Staff Paper

CONSUMER PERSPECTIVES ON CROP PROTECTION TECHNOLOGY CHOICE

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There are many ways to control pest damage to food and fiber, each with different costs and benefits to consumers. Some mean higher food prices while others mean lower prices. Some would increase the amount of pest damage on food while others would lower it. Pest control methods also likely affect food safety, environmental quality, farmworkers, and, possibly, the survival of many farms. This chapter examines the tradeoffs consumers are willing to make or accept between these various aspects of crop protection technologies.

One tradeoff of obvious importance to consumers is between the price of food and pest damage on food. Pest damage is unappealing, inconvenient, and can sometime reduce the shelf-life of fresh foods or cause ill health. Consumers surely wish to avoid pest damage on foods if they can, but a tradeoff with price is often unavoidable because preventing crop damage is costly. For example, without any protection, it is virtually impossible to avoid severe pest infestation of apple crops. With some spraying, pest trapping, and cultural practices such as pruning, apples can be grown with limited pest damage. Complete elimination of pest damage in the fruit that goes to market either requires more spraying or discarding the damaged portion of the crop. The cost is reflected in the price of food.

Two additional important consumer tradeoffs are between food prices and hazards to consumers and the environment from pest control. Many of the methods for controlling pests can be hazardous to nontarget organisms unless precautions are taken. Surely consumers would prefer no hazards at all, but a tradeoff is inevitable because preventing pest damage is

more costly when precautions must be taken, and that means higher food prices as well. For example, aerial spraying of fields with a pesticide that kills a broad range of pests is faster and cheaper than hiring laborers to trap pests in the field and precisely handpick or apply pesticide to them. But aerial spraying contacts more nontarget organisms and requires a larger amount of pesticide to be used, thus increasing the amount of hazard in food and the environment.

The technology used to protect crops from damage may have other social and economic impacts important to consumers. For example, labor intensive technologies, such as hand-picking pests, are costly in high wage countries like the U.S., so if this type of pest control technology was required, american agriculture may become uncompetitive. Other technologies that promise to reduce the amount of synthetic pesticide needed to control pests, such as computerized field scanning, may require such a large farm operation to be cost-effective that they make the family farm uncompetitive. Still other technologies, such as genetic engineering of plants and animals, may raise suspicions about their long term effects on biological diversity and the morality of circumventing the constraints of natural reproductive processes. Finally, some technologies may be harmful to farm workers unless special precautions are taken.

Tradeoffs that a perfectly informed consumer would be willing to make between food price, pest damage, food safety, environment quality, and other social and economic impacts of technology determine the crop protection technologies they prefer to be used. However, in today's market place, consumers are not perfectly informed about every aspect of these tradeoffs. They may have very good information about the price and cosmetic quality of fresh produce, but little or no information about the associated levels of hazards in food and the environment or the implications for farm size and competitiveness. Rather, government and the food industry make many choices about these tradeoffs on their behalf. The price, quality,

safety, "environmental friendliness," and other economic and social impacts of food the consumer has available to them in the market reflects those government and industry choices.

An important question is whether a competent food consumer, if fully informed of the choices government and industry has made for them, would consent to those choices. For example, would a fully informed and competent consumer consent to purchasing a food if she knew that she was accepting a negligible risk of cancer in return for a lower priced food product with less pest damage? Would she consent to purchasing a food if she knew that getting a cheaper product would result in pesticide residues in groundwater in concentrations approaching one molecule in an olympic-sized swimming pool? Would she consent to purchasing a food that has been genetically engineered to increase pest resistance if she knew that it meant food prices stayed the same while pesticide leaching into groundwater had stopped?

The choices lawmakers and the food industry make in regulating and choosing among alternative technologies for controlling pest damage to crops will affect consumers in many ways. The wrong choice can lead to extreme voter and consumer dissatisfaction with the level of food prices, food quality, food safety, environmental quality, and other potential impacts of pest control. This dissatisfaction can be very costly and delay the diffusion of new crop protection technologies, as several recent controversies have amply demonstrated (F. Reed Johnson, 1988; Lacy et al., 1991; Smith et al., 1988; van Ravenswaay and Hoehn, 1991c). In order to avoid choosing the wrong policies or spending valuable time and resources researching, developing, and promoting technologies that are ultimately unacceptable to consumers today and in the future, we need to understand consumer concerns as well as the tradeoffs they prefer among different factors affected by alternate crop protection technologies.

This chapter will focus on what we know about the food safety and environmental tradeoffs consumers may be willing to make in exchange for the consumer benefits of pest

control (i.e., lower prices and less pest damage on fresh foods). Since an understanding of the tradeoffs consumers prefer requires an understanding of what consumers perceive the relevant tradeoffs to be, we first examine studies of consumer perceptions of health and environmental risks of pest control methods. We then survey the literature on consumer willingness to pay for foods produced by reduced pesticide techniques such as integrated pest management, organic, and genetic engineering methods. We also examine evidence regarding what consumers are willing to sacrifice in terms of pest damage for these same foods. The findings of this literature are then contrasted with evidence from the market place. Finally, conclusions and implications for those involved in the decisionmaking process regarding technology choice are drawn.

Perceptions of Health Risks from Crop Protection Technologies

Results from random sample surveys suggest that pesticide residues in food are the most serious consumer concern about food safety. The survey responses indicate an extremely high level of concern for both residues of pesticides and antibiotics and much lower levels of concern for food additives and preservatives in food (Food Marketing Institute, 1989 and 1990; Atkin, 1990; van Ravenswaay and Hoehn, 1991a). To illustrate this, consider the results from the Food Marketing Institute (FMI) national sample survey results about particular hazards in food. About 80% of the FMI respondents in 1989 and 1990 reported that they thought pesticide residues in food were a serious health hazard. About 60% of respondents rated "antibiotics and hormones in poultry and livestock" as a serious health hazard, while additives and preservatives were rated as a serious health hazard by only 26% of those responding. Although similar results have been obtained in other surveys, it is these FMI data that are most widely cited as evidence of significant consumer concern about pesticide residues in food.

There is evidence that food safety concern about pesticides has been increasing (van Ravenswaay, 1992). This is illustrated by the findings of two random sample Pennsylvania

surveys conducted in 1965 and 1984. The respondents of these surveys were asked: "How much danger do you feel there is to the person who eats fruits and vegetables that have been sprayed or dusted with pesticides--none, very little, some, or a great deal?". The percentage answering "some" or "a great deal" was 41% in 1965 and 72% in 1984 (Bealer and Willits, 1968; Sachs et al., 1987; Blair and Sachs, 1986).

Several surveys have attempted to learn more about consumer perceptions of the pesticide food safety problem by investigating where consumers perceive the problems, what health risks they perceive, and how large they perceive these risks to be. For example, to find out where consumers perceive pesticide problems, van Ravenswaay and Hoehn (1991a) asked a national random sample of households: "What do you think the chances are that there are any pesticide residues in each of the following types of food that you might buy when grocery shopping?" Like an earlier USDA study, differences in perceptions were found across food groups (Jones and Weimer, 1977). For example, on average, respondents thought about 60% of fresh fruits and vegetables would have some residues, whereas they thought about 40% of frozen or canned fruits and vegetables and 30% of dairy products, bread, and baked goods would have some residues. However, unlike the USDA survey, there were very few respondents saying that they believed the chance of some residues in these foods was zero. The results (van Ravenswaay and Hoehn) also indicate that consumers perceive some differences in the amount of residues on particular fresh fruits and vegetables, but the differences are not large. For example, about 55% of apples were perceived to have residues compared to 48% of oranges.

It is interesting to compare the results from the van Ravenswaay and Hoehn survey to FDA's own findings on residues in food (FDA, 1987). Data on FDA's estimates of the percentage of foods with detectable levels of residues is available for 10 of the 12 food items that respondents were asked about. For 6 of these 10 items (i.e., apples, lettuce, oranges, fish,

cereals, and baked goods), FDA found greater percentages of foods with detectable residues than perceived on average by respondents. In 2 of the 10 food items (i.e., fresh fruits and vegetables and dairy products), the percentage of foods perceived to have residues by the average respondent was similar to that found by the FDA. For tomatoes and juices, FDA's estimate of the percentage bearing residues is much smaller than perceived by respondents on average. Thus, it appears that in most cases, consumers' perceptions of the portion of foods with no pesticide residues is overly optimistic.

The van Ravenswaay and Hoehn national survey found that consumers perceive a wide range of health problems to be associated with pesticide residues in food. Risks associated with cancer and allergies were perceived to be greatest. On average, moderate risks of heart disease, nervous system disorders, and impaired immune function were also associated with pesticide residues in food. On average, residues were associated with low levels of risk of impaired child development, birth defects, and mental illness.

The van Ravenswaay and Hoehn survey also asked respondents about the level of health risks from pesticide residues in food. Respondents were asked what they thought "the chances are that someone in your household will have health problems someday because of the current level of pesticide residues in their food." A wide range of risks estimates were found among respondents. About a quarter thought the risks were 1 in 1,000,000 or less, about 45% thought the risks were between 1 in 100,000 and 1 in 1,000, and a quarter thought the risks were 1 in 100 and greater. However, given that little is known at this point about how the general public interprets and understands probabilities, these responses should be interpreted with some caution.

Even so, it is interesting to compare the risk perceptions found by van Ravenswaay and Hoehn with those of scientists and the regulatory community. Two "worst case" estimates of the

additional risks of cancer from pesticide residues in food have been developed by the EPA (EPA, 1987) and the National Research Council (NRC, 1987). Translated into lifetime additional cancer risks for an average household of 2.7 persons, the EPA's worst case estimate is 3.8 per 1,000 and the NRC's worst case estimate is 1.6 in 100 (see van Ravenswaay, 1992). Over half of the respondents in the van Ravenswaay and Hoehn study did not perceive the health risks to their household to be as high as the worst case estimates of EPA and NRC. Less that 30% reported that they perceived risks to be about the same as these worst case estimates and about 15% think the risks are much higher.

The results of Hammitt (1986) and Rae (1987) and Goldman and Clancy (1991) suggest that there are systematic differences in risk perceptions between organic or conventional food consumers. Hammitt's focus groups with conventional and organic consumers revealed that the median conventional food consumer's estimate of the risk of eventually dying from consuming conventional fresh produce was 8×10^{-7}. The median for organic consumers was 8.5×10^{-4}, or three orders of magnitude greater. Rae's findings among Boston food shopppers are similar to Hammitt's, once differences in risk definitions are taken into account (see van Ravenswaay, 1992). Goldman and Clancy's survey of shoppers at an organic food cooperative in upstate New York found that higher levels of expressed concern about the health effects of pesticide residues in food was associated with a greater frequency of organic food purchasing.

Rae's results are also of interest in that they reveal perceptions of cancer risks avoided if only organic foods are eaten. Rae asked consumers at four organic food stores in the Boston area what they thought their chance of getting cancer during their lifetime would be, in percentage terms, if they ate only organically grown food and if they ate only conventionally grown food. The average risk response for the only-organic scenario was 25.8%, or roughly a 1 in 4 lifetime chance of cancer. (This, incidentally, is essentially identical to the NAS estimate of

lifetime cancer risk based on actual incidence data.) The average response for the conventional-only scenario was 45.6%, almost double the lifetime cancer risk. Thus, the average respondent apparently believed that eating only organic food would mean avoiding a 1 in 5 additional risk of cancer.

In summary, the empirical studies on health risk perceptions of pesticide residues suggest that consumers perceive a wider range of health effects than the cancer risks typically addressed in official announcements. There are wide variations in people's perceptions of personal health risks from pesticide residues. Organic consumers in particular appear to perceive very large health risks from pesticide residues in food. However, on average, consumers' perceptions of the proportion of foods with any residues and the risk of health problems from eating conventionally produced foods is surprisingly close to government regulators.

The Pesticide Issue: More than a Food Safety Concern?

Several anomalies exist in the survey results reported on food safety concerns associated with pesticide residues. Perhaps the best example comes from the 1990 FMI survey. According to this survey, almost 80% of the population think that pesticide residues in food are a **serious** health hazard, yet only approximately 20% have doubts about the safety of the food supply. Further, when asked an open ended question about food safety risks, only 19% indicate that "pesticides, residues, insecticides, or herbicides" are a threat to safety. The Atkin (1990) survey reports similar findings.

There are at least two possible explanations for these types of anomalies. The first explanation has to do with the wording of the questions. It is well known that the wording of a question can significantly influence responses. To illustrate, note that in the FMI survey just described, respondents were not asked if they think there are dangerous levels of pesticides or animal drugs in food. Rather, they were asked whether pesticides and animal drugs in food are

a hazard. This implies that the question asks: if these substances are in food, would you consider them to be a hazard. If respondents interpreted the question this way, their responses do not necessarily contradict the responses to the open ended questions.

Alternatively, the high level of concern evident from the specific hazard questions may reflect more than food safety apprehensions about pesticides. In particular, the high level of concern over pesticides may also reflect environmental or other concerns about the use of pesticides. Results from several studies provide indirect evidence supporting, though in no sense proving, this hypothesis. First, there is clear evidence that consumers are becoming more worried about and protective of their environment. For example, a national CBS/New York Times poll in 1981 found that 45% of those surveyed agreed that protecting the environment is so important that requirements and standards couldn't be too high and that continuing environmental improvements should be made regardless of cost. Only five years later a similar national poll found that 68% agreed with this same statement (Berrier, 1987). More recent evidence of the high level of concern for the environment comes from a survey of North Carolinians which revealed that eighty-five percent of all respondents felt that the government should protect the environment even if it limited economic development (Hoban, 1990). Not only is concern for the environment increasing, but leading environmental issues focus on consequences of pesticide use on, among other things, water quality and wildlife.

The few studies that have specifically examined consumer perceptions of the environmental consequences associated with pesticide use suggest that these concerns may be greater than food safety concerns. In interviews with shoppers at three retail grocery locations in State College, Pennsylvania, Weaver et al. (1992) found that respondents agreed or strongly agreed that they were concerned that pesticide use harms groundwater (91%), wildlife (88%), the environment (85%), and farmworkers (80%), as well as their personal health (80%).

Similarly, in telephone interviews with a random sample survey of Pennsylvanians, Sachs et al. (1984) found respondents believed that pesticide use harms wildlife (81%) and farmworkers (79%), as well as consumers' health (71%). Several studies reviewed in Goldman and Clancy (1991) suggest that organic food consumers also perceive pesticide use as dangerous to wildlife and drinking water supplies.

A recent random sample survey of U.S. households (Hoban and Kendall, 1992) suggests that the use of biotechnology to protect crops from damage may address these environmental concerns among most, but by no means all, consumers. Over three-quarters of the respondents in that study were accepting of or neutral about the use of biotechnology to produce cotton plants that resist herbicide damage, food crops that resist insect damage, bacteria that prevent frost damage on crops, and farm animals that resist disease. Nearly two-thirds of the respondents said they thought the use of biotechnology in agriculture would have positive effects on the environment. About 60% thought it would have positive effects on farmers' use of chemicals and on fish and wildlife.

Although it is unclear the extent to which environmental and other concerns may have contributed to the high level of concern about pesticides residues in food, it is clear that these environmental concerns are significant and that these concerns may affect decisions to buy organic foods possibly more than personal safety concerns. Further, environmental concerns about pesticides may lead many consumers to accept foods that have been genetically engineered to resist pest damage. In the next section, we examine what is currently known about how consumers value reduced pesticide levels in food.

Understanding the Tradeoffs

Just because consumers are concerned about the effect of pesticide use on the environment and food safety does not necessarily mean they are willing to spend more to reduce

pesticide use. What is needed is an understanding of the tradeoffs consumers are willing to make between price and other product attributes such pest damage to avoid these concerns or risks. Such information is essential to those researching, developing, and promoting new crop protection technologies. A new technology will survive and be remunerative only if there is a market for it's product. As will become more evident below, determining consumer willingness to pay (WTP), say for a product with reduced pesticide levels, and the tradeoffs they are willing to make is a very complex and difficult proposition. Even more complex is determining why consumers might be willing to pay to reduce pesticide residues--is it for food safety reasons, environmental concerns, or something else?

There are two types of studies that have been conducted in an attempt to discover more about consumer interest in reduced pesticide foods and the price or quality tradeoffs consumers are willing to make to obtain them. The first type, referred to as contingent valuation studies, attempt to simulate a market by asking a sample of consumers whether they would buy a particular product under certain market conditions. The studies of this type reviewed below vary enormously in terms of the specificity of the hypothetical purchase scenario given to respondents. For example, some studies describe only a general product category (e.g., "certified organic" or "pesticide free") and give no specific price or marketing information, whereas others provide respondents with a photo or actual sample of a particular product offered at different prices at particular locations and times. In general, consumers are better able to predict their likely purchase behavior when the product qualities and market setting are more specific, so the latter types of studies provide more accurate information about the tradeoffs consumers may be willing to make between price and the other product attributes. Further, only a few of the studies available have attempted to get representative samples of U.S. consumers, so caution is needed in generalizing from results of many of the studies reviewed in this section. Despite

these shortcomings, however, the studies do provide some indication of consumer interest in reduced pesticide foods and the types of tradeoffs they **may** be willing to make to get them. The main findings of these contingent valuation studies are summarized in the next sub-section.

Contingent Valuation Studies

Table 1 summarizes the results from three relatively simple contingent valuation studies. Two of the three surveys summarized were conducted in Georgia. In 1988, Ott and Maligaya administered questionnaires to 313 shoppers at 9 supermarkets in the Atlanta suburbs. In 1989, Misra, Huang, and Ott received 389 responses to questionnaires mailed to the 580 members of the Georgia Consumer Panel maintained by the Department of Agricultural Economics at the Georgia Experiment Station. The third study was conducted in Michigan in 1990. Atkin conducted a telephone survey of 600 Michigan households for the Michigan Department of Agriculture.

Each of these surveys asked slightly different questions and gave respondents somewhat different response categories. The two Georgia surveys asked whether respondents would be willing to pay more for certified pesticide-free fresh produce. The Michigan survey asked respondents about their willingness to pay for food products grown without the use of pesticides and/or chemicals.

Although a direct comparison of these studies is difficult, the results in Table 1 show that one-quarter to one-third of those interviewed said there were not willing to pay a higher price for foods with reduced levels of pesticides. The results also show that at least 10%, and perhaps as much as 40%, said they were willing to pay as much as 10% or more for reduced pesticide foods. Van Ravenswaay (1992) shows that the Ott and Maligaya results imply that the average Atlanta consumer is willing to pay $10 a year to eliminate pesticides on produce, while the Atkin

study implies the average Michigan consumer is willing to pay at least $122 dollars more per year to eliminate pesticide residues in all foods eaten at home.

Three other contingent valuation studies focus on the WTP of particular types of consumers. Hammitt (1986) asked a group of 45 organic food consumers what they were willing to pay for organic food. The median response was that they would be willing to increase expenditures on fresh produce by 50% to purchase safer produce. Hammitt asked the same question to a focus group of conventional food shoppers. The median response for this group was 5%.

Rae (1987) found that the WTP of the 400 food consumers he interviewed in four Boston area supermarkets which sell both organic and conventional produce was similar to that of the organic food shoppers questioned by Hammitt. Rae obtained his measure of WTP by asking the shoppers if they would support a referendum requiring the EPA to eliminate the use of most pesticides if they knew it would increase the cost of food by X percent, where different respondents were given different percentages (e.g., 20, 40, 50, 60, 80%). If they were not willing to support the referendum they were asked to report the percentage they would be willing to pay. The average response was a WTP of at least 38% more in food costs. Adjusting for the fact that some respondents supporting the referendum may have been willing to pay even more than they were asked, average willingness to pay was estimated to be 49% or $115 more per month. Discounted at 5% over 40 years, this implies a lifetime willingness to pay of about $24,000.

A 1987 California random sample survey of 1,950 households in three California counties (Jolly, 1989 and 1991) asked those who purchased organic foods the premium they were willing to pay for organic apples and peaches. Jolly estimated that they were willing to pay an average of 37% (or 25 cents) more for organic apples when conventional apples were priced $.68/pound

and 69% (or 33 cents) more for organic peaches when conventional peaches were priced $.49/lb. Thus, organic premiums were found to vary with the price of the conventional product and by type of product. These premiums are similar to those obtained by Hammitt and Rae and they are all consistent with the highest WTP responses in the studies summarized in Table 1.

The contingent valuation studies summarized thus far did not describe any differences between the product in question and the corresponding "conventional" product other than level of pesticide residues or an organic label. Consequently, these willingness to pay figures likely indicate the premium consumers are willing to pay for a reduction in pesticide level or to get organic guarantees, given no other differences in the product in question, and given "usual" prices and qualities for all close substitutes (whatever these are--and they most likely vary by study). The main conclusion from these surveys is that there is a wide range of willingness to pay, with those currently consuming organic products at the high end, willing to pay premiums as high or higher than 50% and spending what amounts to as much as or more than $24,000 in a lifetime to reduce the level of pesticides in the food they consume.

Unlike the previous studies, van Ravenswaay and Hoehn (VH, 1991a and b) conducted a detailed and complex contingent valuation survey investigating the demand for reduced pesticide residues in fresh apples, as well as consumer willingness to accept pest damage in order to reduce risks from pesticide residues. VH used focus groups and in-person interviews to develop product labels describing three levels of reduced pesticide residues on apples. The labels were for apples certified and tested to have **no pesticide residues, no detectable pesticide residues,** and **no residues above federal limits**. A brief description of pesticides and federal limits on residues was developed. Photographs were chosen to portray apples that varied only in terms of pest damage. Four photos were chosen with four levels of pest damage varying from no damage to damage on 24% of the surface area shown in the photo. Respondents were asked their

perceptions of current risks from pesticide residues on food, as well as how much risks would change if all foods were certified and tested to have no residues, no detectable residues, and no residues above federal limits.

The survey asked respondents how often they purchased apples in each season of the year and how many apples they typically purchased each time. The survey then asked respondents how many apples they would buy on a typical shopping trip in the fall at four different prices. These prices ranged from $.39 to $1.49 with different respondents randomly assigned different combinations of prices. Respondents were asked what their purchases would be if the quality of all apples was as shown in each of the photographs, if all apples, but no other fruits, were sold with each of the labels, and if the prices of substitute fruits were the ones currently prevailing at the time of the survey. The estimates of WTP are thus contingent upon and must be interpreted in terms of this particular set of circumstances.

Based on 906 completed surveys, VH estimated that consumers were willing to pay an average of 23.6 more cents per pound for apples if all apples, but no other fruits, were certified and tested to have no residues above federal limits. If the apples were labeled as having no pesticides, it was estimated that consumers would be willing to pay an average of 37.5 cents more per pound over the no-label apple. While consumers were willing to pay 14 cents more for the no pesticide apple over the federal limit apple, no statistically significant difference was found in added willingness to pay between the federal limit apples and the no detectable residue apples. These results, which are consistent with those in the studies described above, imply that though the average consumer prefers and is willing to pay the most for the "no-pesticide" apples, if apples are going to have residues, the federal limit properly enforced will significantly and adequately reduce risks "enough".

Interestingly, VH found that a consumer's willingness to pay for the labels was not well explained by the respondents' risk perceptions. While risk perceptions were statistically significant in explaining differences in willingness to pay among respondents, the results showed that respondents who perceived little risk from pesticide residues were willing to pay about the same amount (in fact, a penny less) than those who perceived large risks from pesticide residues. VH conjecture that WTP may be more closely related to the respondent's level of uncertainty of risks rather than to perceived average size of risks. While uncertainty may affect a consumer's WTP, the findings may also be more evidence that the "pesticide problem" perceived by consumers is much more than a food safety issue.

The only other study which attempted to explain level of WTP was the 1989 Georgia study described earlier (Misra et al, 1992). They explain WTP as a function of demographic variables, a variable indicating perceptions regarding the importance of testing and certification, as well as an index of pesticide concern. Their analysis indicated that the latter two variables were significant determinants of WTP. However, because consumers could favor testing and certification for any reason and because the pesticide concern variable was constructed using variables capturing food safety, as well as other more general concerns about pesticides, their analysis does not help disentangle the relative importance of food safety concerns versus environmental or other concerns. If we want to be able to anticipate the success or failure of emerging technologies, it essential that we investigate further the relative importance of perceived risk level, perceived uncertainty of risks, specific environmental concerns, and other concerns (eg. philosophical, moral, and social) in the determination of WTP.

When examining consumer willingness to accept pest damage, VH found that consumers would only accept apples with damage on 7.5% of the surface in the photo to ensure no residues above federal limits, with no increase in price. For the no residue apple, consumers would

accept blemishes on 11.9% of the surface area. Since the surface area of an apple is much larger than the surface area in the photo, the acceptable levels of damage are even smaller than those indicated here. Further, it is likely that consumers would accept even less damage if they had to pay a higher price for the reduced or no-pesticide apples.

Given that reduced residue products are often, though not always, less aesthetically appealing than conventionally grown produce, these results suggest that a more thorough understanding of a consumers willingness to tradeoff between price, level of pesticides, **and** appearance of the product is critical. Consumers may state that they are willing to pay for reduced pesticide foods, but if the appearance of these foods are significantly different from foods they currently purchase, they may ultimately decide they are not willing to pay the premium.

Only three other studies have examined consumers' willingness to accept pest damage. One study examining this issue is the 1988 Ott and Maligaya study of Atlanta suburban supermarket shoppers described above. Another, conducted by Bunn et al. (1990) consisted of 229 interviews with customers at twelve supermarkets in the Los Angeles and San Francisco Bay areas in 1988. The most recent study, conducted by Goldman and Clancy, involved a survey of 400 shoppers at a food cooperative in New York.

The Ott and Maligaya study asked consumers if they would accept cosmetic damage to obtain pesticide-free fresh produce. Most (61.5%) respondents said no. When asked if they would accept insect damage, even more respondents (88.4%) said no. While these results further illustrate the importance of the appearance of a product, the specific results are difficult to interpret as it is unclear whether the respondents were under the impression that the conventional and pesticide-free products were selling for the same price or not. Undoubtedly,

how they interpreted the question would significantly affect their response (see the Goldman and Clancy discussion below).

The Bunn et al. study presented respondents with three photos of oranges--one perfect orange, one with 10% surface scarring from thrips, and one with 20% scarring. Respondents were asked how much more or less willing they would be to buy each of the scarred oranges than the perfect one, and most (78% and 88% for each photo) were less willing to buy. When respondents were told that the scarred oranges were grown with 50% less pesticide and asked again about their willingness to buy the scarred oranges, most respondents (63% and 58% for each photo) reported that they would be more willing to buy the scarred oranges than the perfect orange. Only 25% and 34%, respectively, reported being less willing.

The Goldman and Clancy study asked respondents "how likely they would be to buy produce labeled residue free rather than produce labeled conventional residue that cost the same, under each of the following conditions: if they looked the same; if the residue free was less brightly colored, irregular in shape, or smaller in size; if the residue free had surface blemishes; and if the residue free had a bug in it (p.91)". These same questions were repeated with the residue free costing 50%, and then 100%, more than the conventional. Respondents answered using a five point scale ranging from very unlikely to very likely. The results are summarized in Figure 1.

Although the respondents in this study are not representative of the "average" U.S. shopper, the results are informative. They clearly illustrate the tradeoffs the shoppers interviewed are willing to make between price, appearance, and pesticide level (none or some). With no difference in price and/or appearance most people stated they are more likely to buy organic rather than conventional. However, a premium of 50% drastically reduced the number of people likely to buy organic, as did the existence of blemishes and, particularly, the presence

of insects. Given that the consumers interviewed were food co-op shoppers, it is likely that the decrease in willingness to buy organics as price increases and/or aesthetic quality diminishes would be even greater if the survey population was **all** consumers.

The results from all four of these studies examining consumer willingness to accept pest damage suggest that consumers are very concerned about the appearance of a product but they may be willing to accept a small amount of pest damage if they also learn that it reduces risks. The results also indicate how misleading conclusions regarding possible consumer interest in, and support for, reduced pesticide products may be if they are based on a study which only examines the tradeoff between price and pesticide level. Clearly, if we are interested in estimating potential demand for these products, and thus, implicitly estimating support for the associated technology, we need to examine more closely all the attributes of the products in question and all competing products, and then determine the tradeoffs consumers are willing to make with regard to these attributes.

Evidence from the Market Place

The second type of studies that have been conducted to examine interest in and willingness to pay for products with reduced pesticide levels either use market data to determine premiums paid or the total amount spent on these items and/or simply ask consumers what they pay for or spend on these products. The results from these studies are summarized in this sub-section.

Van Ravenswaay and Hoehn (1990) used actual market data on factors affecting the demand for apples to estimate expected apple demand with and without the Alar controversy. The implied consumer willingness to pay for the removal of Alar was then derived. They found that New York consumers were willing to pay 30% more for Alar free apples or $2.35 more for that year to avoid the risks from Alar. These results are unique in that they provide an estimate

of what consumers **did** pay to avoid Alar. Interestingly, the average estimate of WTP is well within the range of estimates obtained from the contingent valuation studies described above. Even so, the special circumstances of the Alar incident may limit the extent to which we can generalize from these results to willingness to pay for other reduced pesticide products.

Van Ravenswaay and Hoehn used their estimates of WTP to avoid Alar and the NRDC estimates of cancer risks to calculate a consumers' WTP to reduce the annual risk of cancer death from pesticide residues by one in a million. The validity of this estimate depends crucially on several assumptions. The first is that consumers' perceptions of the annual cancer death risks from Alar were similar to the NRDC estimates. The other assumptions are that consumers were only concerned with cancer risks and that consumers stopped buying apples during the controversy only to avoid these health risks.

Van Ravenswaay and Hoehn estimated that consumers were willing to pay about $4 a year (1983 $) to reduce the annual risk of cancer death from pesticides residues by one in a million. Despite the fact that more recent studies have found that consumers are concerned about more than cancer risks, the estimate obtained is similar to the findings of studies examining peoples' responses to occupational risks, seat belt use, and smoke detectors. A critical review of those studies (Fisher et al., 1989) revealed that people are willing to pay between $1.6 and $8.5 in 1986 dollars (i.e., $1.44 to $7.65 in 1983 dollars) for a one in a million reduction in annual mortality risks.

Many of the other contingent valuation studies reviewed in this chapter make calculations similar to those of van Ravenswaay and Hoehn. The critical assumption underlying these estimates--that consumers are only interested in the particular reduced pesticide good(s) for health reasons--is much less likely to hold in these other studies than it is in the Alar study. Recall, for example, the Goldman and Clancy finding that many organic consumer rate

environmental concerns regarding pesticides over health concerns. Consequently, the calculations from these other studies are not reviewed here.

A second "market based" estimate of consumer WTP for reduced pesticide foods was derived in Rae (1987). In addition to calculating consumer WTP based on responses to a question about a referendum requiring EPA to eliminate most pesticides, Rae also estimated WTP for organic foods using reported food expenditures and travel costs. Rae estimated that the average Boston area Bread and Circus consumer spends (including travel costs) between $27 and $31 per month extra on organic foods. Using a 5% discount rate, the present value of 40 years worth of these expenditures implies a lifetime willingness to pay for organic food of $5,850-6,700, considerably less than the lifetime estimate ($24,000) based on the contingent valuation question.

Hammitt (1986) also provided a second estimate of organic consumers' WTP for reduced pesticide residues by estimating the average price premium for various organic produce items. Weekly prices were recorded for 27 organic and conventionally grown produce items at two food cooperatives, one health food supermarket, and two supermarkets in West Los Angeles and Santa Monica over a ten week period in the spring of 1985. Approximately 50 price observations were recorded for each food. Price premia were estimated via linear regression incorporating store and time effects and assuming perfectly elastic supply at the store level. The estimates of the price premia varied by type of produce. For example, the estimated organic price premium was 2 cents for potatoes, 37 cents for apples, and 62 cents for broccoli. On average, the organic price premium was about 45% higher than the conventional price. Given that we do not know how many people were buying organics at these prices and what the qualities of these produce were, Hammitt's estimates are not very informative in terms of understanding the potential demand for organics and/or the tradeoffs people are willing to

make. They simply indicate that those consumers purchasing organics at the time had a willingness to pay at least as high as these premia, which are similar in magnitude to the contingent valuation based estimates of WTP for organic consumers.

Although Hammitt did not try to estimate how many people were buying organics or the quantity of produce being sold at these premia, several surveys and polls have attempted to estimate the percentage of households that purchase organically grown or reduced residue foods. Results from three surveys conducted in 1989 and 1990 are summarized in Table 2. One of the surveys is the 1989 version of a national telephone survey conducted annually by a trade publication called The Packer. The second is a mail survey conducted by Jolly et al. of households in three counties in California. The third is the Michigan telephone survey conducted by Atkin in 1990.

Although it is difficult to compare results since the questions were different, the one consistent conclusion that can be drawn is that only a small percentage of the households interviewed (no more than 11%) can be described as frequent purchasers of organic food (more than 4 times a month or "occasionally"). The relatively small percentage of organic shoppers indicated by these surveys is not surprising given the size of the premiums estimated by Hammitt and the contingent valuation surveys summarized earlier. For example, the Atkin study (see Table 2) indicated that only 7% of those surveyed would be willing to pay 25% or more for organic foods. Further, organic food often looks different, is marketed differently, is not always conveniently available to consumers, and is subject to ambiguous product definition (there are no current national standards defining what qualifies as organic). These factors as well as price premiums are likely to be critical in understanding consumer tradeoffs with respect to pest control methods.

While the "market" based studies just described have provided some valuable information in terms of current interest in pesticide-reduced or -free foods, like the contingent valuation studies, they illustrate that we have a long way to go in terms of understanding consumers' willingness to tradeoff various attributes of a good including pesticide level, price, and appearance. An understanding of these tradeoffs (and factors affecting these tradeoffs) is required before we can begin to predict the potential demand for products from different technologies. Given the complexity of the problem at hand it is increasingly clear that determining these tradeoffs will require carefully designed experiments or surveys and performing careful analysis of detailed market data. To date, lack of resources and industry cooperation have made it impossible to conduct such studies and/or to obtain the required detailed market data.

Conclusions

Choice of technology affects consumers in two ways. They are affected directly because technology choice influences the price and various attributes of foods such as extent of pest damage and safety. Technology choice also affects the consumer in less direct ways as well. These other impacts are not reflected in product's attributes, but in impacts experienced at the point of production. They include the effects of a technology on the environment, on society in general and/or on the well-being of certain segments of society. In addition, some technologies may be morally or ethically objectionable and thus, unacceptable to a consumer no matter how they affect food attributes.

A consumer's acceptance or rejection of a technology depends on their preferences for the various crop attributes, as well as the value they place on the incidental effects or other aspects of the technology. As argued earlier the value a consumer places on these other effects of a technology will likely influence their preferences or willingness to make tradeoffs between

the price and various attributes of a particular product. Given that consumers can ultimately accept or reject a technology in the market place, an understanding of consumer preferences for the various food attributes and how these preferences are affected by other external concerns is essential. Those researching, developing, and promoting new technologies would benefit tremendously if this information were available to them. Such information is also essential for effective public policy decisions. We need to know how consumers value food safety and environmental quality if we are to be sure that there is a payoff to costly regulations of pest control methods. Further, the best solutions for alleviating the current level of concerns regarding pesticides will likely differ drastically depending on whether consumers are most concerned about, say, environmental issues or health risks.

In this chapter, we have reviewed what is known about current consumer concerns regarding the food supply and indirectly regarding current crop protection technologies. The evidence is clear that environmental and food safety concerns are high and have been increasing. Most of these concerns focus on the use of pesticides. Although studies have not specifically asked about moral objections to, or concerns regarding social or economic injustices because of the use of pesticides, there is not much evidence that these types of concerns are extremely important to food consumers.

In an attempt to determine more about the potential demand for reduced pesticide residues in foods such as those produced by integrated pest management or organic methods, several contingent valuation and market based studies have been conducted. Most of the contingent valuation studies have focused on consumers' willingness to tradeoff food price to reduce pesticide residues. That is, most studies have examined what consumers are willing to pay to purchase goods which differ from their conventional counterpart only in terms of level of

pesticide residues. These studies indicate a positive, but wide range of willingness to pay for these reduced pesticide products.

Despite heightened environmental and safety concerns, surveys suggest that only a small percentage of consumers are paying the premia currently required to purchase organic foods. Interestingly, this finding is not necessarily inconsistent with many of the contingent valuation studies. Most of the contingent valuation studies found that only a small percentage of consumers were willing to pay premia as high or higher than 50%, which is not an uncommonly high premia for organics (see for example Hammitt or Goldman and Clancy).

The few attempts that have been made to identify the determinants of WTP have done little in terms of revealing the relative importance of food safety, environmental, social, moral or other concerns. However, if the factors determining WTP are at all similar to those motivating current organic purchases, results indicate that both environmental and food safety concerns are playing an important role. Van Ravenswaay and Hoehn speculate that WTP may be more closely associated with the uncertainty about health or environmental risks than with the perceived average level of these risks. Future research investigating the determinants of WTP should investigate the role of both the level and uncertainties regarding the incidental impacts of technologies.

The handful of studies that have investigated consumer willingness to accept pest damage indicate a major shortcoming of studies that focused only on the price-pesticide tradeoff. Results indicate that aesthetic quality is an extremely important determinant of a consumers' purchasing decision. Consequently, consumers may state that they are willing to pay for reduced pesticide foods, but if the appearance of these foods are significantly different that the foods they currently consume, they may not actually pay the premium in a market situation. At the present time, consumers only appear to be willing to accept a small amount of cosmetic damage,

particularly insect damage, when purchasing reduced pesticide products. While this could possibly change through education and/or as concerns about the environment or food safety increase, these studies highlight the need for a better understanding of how product attributes change with different production methods and the tradeoffs consumers are willing to make between these attributes. Such an understanding would enable us to better anticipate consumer reaction to and support for emerging technologies. What is clear from the little research that has been conducted in this area is just how difficult the task before us is.

Implications for Technology Choice

Although research in this area is in its infancy and, consequently, does not provide many of the answers needed to draw specific implications for crop technology choice or policies influencing technology choice, it is possible to speculate about **possible** implications. To illustrate, suppose further evidence ultimately confirmed that current concerns regarding the food supply were driven equally by health and environmental concerns regarding the use of pesticides. Suppose also that it was confirmed that current organic methods produce slightly higher priced foods that are, on average, less aesthetically appealing than their conventional counterpart. Several possible actions could be taken to alleviate concerns regarding the food supply.

First, policies designed to increase consumer confidence in the safety aspects of the food supply could be implemented. These policies would have to reflect the fact that consumer concerns seem to be arising from two sources. Some consumers apparently feel that current federal safety standards are not stringent enough, while others feel that the current safety standard is acceptable, but insufficiently enforced. For example, recall the van Ravenswaay and Hoehn WTP results which indicated that consumers were willing to pay for a guarantee that

residue levels meet the federal standard and that they were willing to pay even more to ensure no pesticides.

Concerns regarding the enforcement of current standards could be allayed by improved monitoring of food safety risks along with improved communication with consumers about monitoring efforts and findings. Communications could be improved through periodic publications and press announcements about monitoring efforts written in a language the general public can understand. In addition, a public dialogue and discussion of the risks and tradeoffs associated with various technologies could be initiated. The dialogue should include all participants in the food system, not just consumers. It should address **all** the tradeoffs involved, as well as, the entire range of health problems that cause consumers to worry. To the extent that the tradeoff discussion involves discussions of the impact of different technologies on the environment as well as on price, safety, and other food attributes, this approach may also alleviate environmental concerns.

A second alternative for increasing public confidence in enforcement is to establish certification programs which provide consumers guarantees that the food they buy meet federal food safety standards. Such a program would need to establish the type of testing requirements that would have to be met for certification as well as the type of label that would provide the guarantee. Naturally, the costs of such a program would have to be investigated. For example, in the case of pesticides, almost all foods meet federal standards, so it is unlikely that a major cost would be the elimination of some foods. To the extent that a certification program also encourages producers to use fewer pesticides, this policy option would also help alleviate concerns about the environment.

The initiation of a public dialogue and/or certification programs similar to those described above would undoubtedly also be useful to those consumers who are concerned about

the acceptability of current federal safety standards. An open discussion of the problems with and benefits of the present standard setting process and the potential costs and benefits of changing the standards could help build consumer confidence and possibly make federal regulation more useful and efficient. A certification program would also provide these consumers with a way of avoiding potential risks.

Given the assumption that consumers are concerned about both health and environmental risks, those policies above which help alleviate both health and environmental concerns may be the most effective. For example, a campaign to 'convince' consumers that the food supply is healthy may have little effect if consumers are still worried about environmental issues--consumers may still shun products because of these other concerns.

Another approach to dealing with the health and environmental concerns of consumers is to look for alternate technologies that are capable of producing foods with reduced pesticide residues, but that are also cheap and cosmetically appealing. Existing research suggests that the niche for such technologies may be substantial. Most studies indicate that a majority of people are willing to pay for reduced pesticide foods. At the present time, the demand for these products is quite small, most likely because of the large premiums required to purchase these foods and perhaps because these foods are less aesthetically appealing. If current aesthetic standards cannot be maintained, the demand for reduced pesticide products, and hence the support for these alternative technologies, may be enhanced by an educational campaign aimed at convincing consumers that the sacrifice in quality is worth the benefits due to reduced health risks, as well as the environmental benefits due to a reduction in the use of pesticides.

As an example of a product which could potentially fill the niche discussed above, consider a biotechnology product that reduces the need for pesticides. What can we say about the future of such a product? The novelty and uniqueness of biotechnology products makes it

difficult to speculate about their success from the work reviewed in this chapter. The issues regarding biotechnology are arguably much more complex than those surrounding the use of pesticides; the key issues go much farther than food safety or environmental concerns. Complex social, philosophical, and ethical issues arise and uncertainties regarding each of these concerns are much greater than those associated with pesticides. (See Lacy et al. (1991) for a comprehensive summary of what is currently known about consumer concerns regarding biotechnologies in general.)

Despite current understanding of some of the issues and the concerns of consumers, relatively little work has been done asking the general public specifically about how these concerns will possibly affect consumer reaction to these new crop biotechnologies. To date much of the work in this area has examined potential consumer response to the introduction of animal biotechnologies such as bST and pST. If we knew more about how some of these same concerns affected the demand for reduced pesticide products and consumers willingness to tradeoff between various food attributes perhaps we could make an educated guess about the future of biotechnology. Unless more work is done in this area, we may be forced to wait and see--a very dangerous approach.

Table 1: Survey Evidence on Willingness to Pay to Avoid Pesticide Residues

	313 Atlanta suburban supermarket shoppers (1988): WTP for pesticide free fresh produce	389 Members Georgia Consumer Panel by mail (1989): WTP for certified pesticide free fresh produce	600 Michigan Households by telephone (1990): WTP for food products grown without the use of pesticides and/or chemicals
NO	34%	26%	29%
YES	66	45%	66
DON'T KNOW	0	29	5
YES:			
5%	56	24	23
10%	10	15	21
>10%	na	6	17*
DON'T KNOW	na	na	5

*10% were willing to pay 15% or 20% more. 7% were willing to pay 25% or 30% or more.

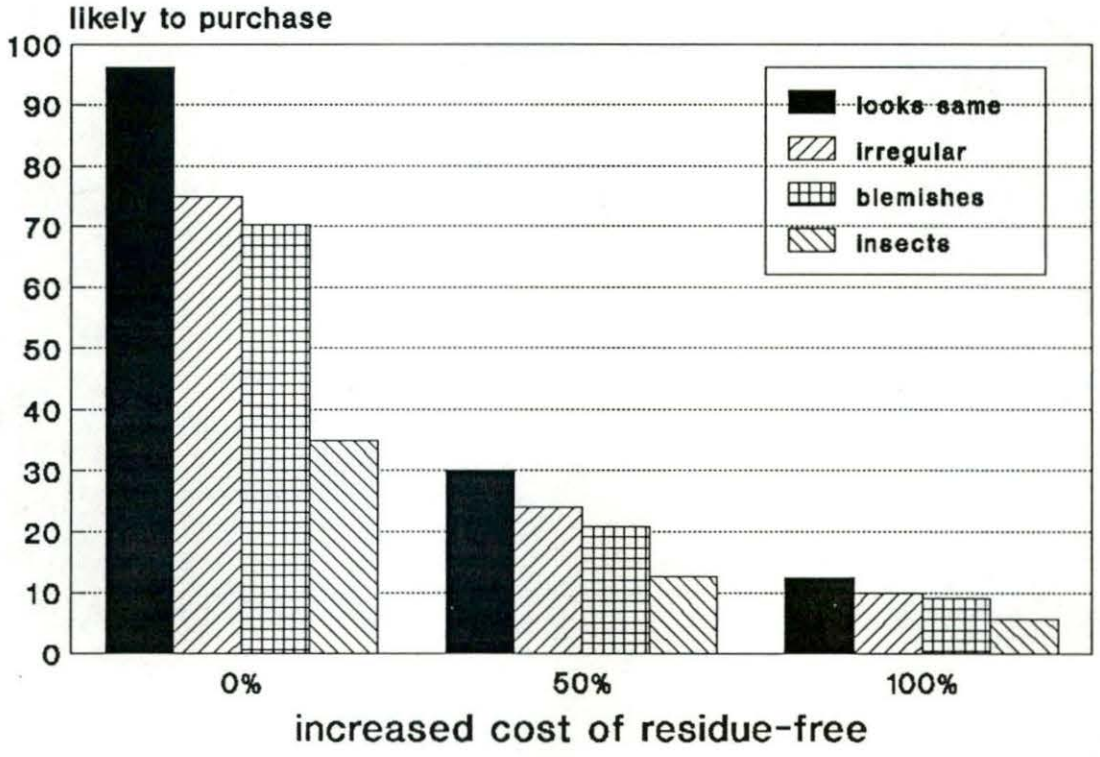
SOURCES: Stephen Ott and Arlyn Maligaya, "An Analysis of Consumer Attitudes Toward Pesticide Use and the Potential Market for Pesticide Residue-Free Fresh Produce, Department of Agricultural Economics, University of Georgia, Jan. 1989; Stephen L. Ott, et al., "Consumer Risk Perceptions About Pesticide Use in Fresh Produce Production," Department of Agricultural Economics, University of Georgia, 1990; "Consumer Attitudes About Food Issues in Michigan," by Charles Atkin, Michigan State University, for the Michigan Department of Agriculture, March, 1990.

Table 2: Survey Evidence on Purchase of Organic Foods

	1,260 households nationally, Oct, 1989 for Fresh Trends mail survey: Seek and buy organically grown produce in previous 12 months	946 households in 3 California Counties* for U. of California mail survey: Purchase organically grown products	600 households in Michigan for MDA/MSU telephone interview: Ever purchase organically grown foods; how often
NO	89%	38%	48%
YES	11	62	45
DON'T KNOW	0	0	7
16-30 times/month[a] Very often[b]		2[a]	7[b]
5-15 times/month[a]		9[a]	
1-4 times/month[a] Occasionally[b]		23[a]	23[b]
less than once/month[a] Seldom[b]		28[a]	15[b]

*Marin, Sacramento, and San Diego counties

SOURCES: The Packer Focus: Fresh Trends 1990; Desmond Jolly, et al., "Marketing Organic Foods in California," University of California, Sustainable Agriculture Research and Education Program, August, 1989; "Consumer Attitudes About Food Issues in Michigan," by Charles Atkin, Michigan State University, for the Michigan Department of Agriculture, March 1990.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looks same
irregular
blemishes
insects
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50%
100%
increased cost of residue-free

Figure 1

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