareness of food risks.

International Actions on Microbial Food Safety

FAO food safety projects, sparked by the cholera epidemic in Latin America, are aiming to strengthen food contamination monitoring and technical facilities; upgrade handling practices at all levels of the food chain; train national personnel; support mass media campaigns; improve legislation and regulations on food control and consumer protection; and improve import and export inspection and quality control programs that protect the national food supplies and promote trade opportunities (Food Chemical News, June 24, 1991).

To improve collecting and collating of data on foodborne infections and intoxications, WHO organized a November 1990 meeting, "Consultation on Surveillance of Foodborne Infection and Intoxications in Europe." Epidemiological investigation methods and novel surveillance systems were discussed as ways to obtain actual incidence rates of human cases of foodborne illness. Once the incidence is established, cost effective preventive measures for the major sources of food borne illnesses can be identified and established (WHO).

At a conference sponsored by FAO, WHO, and the GATT, it was recommended "that WHO give priority attention to microbiological contamination and increase its efforts to assure safety of all products containing the minimum contamination possible from the standpoint of protecting human health" (Food Chemical News, April 8, 1991).

In the United Kingdom, a series of foodborne disease scandals led to establishing a Committee on the Microbiological Safety of Food which released two reports in 1990. They recommended improvements in epidemiological data as well as studies examining all stages of the

food chain paying particular attention to Salmonella, Campylobacter, and Listeria in poultry (Richmond).

## PESTICIDE RESIDUES

Pesticides are used to control insects, diseases, funguses, rodents, and other pests that spoil food. They are also used to control the cost of food production. For example, herbicides are used to control weeds that reduce yields--especially in no-till agriculture. Other chemicals--not technically pesticides--are used to regulate or promote the growth of plants.

To protect consumers' health, the U.S. Environmental Protection Agency registers the use of pesticides and sets tolerances on the level of residues that may be present in food. These tolerances are enforced by the Food and Drug Administration, and, in the case of meat and poultry, by the Food Safety and Inspection Service.

Today, it takes many years for a new pesticide to go through all the tests needed to determine its safety to workers, the environment, and food consumers. Beginning in 1978, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) imposed new requirements on what must be known about the chronic toxicity and presence of food residues of pesticides before the Environmental Protection Agency (EPA) can approve their use on specific crops. Consequently, pesticides introduced in the last decade have faced tougher scrutiny than ever before.

However, many widely used pesticides and plant growth regulators currently on the market were approved for use prior to these new data requirements and at a time when little was known about their potential to cause cancer. As the new toxicity data has become available on these older pesticides, the EPA has sometimes had to revise its risk assessments and to reconsider whether the pesticide should be reregistered or banned.

Despite the new evidence that some widely used pesticides pose unacceptable cancer risks, most toxicologists do not view pesticide residues as the most serious health risk. However, pubic reaction to the new risk assessments has been very negative. It is the public reaction, rather than scientific concerns about health risks, that has primarily triggered the public policy controversy over pesticide residues in food.

## Consumer Pesticide Fears

Several studies have sought to estimate the impact that consumer reaction to the new risk information on pesticides has had on consumer food purchases.

One example is ethylene dibromide (EDB), a grain fumigant that became widely used after World War II. In 1983, the EPA announced that it suspected that EDB might be a carcinogen. At around the same time, the state of Florida developed a more sensitive testing method for detecting residues of EDB in food. When they began applying the test in December of 1983, previously undetectable traces of EDB were found in many grain-based products.

The residue findings and the suspicion that EDB might be carcinogenic were heavily reported in the news media between December 1983 and March 1984. Consumers reacted by curtailing purchases of cake and bread mixes and other grain-based products. Sales losses in the grain products industry during the first half of 1984 have been estimated at between $18 and $30 million or between 4% and 6% per month during the height of the controversy (Johnson). The EPA ultimately decided to ban EDB, thus putting an end to the public controversy.

Another example is Alar, a growth regulator used principally in apple production since 1963. In 1984, the EPA announced that it was going to re-examine its risk assessment on Alar because new scientific evidence suggested that Alar, and its derivative, UDMH, might be carcinogens. However, EPA's Scientific Advisory Panel deemed the existing toxicity data too

inaccurate to justify a revised risk assessment. Consequently, the EPA requested the manufacturer of Alar, Uniroyal, to conduct new toxicity studies, and the decision to ban Alar was deferred for two years.

This action by the EPA evoked much controversy, and several states and consumer groups petitioned the EPA to immediately ban Alar. The controversy escalated in 1989 when a major news show--CBS 60 Minutes--reported that the Natural Resources Defense Council, a widely known environmental group, had determined that Alar was a dangerous carcinogen to children. Public panic resulted and sales of apples and apple products fell.

It has been estimated that fresh apple purchases fell as much as 10% after the initial announcement by the EPA in 1984 that Alar might be a carcinogen, and by as much as 30% following the 60 minutes program (van Ravenswaay and Hoehn, 1991a). This decline in purchases appears to be consistent with the reaction of people to similar types of risks in other types of settings (Fisher, et al.)

Several incidents of pesticide contamination of food were also widely reported during the decade of the 80s. In March 1982, 80% of the milk in Hawaii was found to be contaminated with the carcinogenic pesticide heptachlor. An estimated 29% loss in sales occurred in the 16 months following the incident (Smith, van Ravenswaay, and Thompson). In 1984, aldicarb contamination of California watermelons affected watermelon sales nationwide. In 1987, milk produced in Arkansas was found to be contaminated with heptachlor. In 1988, chicken and milk in several southern states were reported to be contaminated with heptachlor.

These and related events caused a decline in public confidence in the safety of fresh produce and in pesticides used in food production. Nationwide surveys conducted annually by the Food Marketing Institute show increases over time in consumer concern about pesticide

residues. A major policy issue in the U.S. today is what should be done in response to public concern about pesticides.

## Responding to Consumer Concern About Pesticides

Some argue that the way to respond to public concern about pesticide residues is to adopt tougher risk standards in regulating pesticides. Currently, pesticide residues on raw commodities are regulated using a risk-benefit approach, whereas residues on processed foods are subject to the Delaney Clause or "zero cancer risk" standard. It has been argued by some that residues on raw commodities should also be subject to the Delaney Clause. Others argue that residues on both raw and processed food should be regulated using a "negligible risk" standard such as no more than a "one in a million lifetime risk" of cancer. A study by the National Academy of Sciences published in 1987 recommended the latter policy alternative be adopted (National Research Council, 1987b). That policy has subsequently been adopted by the EPA.

Another way to respond to consumer concern about pesticide residues is to invest more dollars in the efficient operation of the current system of regulation. This would involve increased investments in more and better toxicity and residue data, thus speeding up the process of review of older pesticides. Similarly, more investment in monitoring pesticide use, monitoring residues in food, and following up violations with penalties would provide assurance the system is working.

A recent study lends support to the latter approach to dealing with consumer concerns. A contingent valuation study of a random sample of U.S. households found a significant willingness to pay for guarantees that pesticide residues in food meet federal standards (van Ravenswaay and Hoehn, 1991b and 1991c). Willingness to pay for a tougher standard, such as "no detectable residues," was found to be no higher than willingness to pay for a guaranteed federal standard.

An additional willingness to pay was found for eliminating pesticide residues (i.e., the zero risk standard). However, it was also found that consumers are unwilling to accept the type of pest damage likely to result if pesticides cannot be used.

This study also found that respondents were willing to pay for guarantees that pesticide residues meet federal standards regardless of their risk perceptions. Respondents who saw little health risk from pesticide residues were willing to pay almost as much as respondents who perceived large health risks. This finding suggests that there is a great deal of uncertainty among american consumers about the health risks that pesticide residues pose, thus suggesting that policies should be directed at reducing uncertainty about risks rather at than tougher risk standards.

This uncertainty could be reduced without having to result to the tougher standards that could mean more pest damage. For example, investments could be made in more and better toxicity and residue data, thus, speeding up the process of review of older pesticides. Research on safer, but equally effective and less costly alternatives to the older pesticides could be subsidized. Finally, certification programs could be developed to establish that foods meet federal standards for pesticides. First, however, it would be necessary to more fully establish that consumers would be willing to pay the testing costs.

## International Policy Issues on Pesticides

The desire to aid in the harmonization of international food safety standards is an additional reason why the U.S. might not want respond to consumers' concerns about pesticides by extending converage of the Delaney Clause to pesticide residues on raw foods as well as processed foods.

To harmonize food safety standards and remove barriers to international trade, the Codex Alimentarius Commission establishes maximum residue limits (MRL) for residue concentrations on raw agricultural commodities. However, the U.S. has only accepted approximately 29% of the Codex standards for pesticide residues. Thirty-seven percent of Codex standards are not as strict as U.S. standards. Thirty-five percent of Codex pesticide residue standards are stricter than the U.S. standards (Bredahl and Forsythe quoted in Nemajovsky and Centner).

Nemajovsky and Centner have pointed out that if the Delaney Clause were applied to both raw and processed food in the U.S., the percentage of Codex pesticide residue standards that are not as strict at the U.S. standard would increase. However, U.S. policy stated in the GATT talks is that harmonization of health and sanitary measures should be recognized as a basic principle furthering the objectives of GATT (GATT secretariat). Extension of the Delaney Clause to raw foods would seem inconsistent with this policy on international trade.

## ANIMAL DRUG RESIDUES

Animal drugs are used both therapeutically and subtherapeutically in livestock production. Both uses lower the costs of producing meat, dairy, and other products derived from livestock.

Therapeutic uses of animal drugs aim to cure sick animals. Examples include dairy cows that get mastitis or calves that get scours. Subtherapeutic uses are for improving animal growth. For example, low doses of antibiotics and sulfa drugs have been shown to increase weight gain and the efficiency of animals in converting feed to muscle gain or milk output. Animal drugs now under development promise to increase the leanness of pork and significantly reduce the costs of producing milk.

To protect consumers' health the Food and Drug Administration registers the use of animal drugs and sets tolerances on the level of residues that may be present in meat and dairy

products. The tolerances are enforced by the Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture.

New animal drugs must undergo extensive safety testing. However, like many pesticides, many animal drugs now on the market were registered for use many years ago. Many of the "old" safety evaluations are now considered outdated and inadequate. As new data becomes available, the toxic potency of many drugs widely used to promote weight gain and disease control in livestock may come into question. For example, the safety of sulfa drugs--which are widely used in swine and veal production--is seriously being questioned. While it has long been recognized that some sensitive individuals are allergic to sulfa drugs, recent studies by the National Center for Toxicological research indicate that sulfamethazine may be a carcinogen. Based on preliminary risk assessments, the Food and Drug Administration has warned that it will ban sulfamethazine use as well as subtherapeutic uses of antibiotics in livestock feed (Food Chemical News, May 27, 1991.)

Adequate or timely detection methods do not exist for approximately 70 percent of the animal drugs residues in meat, milk, and eggs that the USDA is responsible for monitoring (U.S. Congress, 1985). Currently, progress is being sought in developing tests for detecting their presence in food. The Food Safety and Inspection Service (FSIS) has made considerable progress in developing tests for detecting antibiotic and sulfa drug residues.

## Enforcement Problems

Drug residues above the legal tolerance limit occur when the cost to producers of complying with the law exceeds the expected cost of violating it. The cost of compliance depends on the cost to the producer of using the next best alternative to drugs. The expected cost

of violating the law is a function of the probability that a violation is detected times the size of the penalty imposed on the violator.

Continuing residue problems with antibiotics and sulfa drugs in swine and veal calves in the U.S. reflect the fact that the cost of violating is often much smaller than the cost of compliance. For example, in the 1980s, FSIS found violation rates of 5% or more for antibiotic and sulfa drugs in veal calves. Despite large increases in the rate at which FSIS sampled calves at slaughter, no statistically significant change in the violation rate occurred--primarily because the penalty for being caught was much smaller than the benefit of drug use in calves (van Ravenswaay and Bylenga).

FSIS faces two major constraints in enforcing the law. One is that sampling is expensive, so sampling rates must remain very low. Second is that it is very difficult for FSIS to penalize violators even when they have been caught.

There are two reasons why FSIS cannot effectively penalize violators. First is that the law limits the penalty to the condemnation of the carcass. However, many residue tests can take weeks to obtain test results, making it impractical to hold carcasses at the slaughter plant until the test results are available. Consequently, by the time a violation of federal drug residue standards is found, the carcass has already been sold at retail and consumed, and the only penalty that can be levied is requiring the producers' next livestock shipment to be intensively tested. Second, the current marketing system often makes it difficult to determine who produced the animal, so FSIS cannot always penalize producers for the cost of the carcass nor subject their future shipments to follow-up testing.

To help overcome the first these problems, the FSIS has invested heavily in developing rapid tests. This has been accomplished for antibiotics and sulfa drugs. However, FSIS has not

yet been successful in obtaining authority for imposing a mandatory animal identification system for all species. (A mandatory program exists only for swine.) Until this occurs, the faster testing will have little effect on violation rates.

Other Ways to Change Economic Incentives that Affect Food Safety

There are other alternatives that USDA could explore to discourage illegal drug use in livestock production. One is investing in research to develop substitute technologies for drug use that are equally effective and less costly. Emphasis must be on the "less costly" part of the equation. FSIS took this approach in trying to get producers to stop illegal drug use in veal calves. They came up with an equally effective technique, but the technique was much more costly than using drugs (van Ravenswaay and Bylenga).

Another approach is for USDA to research the possibility of consumer willingness to pay for meat products certified as meeting U.S. standards. If consumers were willing to pay a premium for such guarantees which covered the extra costs of compliance, then a higher testing rate alone would result in greater compliance levels.

Whether such consumer willingness to pay for guarantees would be found is hard to predict. Unlike pesticides, consumer concern about animal drug residues has been relatively muted. However, several studies of consumer reaction to new animal drugs such as BST and PST suggest that there may be a substantial demand for such guarantees. For example, studies have found that consumer milk purchases may decline significantly if BST is introduced--even if the price of milk were to decrease by 40 cents per gallon (McGuirk and Kaiser; Preston et. al.; Douthitt; Slusher). Surveys have also found that as much as a quarter of consumers report that they would eat less pork if it were produced with PST--even if the pork were leaner (Florkowski et al.; Halbrendt et al., 1989).

The fate of BST and PST may be more in the hands of the international community than it is in the hands of U.S. regulators. The position of the U.S. Food and Drug Administration is that BST is safe. However, the Codex Alimentarius Commission recently voted to sanction the use of four hormones (estradiol, progesterone, testosterone, and zeranol) as growth promoters in livestock (Food Chemical News, July 8, 1991). The reasons given for the vote--which was against the position of the U.S.--was consumer concern in the European Community. Since it is stated U.S. policy in the GATT negotiations that Codex standards should become the standard for international trade, the U.S. will have to decide whether it will adopt a less strict standard for its domestic market.

## POLICY AND RESEARCH ISSUES FOR THE FUTURE

### Overview of Risk Management Data Needs

Both FSIS and the FDA agree that microbial hazards will continue to be the major human health risk (GAO). However, which microbes are the sources of greatest economic losses, the foods they are associated with, the points of entry into the food chain, and the benefits and costs of alternative control strategies are unknown. New food safety research and data collection can help to reduce uncertainty in decision making and reduce costs due to the misallocation of resources.

Roberts and Smallwood state that physical/biological data are needed to quantify the underlying technical relationships in the production, processing and marketing of agricultural commodities. Such data are necessary to establish how chemical and microbial contamination levels relate to production, processing, marketing, product quality, and health risks. Rapid inexpensive tests for microbial chemical contaminants are critical for linking food firm actions with contamination levels. New research is expanding the range of human health effects

evaluated for chemical contaminants from cancer risk to effects on the immune system, to neurological effects, and to developmental effects of fetuses or children exposed. Also critical to estimating the distribution of likely human health effects is the variability in individuals susceptibility to different contaminants.

Economic/behavioral data are needed to understand factors affecting the choices of market participants. To alter food production and handling practices to reduce foodborne risks, one must know something about the economic tradeoffs facing producers, processors, and consumers. For example, reducing chemical use on farms and in the marketing system requires knowing the impacts of pesticide, fuel, labor prices, and alternative pest control strategies (such as biological and mechanical controls, crop rotation, and planting resistant varieties) on pesticide usage, productivity, and food prices.

## Public Uncertainties About Risk

A key food safety issue surrounding chemical agricultural technologies appears to be related to public uncertainties about how they are being used and the possibility of chronic toxicity. However, we have yet to identify the most appropriate policy alternatives for reducing public uncertainties. Some argue that what is needed is more education of the public about food risks and methods of agricultural production. Others argue that public confidence can be won only by having tougher federal standards. Still others believe that more investment in the current regulatory process is needed.

The effect of these different types of approaches on public risk perceptions is just beginning to be researched. The way people perceive health risks is beginning to be characterized and measured. The effect of new and different types of risk information on those perceptions is beginning to be assessed. Much more work is needed.

## Assessing the Risks of New Foods and Dietary Patterns

Regulatory programs are built on estimates of the toxic potency of substances, the presence of those substances in food, and the amount of those foods that people consume. As consumption patterns change, old estimates of exposure become outdated. We need to continually update our knowledge of food consumption patterns to ensure that our regulations are based on reasonable assumptions.

For example, as we learn more about the relationship between diet and health, food consumers are being encouraged to eat more cereals, fruits, and vegetables and discouraged from eating as much animal and fish protein. Because most microbial contaminants are associated with seafood or animal protein products, foodborne disease exposure may decline with such dietary changes. On the other hand, if fruits and vegetables are increasingly eaten raw rather than cooked, the risk from fruits and vegetables may increase.

Changes in the source of the foods should also be considered as international trade flows increase. As more exotic produce is imported from other countries with different microbial contaminants or as sustainable agriculture increases use of manures instead of sterile chemical fertilizers, the nature and magnitude of food risks may change.

## Labelling

Research on consumer willingness to pay for reduced risks from pesticide residues in food indicates that U.S. consumers are willing to pay a substantial amount for guarantees that foods meet federal safety standards. Additional research is needed to determine willingness to pay for different types of guarantees in different types of food, as well as in different countries. Whether and what types of labels would be possible under harmonized international food safety standards is also at question.

Research is also needed on the costs of testing foods for contaminants. Methods for testing for the presence of contaminants is rapidly improving. However, little is known about the costs of providing the testing.

Both private and public labelling initiatives have been fostered by improved testing. For example, NutriClean, a company based in Oakland, California, offers programs to test for chemical residues in food and certify them as pesticide free. Several supermarkets across the U.S. have contracted with NutriClean to certify their produce.

However, food safety guarantees on the label need to be first established in national and international law before they are likely to gain wide public understanding and acceptance. For example, until recently, definitions of organic food did not exist in most states of the U.S. Thus, what could be sold and labeled as being organic was difficult for consumers to establish. However, Title XXI of the Food, Agriculture, Conservation, and Trade Act of 1990 (P.L.101-624) has directed the Secretary of Agriculture to establish national organic standards. To be sold or labelled as organically produced, an agricultural product must 1) have been produced and handled with the use of synthetic chemicals, 2) not have been produced on land to which any prohibited substances have been applied during the previous 3 years, and 3) have been produced and handled according to an "organic plan" approved by the certifying agent, usually the state (Lynch). Organic food labels may indicate that the product meets USDA standards for organic production and may incorporate the USDA seal.

The National Academy of Sciences recommends labelling of retail poultry products "to inform consumers how to handle the poultry to prevent diseases originating from microbial contaminants" (National Research Council, 1987a). FSIS/UDSA has proposed that packages of meat and poultry produced under superior hygienic conditions be labelled to give consumers an

incentive to purchase such packages and firms a means to recover the extra production costs (Federal Register, FSIS, APHIS animal id system).

The development of detection methodology has also made possible laws like Proposition 65 in California. This law, the "Safe Drinking Water and Toxic Enforcement Act of 1986", requires that any persons in California exposed to a natural or synthetic chemical which the Governor has determined to be a carcinogen or reproductive toxicant must be warned of that exposure. As such, the law requires all food which contains any amount of one of these chemicals to be labeled. While the practical regulations are yet to be worked out, this state law represents a new movement in consumer desire for labeling (Phipps, Allen, and Caswell; Kramer and van Ravenswaay).

## Economic Methods of Valuing Food Safety

As science offers us more information about the health risks associated with agricultural technologies, it also offers us more choices about managing those risks. Economists have much to offer in developing knowledge about the tradeoffs we face between the costs and benefits of risk management.

Perhaps most controversial in terms of appropriate methods for developing information about these tradeoffs is the economics of valuing the benefits of risk reduction.

One issue is who benefits from food safety improvements and how? Food consumers obviously benefit directly from lower risks, but food producers may benefit from higher product demand, and taxpayers may benefit from reduced public health costs. Indirect beneficiaries might also include health consumers and health insurers because reduced demand for health care could result in lower health care prices. Similarly, future generations might benefit if food contaminants affect reproduction.

A second issue is how to measure benefits. Economic theory tells us that the relevant measure of benefits is peoples' willingness to pay for them. However, it is difficult for the researcher to observe willingness to pay for food safety improvements for two reasons. First, health risks are an attribute of food, so it is difficult and costly to isolate the effect on food demand of risk reductions from the effect of other food attributes would have. Second, there are few clearly identified food risk choices currently offered to consumers in actual markets, so it is difficult for the researcher to observe the choices consumers prefer.

Most of the work to date on the benefits of food safety improvements has concentrated on estimating the direct consumer benefits. Several methods have been employed, and there is a great deal of controversy over which method is most appropriate given the difficulties of observing the tradeoffs consumers prefer.

Where markets for risk reduction exist--such as organic markets and food contamination scares like Alar--then hedonic methods could be used to deal with the food attribute problem in developing estimates of direct consumer benefits (Hammitt; van Ravenswaay and Hoehn, 1991a). A major problem, however, is characterizing what the health risk attribute is. For example, are environmental benefits included along with reduction in the risk of human illness. In addition, an enormous amount of data is needed if attributes other than health risk vary with changes in food safety actions. This is a problem, for example, in organic product markets where cosmetic quality and product size vary with the risk attribute. Nonetheless, the added willingness to pay for organic food may be a rough indicator of willingness to pay for risk reductions (Hammitt; Jolly).

Where markets do not exist, they can be simulated either in the laboratory, in a test market, or through survey methods known as contingent valuation methods. The first two

methods allow greater realism in the description of the product of interest, but, because of cost, cannot be conducted with samples large enough to permit statistically reliable inferences to the population of food consumers. Survey or contingent valuation methods permit the use of large, random, and representative samples, but require extremely careful design and interpretation. Contingent valuation is a widely accepted method in environmental economics, but is still considered very controversial by most agricultural economists. Nonetheless, it is beginning to be used in the area of food safety (Malone; McGuirk and Kaiser; Ott; Preston, et al.; van Ravenswaay and Hoehn, 1991b and 1991c; Zellner and Degner).

An alternative to direct valuation of risk reduction is to approximate it by estimating preventative expenditures. This has been done using travel cost methods (Rae) and averting expenditures (Harrington, Krupnick, and Spofford). Travel cost methods involve estimating extra costs of traveling to an organic food store. Averting expenditures involve additional consumer expenditures undertaken to avoid a risk, such as the extra cost of bottled water, the extra time taken to wash pesticides off produce, or the extra costs of instituting sanitary measures. However, preventative expenditures probably underestimate willingness to pay.

Yet another alternative to direct valuation is the widely used, but controversial, cost of illness approach (Cohen, et al.; Curtin; Curtin and Krystynak; Kvenberg and Archer; Mauskopf, et al.; Roberts, 1987, 1989; Roberts and Frenkle; Roberts and Pinner; Todd). This method involves enumeration of health care cost savings as well as the opportunity costs of foregone income, leisure, and physical well-being. It is likely that cost of illnesses studies underestimate the direct consumer benefits of risk reductions, but may partially capture taxpayers' and insurers' benefits to the extent that medical expenditures are paid publicly or by third party payments.

Relatively little work has been done on estimating benefits to groups other than consumers. Capturing the potential benefits of food safety improvements to producers is just beginning to be analyzed (Hoehn and van Ravenswaay; Swartz and Strand), though most existing studies only look at the gross sales losses from contamination incidents (Johnson; Smith, van Ravenswaay and Thompson; van Ravenswaay and Hoehn). Capturing the benefits to taxpayers, health consumers, and others has remained more elusive.

Much work remains to assess the reliability and validity of each of these methods. In addition, practical issues remain in conceptualizing how consumers perceive the various dimensions of food risks, as well as what methods are reliable and valid measures of those perceptions.

## Sustainable Agriculture Methods and Food Safety

Sustainable agricultural methods may or may not always be compatible with food safety objectives. For example, "no-till" or minimum till methods that reduce soil erosion increase the use of herbicides which may mean more residues in food. Similarly, increased use of manures may increase problems of microbial contamination of food. Likewise, the development of disease and insect resistant plants may help reduce chemical loads on the environment, but not human beings. For example, celery was recently developed which caused itching hands among food handlers because of a 10-fold increase in a natural mutagen and carcinogen in the celery (Ames). The use of biotechnology to develop herbicide-resistent and insect-resistent plants is likely to increase the levels in plants of these naturally occurring toxic substances.

In the U.S., farming methods and technologies are not evaluated in a comprehensive fashion. Different laws address different impacts these methods and technologies may have.

Consequently, one agency of government might be responsible for the food safety impacts, another for environmental impacts, and yet another for soil erosion or water quality.

The same is true in the agricultural research system. Researchers tend to specialize in different parts of the food system. Agricultural economists can help improve policy by identifying the tradeoffs involved among these different objectives of sustainable agriculture.

## The Impact of International Trade on Food Safety

The Codex Alimentarius Commission was established to harmonize international food safety standards. Under the Uruguay Round of the GATT negotiations, harmonization of international health and sanitary measures was recognized as a basic principle furthering the objectives of GATT by reducing nontariff barriers to trade. Thus, it can be expected that, over time, there will be greater alignment of national food safety standards with those established by Codex.

In many cases, the rules established by the Codex may quite different from those established by individual countries in terms of food identity standards, food processing and production methods, animal and plant health and quarantine, maximum residue tolerance levels, and methods of analyzing, sampling, and penalizing in the enforcement process. For example, a cross-national comparison of food safety standards for meat and meat products found large differences among countries' standards (van Oijen).

From an economic perspective, it is not necessarily evident that harmonization of food safety standards makes sense. For example, consumers in different countries may have very different preferences for food safety and different exposures to food contaminants and thus desire a different level of safety than the international standard. Likewise, different countries are likely to face different costs in complying with international standards, so having one international

standards would shift the comparative advantage in production of different commodities. Thus, from an individual country's perspective, the benefits of an international standard in terms of reduced trade barriers or transaction costs may not outweigh the costs. Since little is known about differences between countries in term of consumer preferences and costs of compliance, much work is needed to assess the economic desirability of international standards. Furthermore, how the development of sustainable agriculture might be affected by the desire for standardized rules also needs to be examined.

## Summary of Policy Research Issues

Changes in what we know about the toxic potency and presence of substances in foods, changes in agricultural technologies, changes in dietary patterns, and the increasing internationalization of trade and food safety issues will continue to raise new policy questions. For example, should greater efforts be made to reduce microbial or chemical contaminants in foods? If so, what should these efforts be? Given our ability to detect increasingly minute amounts of substances in foods, should we seek more flexible laws than the Delaney Clause? If we rely more on labelling, how should we communicate risk information to the public? Should we move to uniform, international food safety standards? Are cheaper, more effective systems of food contamination detection possible? What are consumers willing to pay for increased safety in the food supply? Finally, what can be done about public confusion from rapidly increasing and sometimes conflicting information about the safety of specific foods?

Changes in science, technology, lifestyles, and trade patterns will continue to create challenges for policymakers and the food system in dealing with the problems of food safety. In responding to these challenges, it would help to have the best set of information possible for identifying and evaluating the options available.

## References


Ames, B.N. and L.S. Gold. 1990. "Too Many Rodent Carcinogens: Mitogenesis Increases Mutagenesis," Science. 249:970-971.

Ames, Bruce N. 1988. "Response," Science. 240:1045-1047.

Archer, D.L. 1985. "Enteric Microorganisms in Rheumatoid Diseases: Causative Agents and Possible Mechanisms," Journal of Food Protection. 48:538-545.

Archer, D.L., and J.E. Kvenberg. 1985. "Incidence and Cost of Foodborne Diarrheal Disease in the United States," Journal of Food Protection. 48(10):887-894.

Archer, Douglas L. 1984. "Diarrheal Episodes and Diarrheal Disease: Acute Disease with Chronic Implications," Journal of Food Protection. 47:321-328.

Bealer, Robert C. and Fern K. Willits. 1968. "Worriers and Non-Worriers Among Consumers About Farmers' Use of Pesticides," Journal of Consumer Affairs. 2:188-204.

Bean, N.H., P.M. Griffin, J.S. Goulding, and C.B. Ivey. 1990. "Foodborne Disease Outbreaks, 5-Year Summary, 1983-1987," Journal of Food Protection. 53(8):711-728.

Bennett, John V., Scott D. Holmberg, Martha Rogers, and Steven L. Solomon. 1987. "Infectious and Parasitic Diseases," in Closing the Gap: The Burden of Unnecessary Illness, Robert W. Amler and H. Bruce Dull, Eds. 102-114. New York: Oxford University Press.

Bishop, R.C. 1982. "Option Value: An Exposition and Extension," Land Economics. 58(1):1-15.

Blair, Dorothy and Carolyn Sachs. 1986. "Public Concerns About Pesticides and the Safety of the Food Supply." Paper presented at the Internation Federation of Organic Agriculture Movements, University of California at Santa Cruz (August 19, 1986).

Bredahl, M.E. and K.W. Forsythe, Jr., 1988. "Harmonizing Phytosanitary and Sanitrary Regulations Through GATT Negotiations," Working paper, Department of Agricultural Economics, University of Missouri, Columbia, MO.

Brown, J.D. 1969. "Effect of a Health Hazard Scare on Consumer Demand." American Journal of Agricultural Economics. 51:676-78.

Bunn, David, Gail W. Feenstra, Lori Lynch, and Robert Sommer. 1990. The Journal of Consumer Affairs. 24:268-279.

Caswell, Julie (Ed.). 1991. The Economics of Food Safety. New York: Elsevier Science Publishing Co., Inc.

Centers for Disease Control. 1985. Foodborne Disease Surveillance: Annual Summary 1982. Washington, D.C.: U.S. Department of Health and Human Services, Centers for Disease Control.

Centers for Disease Control. 1990. "Foodborne Disease Outbreaks, 5-year Summary, 1983-1987," in CDC Surveillance Summaries, March 1990. MMWR 39(SS-1):15-59.

Chalker, R.B., and M.J. Blaser. 1988. "A Review of Human Salmonellosis: III. Magnitude of Salmonella Infection in the United States," Review of Infectious Diseases. 10(1)111-124.

Choi, E. Kwan and Helen Jensen. 1990. "Modeling the Demand for Food Safety and the Implications for Reguation." Ames Iowa: Center for Agricultural and Rural Development, Iowa State University, Working Paper 90-WP 68 (September). (Also see Ch. in Julie Caswell, Ed., 1991 forthcoming)

Cohen, M.L., and R.V. Tauxe. 1986. "Drug-Resistant Salmonella in the United States: An Epidemiological Perspective," Science. 234:964-969.

Cohen, M.L., R.E. Fontaine, R.A. Pollard, S.D. Von Allmen, T.M. Vern, and E.J. Gargarosa. 1984. "An Assessment of Patient-Related Economic Costs in an Outbreak of Salmonellosis," New England Journal of Medicine. 299:459-460.

Curtin, L. 1984. Economic Study of Salmonmella Poisoning and Control Measures in Canada. Working paper No. 11, Marketing and Economic Branch, Agriculture Canada, Ottawa.

Curtin, L., and R. Krystynak. 1991. "An Economic Framework for Foodborne Disease Control Strategies: A Cost-Benefit Assessment of Salmonella Control in Poultry," in The Economics of Food Safety, Julie Caswell, Ed. New York: Elsevier.

Douthitt, Robin. 1990. "Biotechnology and Consumer Choice in the Market Place: Should ther be Manadatory Product Labelling? A Case Study of Bovine Somatotropin and Wisconsin Dairy Products." Presented at the Second International Conference on Research in the Consumer Interest, Snowbird, Utah (August 9-11, 1990). Department of Consumer Science, University of Wisconsin, Madison.

Environmental Protection Agency. 1987. Unfinished Business: A Comparative Assessment of Environmental Problems. Washington, D.C.: U.S. Environmental Protection Agency.

Environmental Protection Agency. 1990. The Report of the Human Health Subcommittee, Appendix B. EPA SAB-EC-90-021B.

Eom, Young Sook. 1991. "Pesticide Residues and Averting Behavior: A Conceptual Framework for Analysis." Division of Economics and Business, North Carolina State University. (February)

Fisher, A., L.G. Chestnut, and D.M. Violette. 1989. "The Value of Reducing Risks of Death: A Note on New Evidence." Journal of Policy Analysis and Management. 8(1):88-100.

Florkowski, W. J., C. L. Huang, and Brian Goggin. 1989. "Attitudes Towards Porcine Somatotropin: A Consumer Survey of the Atlanta Metropolitan Area." The Georgia Agricultural Experiment Station, College of Agriculture, The University of Georgia. Research Report 570 (August).

Food Chemical News. 1990. "Foodborne Illness Among Elderly, AIDS Patients Seen Likely to Grow," Food Chemical News. 31(52)25-26.

Food Chemical News. 1991. "U.S. Urges Priority Attention to Microorganisms." April 8, 1991. p.10.

Food Chemical News. 1991. "FDA to Propose Ban on Some Low-Level Antibiotics." May 27, 1991. pp.24-27.

Food Chemical News. 1991. "Cholera Epidemic in Latin America Sparks FAO Safety Efforts." June 24, 1991. p.22.

Food Chemical News. 1991. "Codex Commission Supports European Ban on Hormones in Meat." July 8, 1991. pp.42-44.

Food Marketing Institute. 1989a. "Consumer Confidence in Food Safety, An Update." Washington, D.C.: Food Marketing Institute, September 28.

Food Marketing Institute. 1977, 1982, 1986, 1989, and 1990. TRENDS: Consumer Attitudes and the Market Place. Washington, D.C.: Food Marketing Institute.

Food and Drug Adminstration. 1987. Residues in Foods - 1987. Washington, D.C.: U.S. Food and Drug Adminstration.

Foster, William and Richard E. Just. 1989. "Measuring Welfare Effects of Product Contamination with Consumer Uncertainty," Journal of Environmental Economics and Management. 17:266-283.

Garthright, W.E., D.L. Archer, and J.E. Kvenberg. 1988. "Estimates of Incidence and Costs of Intestinal Infectious Diseases in the United States," Public Health Report. 103(2):107-116.

GATT Secretariat. 1988. "Communication from the United States on Health and Sanitary Measures." Multilateral Trade Negotiations: The Uruguay Round. Group of Negotiations on Goods, Negotiating Group on Agriculture. GATT Secretariat: UR-88-0418.

General Accounting Office. 1990. Food Safety and Quality: Who Does What in the federal Government. RCED-91-19A/B. Washington, D.C.: U.S. Government Printing Office.

Green, Stanley S. 1987. Results of a National Survey: Salmonella in Broilers and Overflow Chill Tank Water, 1982-84. Washington, D.C.: U.S. Department of Agriculture, Food Safety and Inspection Service (March).

Haas, C.N. 1983. "Estimation of Risk Due to Low Doses of Microorganisms: A Comparison of Alternative Methodologies," American Journal of Epidemiology. 118(4):573-582.

Halbrendt, Catherine, L. Sterling, C. Gempesaw, W. Florkowski, and C.L. Huang. 1989. "Public Attitudes in the Northeast Region Toward Recombinant Porcine Somatropin," Journal of Food Distribution Research. February: 153-163.

Halbrendt, Catherine, W. Florkowski, L. Sterling, C. Huang. 1990. "Socioeconomic Determinants of Attitudes Toward the Use of Bioengineered Products in Food Production." Department of Food and Resource Economics, University of Delaware.

Hammitt, J.K. 1986. Estimating Consumer Willingness to Pay to Reduce Foodborne Risk. Rand Corporation: Santa Monica, CA. Report no. R-3447-EPA.

Hammonds, Tim. 1986. "The Second Fifty Years: Public Attitudes Toward Nutrition." Washington, D.C.: Food Marketing Institute. (March)

Harrington, W., A.J. Krupnick, and W.O. Spofford, Jr. 1990. Economics and Episodic Disease: The Benefits of Preventing an Outbreak of Giardiasis Due to Drinking Water Contamination. Washington, D.C.: Resources for the Future.

Harrington, W., and P. Portney. 1987. "Valuing the Benefits of Health and Safety Regulation," Journal of Urban Economies. 22:101-112.

Harris, Louis and Associates. 1982. "Consumer Attitudes and the Supermarket," survey done for the Food Marketing Institute (January).

Harris, Louis and Associates. 1983. "Consumer Attitudes and the Supermarket," survey done for the Food Marketing Institute (February).

Hauschild, A.H.W., and F.L. Bryan. 1980. "Estimate of Cases of Food- and Waterborne Illness in Canada and the United States," Journal of Food Protection. 43(6):435-440.

Heimbach, James T. 1981. "Yesterday, Today and Tomorrow: Consumer Perceptions of Food Safety." Washington, D.C.: Division of Consumer Studies, Bureau of Foods, U.S. Food and Drug Administration (unpublished paper).

Hoban, Thomas. 1990. "Public Attitudes Toward Bovine Somatotropin." Presented at the 39th Annual Dairy Conference, Winston-Salem, North Carolina (February 27-28, 1990). Department of Sociology, North Carolina State University.

Hoehn, John P. and Eileen van Ravenswaay, "Consumer Demand for Innovation in Food Safety," American Agricultural Economics Association meetings, Baton Rouge, LA, August 1989. (Agricultural Economics Staff Paper No. 89-74, Michigan State University, July, 1989.)

Howe, C.W. 1990. The Social Discount Rate," Journal of Environmental Management. 18(2):S-1-2.

Huang, Chung L., Sukant Misra, and Stephen L. Ott. 1990. "Modeling Consumer Risk Perception and Choice Behavior: The Case of Chemical Residues in Fresh Produce." Presented at the Second International Conference on Research in the Consumer Interest, Snowbird, Utah (August 9-11, 1990). Division of Agricultural Economics, College of Agriculture, University of Georgia, Faculty Series FS-90-17.

Hutt, Peter B. and Peter B. Hutt II. 1984. "A History of Government Regulation of Adulteration and Misbranding of Food," Food Drug Cosmetic Law Journal. 39:2-73.

Johnson, F.Reed. 1988. "Economic Cost of Misinforming About Risk: The EDB Scare and the Media." Risk Analysis. 8:261-269.

Jolly, Desmond. 1989. "Consumer Willingness to Pay Price Premiums for Organic Apples and Peaches." Department of Agricultural Economics, University of California, Davis (March).

Jolly, Desmond, Howard Schutz, Jagit Johal, and Kathy Diaz Knauf. 1989. "Marketing Organic Foods in California." University of California, Davis, CA: Sustainable Agriculture Research and Education Program, August.

Jones, Judith Lea and Jon P. Weimer. 1977. Food Safety: Homemakers' Attitudes and Practices. Washington, D.C.: Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 360 (January).

Kramer, Carol S. 1990. "Food Safety: The Consumer Side of the Environmental Issue." Southern Journal of Agricultural Economics. 22(1): 33-40.

Kramer, Carol S. and Eileen O. van Ravenswaay. 1989. "Proposition 65 and the Economics of Food Safety," American Journal of Agricultural Economics. 71(5):1293-1299.

Kramer, C.S., and K.P. Penner. 1986. "Food Safety: Consumers Report Their Concerns," National Food Review. Washington, D.C.: U.S. Department of Agriculture. NFR-33, 21-24.

Kvenberg, John E. and Douglas L. Archer. 1987. "Economic Impact of Colonization Control on Foodborne Disease," Food Technology. 41(7):77-81,98 (not consecutive).

Landefeld, J.S., and E.P. Seskin. 1982. "The Economic Value of Life: Linking Theory to Practice," American Journal of Public Health. 72(6):555-566.

Lynch, Lori. 1991. "Title XXI-Organic Certification" in Provisions of the Food, Agriculture, Conservation, and Trade Act of 1990, Susan L. Pollack and Lori Lynch, Eds. Agricultural Information Bulletin No. 624. Washington, D.C.: Economic Research Service, U.S. Department of Agriculture.

Malone, John. 1990. "Consumer Willingness to Purchase and Pay More for Potential Benefits of Irradiated Food Products." Agribusiness. 6(2):163-178.

Mauskopf, J.A., R.W. Leukroth, M.T. French, K.D. Fisher, A.S. Ross, C.R. Hollingsworth, and D.M. Maquire. 1988. Estimating the Value of Consumer Loss from Foods Violating the FD & C Act. Prepared for the Food & Drug Administration.

Mayer, Robert N. 1989. The Consumer Movement: Guardians of the Marketplace. Boston: Twayne Publishers.

McGuirk, Anya M., Warren P. Preston, and Amy McCormick. 1990. "Toward the Development of Marketing Strategies for Food Safety Attributes," Agribusiness: An International Journal.

McGuirk, Anya M. and Harry M. Kaiser. 1991. "BST and Milk: Benefit or Bane?" Choices 6(1):20-26.

Mitchell, Robert C. and Richard Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D.C.: Resources for the Future.

Mossel, D.A.A. 1988. "Impact of Foodborne Pathogens on Today's World, and Prospects for Management," Animal and Human Health. 1(1):13-23.

Mossel, David A.A. 1984. "Intervention as the Rational Approach to Control Diseases of Microbial Etiology Transmitted by Foods," Journal of Food Protection. 6:89-104.

National Academy of Sciences. 1969. An Evaluation of the Salmonella Problem. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1990. Cattle Inspection. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1988. Complex Mixtures - Methods for in Vivo Toxicity Testing. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1989. Improving Risk Communication. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1985. Meat and Poultry Inspection: the Scientific Basis of the Nation's Program. Washington, D.C., National Academy Press.

National Academy of Sciences. 1987. Poultry Inspection: the Basis for a Risk-Assessment Approach. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1987. Regulating Pesticides in Food: The Delaney Paradox. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1983. Risk Assessment in the Federal Government: Managing the Process. Washington, D.C.: National Academy Press.

National Academy of Sciences. 1984. Toxicity Testing - Strategies to Determine Needs and Priorities. Washington, D.C.: National Academy Press.

National Research Council. 1982. Diet, Nutrition, and Cancer. Washington, D.C.: National Academy Press.

National Research Council. 1985. Meat and Poultry Inspection: The Scientific Basis of the Nation's Program. Washington, D.C.: National Academy Press.

National Research Council. 1987a. Poultry Inspection: The Basis for a Risk-Assessment System. Washington, D.C.: National Academy Press.

National Research Council. 1987b. Regulating Pesticides in Food. Washington, D.C.: National Academy Press.

Natural Resources Defense Council (See Sewell and Whyatt)

Nemajobsky, Alexander R. and Terence J. Centner. 1991. "Pesticide Residues in Food: The Delaney Clause and Global Harmonization of Pesticide Standards," Agribusiness: An International Journal. 7(3):187-196.

Office of Technology Assessment, U.S. Congress. 1979. Environmental Contaminants in Food. Washington, D.C.: U.S. Government Printing Office. Stock No. 052-003-00724-0.

Office of Technology Assessment. 1987. New Developments in Biotechnology: Background Paper on Public Perceptions of Biotechnology. Washington, D.C.: U.S. Government Printing Office. ITA-BP-BA-45.

Okun, Mitchell. 1986. Fair Play in the Marketplace: The First Battle for Pure Food and Drugs. Dekalb: Northerm Illinois University Press.

Ott, Stephen L. 1990. "Supermarket Shoppers' Pesticide Concerns and Willingness to Purchase Certified Pesticide Residue-Free Fresh Produce," Agribusiness: An International Journal. 6(6):593-602.

Ott, Stephen L., C.L. Huang, S.K. Misra. 1990. "Consumer Risk Perceptions About Pesticide Use in Fresh Produce Production." Department of Agricultural Economics, University of Georgia: Paper Presented at the Economics of Food Safety Workshop, Alexandria VA, June.

Ott, Stephen L. and Arlyn Maligaya. 1989. "An Analysis of Consumer Attitudes Twoard Pesticide Use and the Potential Market for Pesticide Residue-free Fresh Produce." Department of Agricultural Economics, University of Georgia: Paper presented at the Southern Agricultural Economics Meetings, Nashville, TN, January.

Phipps, Tim T., Kristen Allen, and Julie Caswell. 1989. "The Political Economics of California's Proposition 65," American Journal of Agricultural Economic. 71(5):1286-1292.

Preston, W.P., A.M. McGuirk, and G.M. Jones. 1990. "Consumer Reaction to the Introduction of Bovine Somatotropin." Department of Agricultural Economics, Virginia Polytechnic Institute and State University: Paper presented at the Economics of Food Safety Workshop, Alexandria, VA, June. (Also see Chapter in Julie Caswell, Ed., 1991)

Rae, Douglas. 1987. "Risks of Consuming Pesticide and Fungicide Additives: Perceptions and Behavior of Organic Food Consumers." Final Report to the U.S. Environmental Protection Agency Benefits Staff. (Douglas Rae, 36 Gage Street, Neecham, MA 02192).

Rescher, Nicholas. 1983. Risk: A Philosophical Introduction to the Theory of Risk Evaluation and Management. New York: University Press of America.

Ricardo-Campbell, Rita. 1974. Food Safety Regulation: A Study of the Use and Limitations of Cost-Benefit Analysis. Washington, D.C.: American Enterprise Institute for Public Policy Research.

Rice, D.P., E.J. MacKenzie, and Associates. 1989. Cost of Injury in the United States: A Report to Congress. San Francisco, CA: Institute for Health and Aging, University of California and Injury Prevention Center, The Johns Hopkins University.

Richmond, Sir Mark, 1990. The Microbiological Safety of Food: parts I & II. London: Her Majesty's Stationery Office.

Roberts, T. 1989. "Human Illness Costs of Foodborne Bacteria," American Journal of Agricultural Economics. 71(2):468-474.

Roberts, Tanya. 1985. "Microbial Pathogens in Raw Pork, Chicken, and Beef: Estimates for Control Using Irradiation," American Journal of Agricultural Economics. 67(5):957-965.

Roberts, Tanya. 1987. Statement at hearing on food borne illnesses and deaths before the Committee on Agriculture, Nutrition, and Forestry, U.S. Senate, June 4, 1987.

Roberts, Tanya. 1988. "Salmonellosis Control: Estimated Economic Costs," Poultry Science. 67:936-943.

Roberts, T., and J.K. Frenkel. 1990. "Estimating Income Losses and Other Preventable Costs Caused by Congenital Toxoplasmosis in People in the United States," Journal of American Veterinary Medican Association. 196:249-256.

Roberts, T., and P. Foegeding. 1991. "Risk Assessment fo rEstimating the Economic Costs of Foodborne Disease Caused by Microorganisms," in Economics of Food Safety, Julie Caswell, Ed., New York: Elsevier.

Roberts, T., and R. Pinner. 1990. "Economic Impact of Disease Caused by Listeria monocytogenes," Chap. 22 in Foodborne Listeriosis, A.J. Miller, J.L. Smith, and G.A. Somkuti, Eds. Amsterdam, the Netherlands: Elsevier Science, 137-149.

Roberts, Tanya and David Smallwood. 1991. "Data Needs to Address Economic Issues in Food Safety," American Journal of Agricultural Economics. 73(3):(forthcoming).

Roberts, Tanya and Eileen van Ravenswaay. 1989. "Effects of New Scientific Knowledge on Food Safety Policy," Agricultural-Food Policy Review: U.S. Agricultural Policies in a Changing World. Washington, D.C.: Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 620.

Roberts, Tanya and Eileen van Ravenswaay, "The Economics of Safeguarding the U.S. Food Supply," Issues in Agricultural Policy, Agricultural Information Bulletin No. 566, Economic Research Service, U.S. Department of Agriculture, July, 1989.

Sachs, Carolyn, Dorothy Blair, and Carolyn Richter. 1987. "Consumer Pesticide Concerns: A 1965 and 1984 Comparison," Journal of Consumer Affairs. 21:96-107.

Sapolsky, Harvey M. (Ed.). 1986. Consuming Fears. New York: Basic Books, Inc.

Schucker, R. E., R. C. Stokes, M. L Stewart, and D. P. Henderson. 1983. "The Impact of the Saccharin Warning Label on Sales of Diet Soft Drinks in Supermarkets," Journal of Public Policy and Marketing. 2:46-56.

Sewell, Bradford H. and Robin M. Whyatt. 1989. Intolerable Risk: Pesticides in Our Children's Food. Washington, D.C.: Natural Resources Defense Council.

Shandera, W.X., J.P. Taylor, T.G. Betz, and P.A. Blake/ 1985. "An Analysis of Economic Costs Associated with an Outbreak of Typhoid Fever," American Journal of Public Health. 75:71-73.

Slovic, Paul, Baruch Fischoff, and Sarah Lichtenstein. 1982. "Why Study Risk Perception." Risk Analysis. 2(2):83-93.

Slusher, Barbara J. 1990. "Consumer Acceptance of Food Production Innovations--An Empirical Focus on Biotechnology and BST." Paper presented at the Second International Conference on Research in the Consumer Interest, Snowbird, Utah (August 9-11, 1990). Missouri Agricultural Experiment Station Journal Series No. 11,254.

Smallwood, D. 1989. "Consumer Demand for Safer Foods," National Food Review. Washington, D.C.: United States Department of Agriculture/Economic Research Service. 12(3)9-11.

Smith, M.E., E.O. van Ravenswaay, and S.R. Thompson. 1988. "Sales Loss Determination in Food Contamination Incidents: An Application to Milk Bans in Hawaii." American Journal of Agricultural Economics. 70(3):513-520.

Sporleder, Thomas L., Carol Kramer, and Donald J. Epp. 1983. "Food Safety," Federal Marketing Programs in Agriculture: Issues and Options. Walter J. Armbruster, Dennis R. Henderson, and Ronald D. Knutson, Eds. Danville, IL: The Interstate Printers and Publishers.

Swartz, D.G. and I.E. Strand, Jr. 1981. "Avoidance Costs Associated with Imperfect Information: The Case of Kepone." Land Economics. 57:139-150.

Thompson, M.S. 1986. "Willingness to Pay and Accept Risks to Cure Chronic Disease," American Journal of Public Health. 78(4):392-396.

Todd, E.C.D. 1988. "Botulism in Native Peoples-An Economic Study," Journal of Food Protection. 51:581-871.

Todd, Ewen C. 1985a. "Economic Loss from Foodborne Disease Outbreaks Associated with Foodservice Establishments," Journal of Food Protection. 48(2):169-180.

Todd, Ewen C. 1985b. "Economic Loss from Foodborne Disease and Non-illness Related Recalls Because of Mishandling by Food Processors," Journal of Food Protection. 48(7):621-633.

U.S. Congress, House of Representatives, Committee on Interstate and Foreign Commerce, Subcommittee on Oversight and Investigations. 1976. Federal Regulation and Regulatory Reform. Washington, D.C.: U.S. Government Printing Office.

U.S. Congress, House of Representatives, Committee on Government Operations. 1985. Human Food Safety and the Regulation of Animal Drugs. Washington, D.C.: U.S. Government Printing Office.

Van Oijen, Helena A. 1983. "A Cross-National Comparison of Food Safety Standards for Meat and Meat Products." M.S. Thesis. East Lansing, MI: Michigan State University, Department of Agricultural Economics.

van Ravenswaay, Eileen O. 1988. "How Much Food Safety Do Consumers Want? An Analysis of Current Studies and Strategies for Future Research," in Consumer Demands in the Marketplace: Public Policies RElated to Food Safety, Quality, and Human Health, Katherine L. Clancy, Ed. Washington, D.C.: Resources for the Future.

van Ravenswaay, Eileen. 1989. "The Food Industry Responds to Consumers' Pesticide Fears," National Food Review. Economic Research Service, U.S. Department of Agriculture, Vol. 12, No. 3, July-September.

van Ravenswaay, Eileen O. 1990. "Consumer Perception of Health Risks in Food," Increasing Understanding of Public Problems and Policies-1990. Oak Brook, IL: Farm Foundation.

van Ravenswaay, Eileen O. and Sharon A. Bylenga. 1991 "Enforcing Food Safety Standards: A Case Study of Antibiotic and Sulfa Drug Residues in Veal," Journal of Agribusiness. 9(1):39-53.

van Ravenswaay, Eileen O. and John P. Hoehn. 1991a. "The Impact of Health Risk on Food Demand: A Case Study of Alar and Apples," in The Economics of Food Safety, Julie Caswell, Ed. New York: Elsevier.

van Ravenswaay, Eileen O. and John P. Hoehn. 1991b. "Willingness to Pay for Reducing Pesticide Residues in Food: Results of a Nationwide Survey." East Lansing, MI: Department of Agricultural Economics, Michigan State University, Staff Paper No. 91-18.

van Ravenswaay, Eileen O. and John P. Hoehn. 1991c. "Contingent Valuation and Food Safety: The Case of Pesticide Residues in Food." East Lansing, MI: Department of Agricultural Economics, Michigan State University, Staff Paper No. 91-13.

van Ravenswaay, Eileen O. and John P. Hoehn. 1991d. "Consumer Perspectives on Food Safety Issues: The Case of Pesticide Residues in Fresh Produce," The Proceedings of the American Council on Consumer Interests, Virginia A. Haldeman, Ed., Columbia, MO: American Council on Consumer Interests (forthcoming).

van Ravenswaay, Eileen and Pat T. Skelding. 1985. "The Political Economics of Risk/Benefit Assessment: The Case of Pesticides," American Journal of Agricultural Economics. 67(5):971-977.

Viscusi, W. Kip. 1983. "Predicting the Effects of Food Cancer Risk Warnings on Consumers," Food Drug Cosmetic Law Journal. 43:283-307.

World Health Organization. 1991. Newsletter: WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe. No. 27. Berlin: Institute of Veterinary Medicine.

Zellner, James A. and Robert L. Degner. 1989. "Consumer Willingness to Pay for Food Safety." Department of Food and Resource Economics, University of Florida: Paper Presented at the Southern Agricultural Economics Association Meetings, Nashville, TN, February.