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Working Paper WP93-1

February 1993

Center for International Food and Agricultural Policy

Research Policy
Food and Nutrition Policy
Commodity and Trade Policy
Development Assistance and Policy
Natural Resource and Environmental Policy

THE IMPACT OF REDUCED AGRICULTURAL CHEMICAL USE ON FOOD: A REVIEW OF THE LITERATURE FOR THE UNITED STATES

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A paper prepared for a study of the impact of the reduced use of agricultural chemicals in Germany under the leadership of Dr. Michael Schmitz, Professor for Agricultural Policy, Johann Wolfgang Goethe University of Frankfurt, Frankfurt Am Main, Germany. The author would like to thank Jean Kinsey for her comments on an earlier draft.

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The Impact of Reduced Agricultural Chemical Use on Food: A Review of the Literature for the United States

Concerns about food safety and environmental quality have increased in recent years. Consumers are particularly concerned about the health risks posed by pesticide residues in food and the environmental impact of agricultural chemicals. These concerns have stimulated a considerable amount of recent research to assess the effects of reduced agricultural chemical use. This paper focuses on the research in the United States which has examined the impact of reduced agricultural chemical use on food, including food prices, consumer acceptance, food quality, and food demand and consumption.

This review is divided into three major sections. The first gives an overview of consumer concerns and behavior, using the results of the annual Food Marketing Institute survey of grocery shoppers. The second summarizes two "macro" studies that simulated the impact of reduced chemical use on agriculture in the United States. The third section reviews a number of "micro" studies that analyzed consumer willingness to pay for reduced pesticide residues on fruits and vegetables. These studies primarily rely on either hedonic price models and existing organic food or contingent valuation techniques and consumer surveys of various alternatives not currently available. This paper concludes with a few thoughts that will hopefully add some perspective to the public policy assessment of this issue.

CONSUMER CONCERNS

American consumers are very concerned about the safety of the food which they consume. However, that concern is generally latent, which means that it does not usually change their behavior. In the annual survey of consumers which the Food Marketing Institute conducts each year, over 70% indicated that safety was a very important factor in the food they buy, in each of the last four years (1989-1992). Seventy-one percent gave this response in 1992 (Food Marketing Institute, 1992, p. 70). On the other hand, in the same survey, 72% responded that they were completely or mostly confident that the food in their supermarket was safe in 1992. This figure was down from 82% in 1991, 79% in 1990, and 81% in 1989 (Food Marketing Institute, 1992, p. 71).

As shown in Table 1, 18% felt pesticide residues and 13% felt chemicals posed one of the greatest threats to the safety of the food they ate in 1992. The percent giving this response for pesticide residues was 16% in 1989, 19% in 1990, and 20% in 1991, and for chemicals, 11%, 16% and 15%, respectively. When specifically read a list of food items that might constitute a health hazard, 76% indicated in 1992 that pesticide and herbicide residues are a serious hazard and 53% gave that response for antibiotics and hormones in poultry and livestock, as shown in Table 2.

At the same time, consumers are increasing their consumption of fruits and vegetables, which are the main source of concern about pesticide residues. Moreover, the general demand for organic foods remains surprisingly small. As can be seen in Table 3, 60% of the respondents in 1992 said they are eating more fruits and vegetables to ensure that their diet is healthy. Only 1% of those surveyed indicated they were consuming more organically grown natural foods. Food retailers report that sales of organic produce are very disappointing. It should, of course, be noted that prices for organic products are much higher (Dowdell, 1990).

Most scientists concerned with food safety issues rate the risk from pesticide residues much lower than the typical consumer. The professional staff of the U.S. Food and Drug Administration (FDA) consider microbiological contaminants to pose the most serious food related health risk, followed by malnutrition and diet related factors associated with various chronic illnesses, environmental pollutants such as dioxin and mercury, naturally occurring toxins, and only then pesticide residues and food additives (Senauer, Asp and Kinsey, 1991, pp. 241-242).

The work of two scientists at the University of California at Berkeley on cancer risks has received considerable attention recently. Bruce Ames and Lois Gold claim the potential risk from pesticide residues in food has been substantially overrated. Most of the potential carcinogens in food, of which they say there are many, occur naturally as products of cooking or as toxins which serve as "natural pesticides." They criticize the current use of high-dose tests on rodents and note that about half of all chemicals, both natural and synthetic, are found to cause cancer at very high doses in laboratory animals (Ames, Magau, and Gold, 1987, and Chase, 1992). Farmers and farm workers who are involved in their actual application are almost certainly the ones who face the highest health risks from pesticides, especially if used without following proper safeguards and procedures.

MACRO STUDIES

Texas A&M Study

A consortium of public and private agricultural interests supported a major project to analyze the economic impacts of reduced chemical use on agriculture in the United States. Seven reduced chemical use alternatives were considered: no herbicides, no insecticides and fungicides, no inorganic nitrogen fertilizer, and various combinations, including no pesticides and no inorganic fertilizer. The major impacts are presented for just the no pesticides and no chemicals (pesticides or inorganic nitrogen fertilizer) scenarios. The study assumed the restrictions went into effect in 1991, and analyzed the effects through 1994 in comparison to a baseline. The impacts on yield, production costs, farm income, exports, stocks, utilization and consumption, consumer prices and expenditures, and consumer welfare were estimated (Knutson, Taylor, Penson and Smith, 1990a & b, and Smith, Knutson, Young, and Penson, 1990). Since three of the principle researchers were at Texas A&M University, it would perhaps be simplest to refer to the study by that name.

The commodities included in the Texas A&M study included corn, soybeans, wheat, cotton, rice, peanuts, sorghum, and barley. In addition, the impacts on poultry, pork, beef, and the dairy sector were assessed. These commodities account for over 75% of the pesticides and more than 70% of the nitrogen fertilizer used in U.S. agriculture. The study looked at production impacts on a regional basis. For example, the corn production regions were Corn Belt and Lake States, Northeast, Northern Plains, Southeast and Southwest.

A modified Delphi procedure, which involved over 140 scientific experts, was used to obtain the basic estimates of the effects of reduced chemical use on yields and production costs. The yield estimates came from crop science specialists for each crop in the major producing regions and the cost estimates from an agricultural economist at the same land-grant university or experiment station. The AG+GEM model used for the simulations combined the AGSIM model developed by Taylor and the COMGEM model of Penson and Hughes. It was necessary, of course, to make a number of assumptions, which included that agricultural imports would remain at the level that existed before the chemical reductions went into effect.

Table 4 shows the estimated decline in yields for the eight crops by region and the increase in cost for the no chemical case compared to the USDA/ERS cost of production estimates. The largest yield decline and cost increase occurred for peanuts. As an example of the change in supply, corn production would fall from 8.29 billion bushels in 1994 under the baseline scenario to 7.48 billion with no pesticides, and 5.39 billion with no chemicals (Knutson, Taylor, Penson, and Smith, 1990a, p. 51). The proportionate impact on price is larger than the decline in production because demand is inelastic. Corn price goes from $2.68/bushel in the baseline to $3.40 with no pesticides and $7.90 with no chemicals. The farm income of crop producers would more than double under the no chemical scenario. However, the income of livestock producers would fall by almost half because of the increased cost of feed.

Figure 1 shows the impact on the Consumer Price Index (CPI) for food and beverages of reduced chemical use. The baseline prediction is for an annual percentage change in the food CPI of about 4% in 1993 and 1994. Under the no pesticide scenario, food price inflation would reach 8% in 1993 and then decline slightly. The food CPI would increase even more with the no chemical alternative, by 11.2% in 1993 and 13.3% in 1994. These rates of food price inflation are almost certainly high enough to generate a strong reaction among consumers and to produce significant political pressure.

The projected effect on the overall rate of inflation would be to increase the percent increase in the GNP deflator from 3.9% in the baseline case to 8.2% in the no agricultural chemical scenario. This rate of inflation is high enough for the Federal Reserve Bank to tighten monetary policy and thus reduce overall income growth and job creation.

Average household food expenditures would increase by $228 per year in 1995-98 under the no pesticide case and by $428 with no agricultural chemicals compared to the baseline projection, as shown in Figure 2. Food expenditures in Figure 2 are measured in 1989 dollars. Figure 3 shows the effect of a ban on agricultural chemicals on the budget share for food by income quintile. The 20% of households with the lowest income could be expected to increase the share of their income spent on food from 38% in the baseline projection to 44% in the no chemicals case by 1995-98. The food budget share of the next quintile (second 20%) would increase form 20% to 23%. Consumer surplus was estimated to decline by $18 billion in the 1995-98 period with a pesticide ban and by $35 billion with no agricultural chemicals (Knutson, Taylor, Penson, and Smith, 1990b, p. 29).

The Knutson, Taylor, Penson, and Smith study on the impacts of reduced chemical use has been criticized. Ayer and Conklin (1990) list its major shortcomings as:

i) failing to allow for the effect of new research and technological change in agricultural production if chemical use was restricted,

ii) underestimating the increased use of manure and nitrogen-fixing crops,

iii) holding agricultural imports at the current levels,

iv) not addressing the impact on fruits and vegetables,

v) not sufficiently allowing for improved conservation practices to conserve soil nutrients in response to higher crop prices and farm incomes,

vi) unrealistically assuming a total ban on all pesticides and/or all inorganic fertilizer.

They argue that the economic impacts of reduced chemical use are overestimated because of these shortcomings.

Ayer and Conklin suggest the trade-offs between increased costs and reducing risks through restrictions on agricultural chemicals are not linear, as shown in Figure 4. The costs rise exponentially as the restrictions on chemical use become tighter, reaching R* under the total ban assumed by Knutson, Taylor, Penson, and Smith. The proposal of Kennedy and Waxman, who both are in the U.S. Congress, would fall somewhere between current policy and a total ban.

USDA Study

The U.S. Department of Agriculture (USDA) has also analyzed the impact of an across-the-board reduction in chemical use (both nitrogen and phosphorus fertilizers as well as pesticides) using a ten-sector applied general equilibrium model (Rendleman, 1991). The three agricultural sectors are feed grains and oilseeds, poultry, dairy and livestock, and other agricultural products, including fruits and vegetables. The simulation holds technology constant, but allows for the substitution of inputs.

Table 5 shows the change in output and price for the various sectors and factors of production for a 75% reduction in chemical use. The greatest drop in output and increase in price for the sectors shown would be for feed grains and oilseeds. The various sectors are affected in relation to the cost share of chemicals used and the elasticity of substitution between chemicals and other inputs. Agricultural chemical production, not shown in, the table, would fall by 71.2%, somewhat less than 75% because exports are not cut. Chemical prices would rise by seven fold in the short run.

With reduced chemical use, agricultural output falls and prices rise because of the loss in production efficiency. The marginal products of labor and land are reduced and more of those factors are now used to substitute for the chemicals not used. Equivalent variation, which gives a dollar value for the change in utility, is used as a measure of overall societal loss. As shown in Figure 5, the cost to society increases significantly when the reduction in chemical use surpasses about 25%. With a 75% reduction, the loss was estimated at $13 billion. These losses would be offset, at least partly, by reduced costs for health care and for environmental degradation. On the other hand, reduced chemical use would not only affect price levels, but probably also increase price variability which would further decrease producer and consumer welfare.

Since the total demand for agricultural products is inelastic, total revenue increases and gross farm income rises. However, net farm income may decline because of the rising cost of farm inputs. The distributional effects depend largely on how the reduction is implemented, for example, whether through a chemical use tax, a restriction on chemical production, or a limitation on the farm use of chemicals.

MICRO STUDIES

Rand Study

Hammit (1986) at the Rand Corporation, studied consumer willingness to pay for reduced pesticide residues based on organic foods using a hedonic price model

(Smallwood and Blaylock, 1991). Organic foods are grown without chemical pesticides and inorganic nitrogen fertilizer. He assumed that the organic product would be chosen if the premium paid was less than the willingness to pay for the reduction in risk from pesticide residues. Based on data for organic and conventional produce from five stores in Santa Monica and Los Angeles in 1985, the median organic premium was 45%. Table 6 lists 27 fresh fruits and vegetables, the price of the conventional products and the price premium of the organic products. The organic products were actually lower in price in a few cases, such as for grapefruit.

However, as van Ravenswaay and Hoehn (1991) point out, the price premium really represents the incremental cost of supplying organic food, not the average willingness to pay. Since organic products account for such a small portion of produce sales, the price premium for organic produce is, in fact, more than most consumers are willing to pay to avoid pesticide residues. Only a small segment of the market is willing to pay the, in many cases, substantial price premium for organic produce. Those consumers who purchased organic food perceived a much higher level of risk (health and environmental) from pesticides than those who purchased only conventional products.

Georgia Study

Researchers at the Georgia Experiment Station surveyed a panel of consumers in Georgia in 1989 about their concerns about pesticides (Ott, Huang, and Misra, 1991, pp. 175-188). Fifty-five percent of the respondents indicated pesticides were a food safety concern and 30% said it was their leading concern. However, eating fruits and vegetables grown with pesticides was seen as less of a health risk than consuming foods which are high in cholesterol, saturated fats, salt and sugar.

Only 11% of the Georgia panelists felt that "all pesticides used on fresh produce should be banned." Thirty-five percent responded that "some pesticides are unsafe and should be banned with greater restrictions on remaining pesticides," and 50% indicated "pesticides are safe to use, but desire greater testing and monitoring." Interestingly, 51% of those who saw pesticide use as a concern and who had a home garden used pesticides in their own garden.

Only 3% said they were buying only organic produce, whereas 56% said there was no change in their produce buying behavior. On the other hand, a majority indicated it was very important to have fresh produce tested and certified as residue-free and another one-third said it was somewhat important. Fifty-seven percent would prefer certified residue-free produce over organically grown, but not certified produce.

However, the willingness of consumers to pay more for certified pesticide-free produce is very low. Only 6% of all the panelists said they would be willing to pay over 10% more, 15% said 6-10% more, and 24% said 5% or less more. Even among those who ranked pesticides as a food concern only 8% would pay more than 10% for the residue-free certification. Currently, organic products typically sell for at least 30% more than conventionally grown produce, which is certainly a major factor in explaining the low demand.

Furthermore, the results of the Georgia panel survey suggest that consumers are not willing to accept any deterioration in the quality of fresh produce as a trade-off for the reduction or elimination of chemical use. Only 25% of the potential buyers of organically grown products said they would accept imperfection in appearance due to insect damage or other factors (Huang, 1991, p. 20).

In terms of nutritional characteristics, there is no reason to assume there should be differences in the nutrient content of organically grown food in comparison to that grown with inorganic fertilizer (Huang, 1991). Organic sources of nutrients, such as manure, breakdown into inorganic compounds before they can be assimilated by the plant. Therefore, whether the fertilizer is organic or inorganic, in and of itself, should not effect the nutritional content of the crop produced, as long as the required plant nutrients are available for the plant. Organic foods are not, per se, better or worse nutritionally than foods raised with inorganic fertilizers. The seed's genetic composition, climate, and maturity can have a major impact on the nutritional content of the food crop produced.

Michigan State Studies

Researchers at Michigan State University have conducted several studies of consumer willingness to pay for reduced pesticide residues in food (van Ravenswaay and Hoehn, 1991a, 1991b, and 1991c). In one study a questionnaire describing apples with different amounts of pesticide residues and pest damage was sent to a random nationwide sample of households (1991b). Respondents were asked the amounts they would purchase at specified prices. Apples were chosen because they are widely consumed and their quality (appearance) varies with pesticide use. Although this approach described specific products and market conditions for the respondents to react to, it still relates to only a personal (subjective) evaluation of hypothesized behavior rather than objective observation of actual behavior. It does allow, however, some assessment of trade-offs not currently available in actual markets.

The apples were described using photographs and product labels. Each photo showed an identical red delicious apple except that the percent of the surface area damaged by apple scab or plum curculio varied from 0% to 2.5% to 6% to 24%. In addition to apples with "no labels," labels specified three levels of pesticide residue: certified and tested to have no residues, no detectable residues, and no residues above the federal limits. Respondents were asked the quantities they would purchase of each product at four price levels, ranging from $.39 to $1.49 per pound. Of the 1,888 households which received questionnaires, 48% responded.

One result of the survey is that consumers are much more concerned about pesticide residues on fresh produce than on other foods as shown in Table 7. This means consumers would likely be more willing to pay to reduce residues in fresh fruits and vegetables than in other foods. Interestingly, the Food and Drug Administration (FDA) found a higher percentage of items tested with some detectable residues than consumers perceived for six of the 10 products listed: apples, lettuce, oranges, fish, cereals, and bakery goods (van Ravenswaay and Hoehn, 1991b).

As shown in Table 8, about one quarter of the respondents perceived a risk of 1 in 100 or worse that pesticide residues will cause a health problem for someone in their household. The average is between 1 in 10,000 and 1 in 1,000. This compares to a worst case estimate of an increased cancer risk of 1.4 per 1,000 by the Environmental Protection Agency which translates into 3.8 per 1,000 for households in the survey which averaged 2.7 persons. The National Research Council worst case estimate for increased cancer due to pesticide resides in food was 5.84 in 1,000. This translates into 1.6 in 100 for the surveyed households which is higher than almost 75% of the respondents' perception. Furthermore, as seen in Table 9, consumers are worried about other health risks from pesticide residues in addition to cancer.

When asked what they do to avoid pesticide residues in the fresh produce they consume, 90.8% reported rinsing it with water and only 10.7% buying organic food (see Table 10). Table 11 shows the reduction in health risks respondents felt the specified actions would yield. The average expectation was that the "no residues" case would reduce health problems by about 60% (3.6 on the Table 11 scale).

Table 12 gives the average added price per pound over the no-label apple consumers would be willing to pay and represents the value placed on the action represented by each label. The last category indicates consumers would be willing to pay 23.6 cents more to be assured that the current limits are being strictly enforced and monitored. Current FDA testing shows that very few of the apples tested exceed allowable residue limits.

Consumers would be willing to pay 37.5 cents more per pound for apples certified and tested to have no residues. This is very likely less than the increased costs associated with eliminating pesticides, in terms of higher prices and lower quality (more pest damage). At the time of the survey, apples averaged about 79 cents per pound. However, Table 13 shows the average consumer is willing to accept only a small amount of pest damage even if apples were certified to have no pesticide residues and were no higher in price. According to horticulturalists, with today's apple varieties, growing unblemished apples requires the use of pesticides (van Ravenswaay and Hoehn, 1991b).

The willingness to pay estimates in Table 12 were obtained from estimated demand functions which are described in van Ravenswaay and Hoehn (1991a). As is the case with most other studies of consumer willingness to pay for reduced pesticide residues, they make use of Lancaster's theory of demand so that an individual's purchases are a function of prices, income and demographic factors, and the perceived characteristics of the good. Changes in a good's characteristics cause shifts in demand that reveal the willingness to pay for those characteristics. Data from the survey results were used to estimate a tobit model of the quantity of apples demanded as a function of apple prices, demographic characteristics, pesticide residue and pest damage attributes (quality), and health risk perceptions.

Three approaches to estimating consumer willingness to pay for reduced pesticide residues are reviewed in van Ravenswaay and Hoehn (1991c): using special market circumstances such as the Alar scare in 1989, hedonic price analysis using organic products as was done in the Rand study, for example, and contingent valuation techniques to simulate consumer choices, which was used by van Ravenswaay and Hoehn (1991b) in their survey. Based on the effect of the Alar episode on apple demand in New York City/Newark, it was estimated that consumers would have paid 21 cents per pound (30% more) for Alar-free apples. Based on the cancer risks reported in the New York newspapers, this represented a willingness to pay $4 (in 1983 dollars) to avoid a risk of one additional cancer per million people over their lifetime. Studies of other risks have found people were willing to pay $1.44 to $7.65 to avoid a one in a million mortality risk.

<u>Pennsylvania State Study</u>

A study at Pennsylvania State University estimated consumer willingness to pay for tomatoes with no chemical (pesticide) residues (Evans, Weaver, and Luloff, 1992, and Weaver, Luloff, and Evans, 1992). Face to face interviews were conducted with 560 consumers in three retail grocery locations in November 1990. The National Research Council identified tomatoes as the food which has the highest cancer risk because of pesticide residues and tomatoes are widely consumed.

Some 52% of the respondents would not purchase residue-free tomatoes with cosmetic defects, but 87% would be willing to purchase them even if they were smaller and 87.5% if they were non-uniform in shape. Cosmetic appearance (lack of blemishes or pest damage) seems to be an important quality characteristic, but not size or shape.

In terms of willingness to pay for residue-free tomatoes that were identical to tomatoes produced with pesticides in all other respects: 19% would not pay any more, 25% would pay up to 5% more, 30% up to 10% more, and 26% more than 10% more. A multinominal logit model was used to analyze the factors affecting the probability of responding in one of the above categories concerning willingness to pay. The probability of being willing to pay more than 10% more increased as household income rose and as concern for the harmful effects of pesticide use increased. The strength of response to the following statements was used to measure this concern: i) chemical residues are harmful to those who eat the produce, ii) pesticide use harms farm workers, iii) pesticides harm wildlife, iv) pesticides harm groundwater, and v) pesticides harm the environment. The results indicate that concerns about pesticide use involve more than just possible personal heath effects, but also the effects on farm workers, groundwater, wildlife, and the environment.

This study found that the most important factor in purchasing tomatoes was appearance. It was concluded that many consumers may not be willing to accept much trade-off between increased cosmetic defects in exchange for reduced pesticide use. In addition, if raising tomatoes without pesticides increases costs by more than 20%, the market would probably be highly segmented and rather small (Weaver, Luloff, and Evans, 1992).]

California Study

A survey of consumers in California also found an initial unwillingness to accept cosmetically imperfect produce (Bunn, Feenstra, Lynch and Sommer, 1990). However, the acceptance of cosmetic imperfections increased substantially when accompanied by consumer education concerning the use of pesticides. Some 229 consumers were interviewed in 12 grocery stores in California. They were shown color photographs of three different oranges. The first was of a cosmetically perfect orange, the second showed 10% cosmetic damage from thrips' scars, and the third had 20% surface damage. Consumers were asked their willingness to purchase the blemished oranges compared to the unblemished one. They were told to assume prices were the same. The first "before" column in Table 14 shows a strong unwillingness to purchase the 10% damaged (Level 1) orange. There was an even higher resistance to the 20% damaged (Level 2) orange, in the second "before" column.

After their initial response, consumers were read a statement that informed them that to produce the standard (unblemished) orange, "it was necessary to spray it heavily with pesticides, up to the legal limits. The scarred oranges have also been sprayed, but with only half the amount of pesticides." After this information, consumers were substantially more willing to accept the oranges with cosmetic defects as shown in the "after" columns in Table 14.

CONCLUDING REMARKS

Figure 4 made the point that the costs associated with reducing agricultural chemical use are likely to rise more steeply as the reductions become greater. Figure 6 makes another important point, which can help bring a useful perspective to this issue. The additional benefits received in terms of reduced health risks and environmental degradation are likely to decline as the reductions become greater. The initial reductions in chemical use would yield the greatest benefits. Further restrictions on chemical use may yield substantially fewer additional benefits after some point, which is reflected in the flattening of the curve as a complete chemical ban is approached. Of course, just how flat the right-hand end of the curve in Figure 6 actually becomes is a matter of uncertainty and open to debate.

If Figures 4 and 6 are reasonable approximations, two messages emerge. The first is that some reduction in the current use of agricultural chemicals might yield substantial benefits in terms of reduced health risks and environmental degradation with a minimal impact on overall costs. Presumably, the focus would be on reducing the chemicals causing the greatest health risks and/or damage to the environment first. On the other hand, a complete ban on agricultural chemicals, including both pesticides and inorganic nitrogen fertilizers, could be very costly and produce only modest additional benefits for health and the environment beyond those achieved by more moderate reductions.

In general, there is no indication that most consumers want a complete ban on all agricultural chemicals. However, they are concerned about the environment and food safety. Much can probably be done to address these concerns without a complete ban.

Integrated Pest Management (IPM) techniques, using natural pest controls such as crop rotations and predators, can reduce the need for chemical pesticides. Pesticides remain an option if absolutely necessary, but are applied in ways that minimize the amounts that need to be used. Low-input sustainable agriculture (LISA) techniques can reduce the need for inorganic fertilizers. The heavy use of organic manures, however, can also cause environmental problems, as in the Netherlands, and Denmark (Rustagi and Desai, 1992). In addition, better monitoring and testing of foods for pesticide residues would do much to assure consumers that their food is safe.

Finally, the apparent unwillingness of consumers to accept produce with purely superficial, cosmetic defects deserves further study and should be understood better before reaching any final conclusions. As suggested by the California study of oranges, consumers might be willing to accept produce with minor blemishes if they felt it reduced the need for pesticides. A considerable proportion of American consumers may be more sophisticated in their appraisal of food quality attributes than typically assumed. Producers have traditionally assumed that for tomatoes for example, appearance attributes ("no blemishes, no black spots, and no softness") were the most important factors to consumers. However, USDA surveys show consumers have become unhappy with the taste and ripeness of market tomatoes (Bunn, Feenstra, Lynch, and Sommer, 1990, p. 269). In the last few years, better tasting, riper tomatoes have begun to appear on the market; frequently selling at a price premium.

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Table 1

PERCEIVED THREATS TO FOOD SAFETY BY SEX AND EDUCATION (VOLUNTEERED)

Q: *What, if anything, do you feel are the greatest threats to the safety of the food you eat?*

Base: The shopping public

	Jan. 1989 Total[1]	Jan. 1990 Total	Jan. 1991 Total	Jan. 1992 Total	Sex		Education	
					Men	Women	High School or Less	Some Coll./ College Graduate
Base	772	1,005	1,004	1,000	247	753	498	500
	%	%	%	%	%	%	%	%
Spoilage (NET)	36	29	27	36	34	36	35	36
Pesticides/residues/ insecticides/herbicides	16	19	20	18	13	20	14	22
Spoilage/germs	x	x	16	15	15	15	16	13
Chemicals	11	16	15	13	17	12	12	15
Freshness/long shelf life/expiration dates	x	x	6	12	9	13	12	11
Improper packaging/ canning	17	16	17	10	13	9	9	10
Processing/preparation of foods	4	3	3	10	9	11	9	12
Bacteria/contamination	x	x	3	9	10	8	7	10
Quality control/improper shipping, handling, etc.	x	x	5	9	10	8	7	11
Unsanitary handling by supermarket employees	10	11	10	8	8	8	6	10
Tampering	20	14	8	6	8	6	5	7
Preservatives	7	8	7	6	6	6	4	8
Unsanitary handling by supermarket shoppers	6	4	3	6	4	6	5	6
Additives (nonspecific)	7	6	6	5	5	5	4	6
Pollution/environmental pollution	3	4	3	3	4	3	2	4
Bugs/pests/rats	3	3	2	2	1	2	2	2
Artificial coloring	2	3	1	1	1	1	*	1
Radiation	1	1	1	1	2	*	1	1
Antibiotics	1	2	2	*	*	*	*	*
Other	6	10	4	7	10	6	6	9
None	2	6	3	3	2	3	4	2
Not sure	11	12	19	15	12	15	19	10

x = Not mentioned.

Multiple responses accepted.

[1]In 1989 this question was asked only of those who were not completely confident that the food in their supermarket is safe. Differences may be attributable to methodology.

Source: Food Marketing Institute, 1992, p.72.

Table 2

CONSUMER CONCERN ABOUT SELECTED FOOD ATTRIBUTES, 1986-1992

Q: *I'm going to read a list of food items that may or may not constitute a health hazard. For each one, please tell me if you believe it is a serious health hazard, somewhat of a hazard, or not a hazard at all?*

Base: The shopping public

	Serious Hazard						1992			
	Jan. 1986	Jan. 1987[1]	Jan. 1988[2]	Jan. 1989	Jan. 1990	Jan. 1991	Serious Hazard	Something of a Hazard	Not A Hazard At All	Not Sure
	%	%	%	%	%	%	%	%	%	%
Residues, such as pesticides and herbicides	75	76	75	82	80	80	76	19	2	3
Antibiotics and hormones in poultry and livestock	x	61	61	61	56	56	53	36	5	6
Irradiated foods	37	43	36	42	42	42	35	28	10	27
Nitrites in food	x	38	44	44	37	41	40	38	4	18
Additives and preservatives	33	36	29	30	26	29	26	62	9	4
Artificial coloring	26	24	21	28	21	24	21	50	24	5

x = Not asked.

May not add to 100 percent due to rounding.

[1]Split sample: bases = 498 and 509.

[2]Split sample: bases = 508 and 511.

Source: Food Marketing Institute, 1992, p.73.

Table 3

DIETARY BEHAVIOR

Q: *What, if anything, are you eating more or less of to ensure that your diet is healthy?*

Base: The shopping public

	Jan. 1989 Total	Jan. 1990 Total	Jan. 1991 Total	Jan. 1992 Total
Base	1,031	1,005	1,004	1,000
	%	%	%	%
More fruits/vegetables	59	57	57	60
Less meat/red meat	33	34	34	31
Less fats/oils	22	27	25	28
Eating more chicken/turkey/white meat	16	19	16	14
Less sugar	20	19	19	12
Less snack foods	x	x	4	12
Eating more fish	18	18	14	10
More fiber	13	16	16	8
Less cholesterol	12	15	12	8
Less salt	13	15	10	8
Less fried foods	10	14	7	7
Less dairy/butter/cheese/whole milk	x	x	4	7
More starch/rice/potato/pasta	x	x	3	5
More balanced diet/wider variety	3	5	3	4
More fresh foods	8	6	7	3
Fewer calories	5	5	4	3
More protein	5	4	3	2
More beef/better cuts of meat	x	x	x	2
More dairy products	x	x	x	2
More vitamin/mineral supplements	2	1	2	2
More whole grain	x	x	x	2
More juices	x	x	x	2
More organically grown/natural foods	2	2	2	1
More foods high in vitamins/minerals	2	1	1	1
More low-fat/skim milk	x	x	x	1
Other	20	11	9	12
Nothing	5	7	6	4
Not sure	3	3	3	3

x = Not asked.
Multiple responses accepted.

Source: Food Marketing Institute, 1992, p.56.

Table 4
National Percentage Yield Reduction, Range of Regional Percentage Reduced Yields, and Total Economic Cost/Unit for the No Chemicals Option*

Crop, Region and Units	Percent Change in Yield	Cost Per Unit: ERS Cost/Unit	Cost Per Unit: No Chemical Cost/Unit	Cost Per Unit: Percent Increase
	(Percent)	----------Dollars----------		(Percent)
Peanuts (pounds)				
National	- 78	0.22	0.72	224
Southern Plains	- 72	0.25	0.73	191
Virginia and North Carolina	- 81	0.22	0.78	251
Rice (cwt)				
National	- 63	7.55	17.58	133
Arkansas	- 61	7.08	16.63	135
California	- 72	7.28	20.98	188
Delta	- 62	7.47	14.88	99
Cotton (pounds)				
National	- 62	0.63	1.38	118
Southeast	- 59	0.75	1.17	56
Southwest	- 53	0.70	1.44	107
Delta	- 68	0.57	1.37	142
Corn (bushels)				
National	- 53	2.05	3.30	61
Corn Belt	- 48	2.00	2.91	45
Southeast	- 72	2.69	6.85	155
Southwest	- 72	2.43	6.48	167
Wheat (bushels)				
National	- 38	3.64	5.45	50
Central Plains	- 14	2.86	3.34	17
Northwest	- 58	3.15	5.95	89
Northern Plains	- 41	3.53	5.67	61
Northeast	- 35	5.16	7.59	47
Southern Plains	- 30	5.72	7.58	32
Soybeans (bushels)				
National	- 37	4.95	7.20	45
North Central	- 33	4.74	6.50	37
Delta	- 51	6.17	11.71	90
Sorghum (bushels)				
National	- 37	1.97	3.30	68
Central Plains	- 37	1.83	2.96	62
Southern Plains	- 35	2.28	4.00	75
Barley (bushels)				
National	- 43	2.58	4.11	59
Northwest	- 57	2.58	4.78	85
Southern Plains	- 30	2.64	3.52	33
Northern Plains	- 41	2.46	3.94	60
Northeast	- 35	3.57	5.28	48

* Table 1 only provides an indication of the range of estimates. Therefore, the results for all regions studied are not included in Table 1 but can be obtained from the companion publication titled *Impacts of Chemical Use Reduction on Crop Yields and Costs.*

Source: Knutson, Taylor, Penson & Smith, 1990a, p. 13.

Table 5
Price and output change, by industry, for a 75-percent reduction in use of agricultual chemicals

Sector	Output change	Price change
	Percent	
Manufacturing	–0.8	0
Services	–.3	–.5
Livestock processing	–2.4	5.9
Feed grain/oilseed processing	–7.9	10.8
Other food processing	1.3	2.0
Livestock/poultry/dairy	–5.2	10.2
Feed grains/oilseeds	–20.4	25.1
Other agriculture	–12.9	15.0
Agri-services	–11.3	19.0
Factors of production:		
Labor	0	–0.7
Capital	0	–1.1
Fixed livestock inputs	0	–11.0
Grain land	0	–21.4
Other agricultural land	0	–33.9

[1]All price changes are relative to the numeraire good, domestic manufactures.

Source: Randelman, 1991, p.4

Table 6. Estimated Produce Price and Organic Premium

Product	Conventional Price	Organic Premium
	cents/pound	
Tomato	67.4	116.2
Bing cherry	142.7	94.8
Peach	54.0	67.4
Broccoli	57.9	62.5
Green pepper	90.2	43.4
Spanish onion	25.6	38.5
Yellow squash	46.5	37.4
Zucchini	42.1	37.2
Apple	78.7	37.1
Celery	53.1	28.6
Green cabbage	25.5	25.0
Carrot	29.9	24.5
Spinach	58.4	22.1
Red cabbage	38.1	21.8
Kiwi	261.7	16.4
Cucumber	39.7	14.9
Apricot	59.9	14.8
Banana	25.6	11.7
Orange, valencia	44.2	6.8
Red onion	32.7	3.9
Potato	35.6	2.6
Romaine lettuce	47.8	2.2
Leaf lettuce	49.7	1.4
Avocado	122.9	-2.2
Lemon	75.0	-8.4
Cauliflower	82.3	-9.5
Grapefruit	46.8	-11.8

Source: Hammitt 1986, (Smallwood and Blaylock, 1991, p. 16).

Table 7

What do YOU think the chances are that there are <u>any</u> pesticide residues in each of the following types of food that you <u>might</u> buy when you do the grocery shopping?

0.	No (0%) chance	6.	51-60% chance
1.	1-10% chance	7.	61-70% chance
2.	11-20% chance	8.	71-80% chance
3.	21-30% chance	9.	81-90% chance
4.	31-40% chance	10.	91-100% chance
5.	41-50% chance		

N = 906 U.S. Households

ITEM	AVERAGE SCORE
Fresh fruits and vegetables	5.8
Apples	5.5
Lettuce	5.4
Tomatoes	5.2
Oranges	4.8
Fresh fish (fresh or salt water)	4.3
Fresh Meats (beef, chicken, pork)	4.2
Frozen or canned fruits and vegetables	4.1
Fruit juices or vegetable juices	4.1
Cereals, flour, or uncooked grains	3.8
Dairy Products	3.1
Bread and baked goods	2.9

Source: van Ravenswaay and Hoehn, 1991b, p. 10.

Table 8

What do YOU think the chances are that someone in your household will have health problems someday because of the current level of pesticide residues in their food?

N = 906 U.S. Households

0.	No chance	4.1 %	
1.	1 in a Million	19.5 %	
2.	1 in 100,000	16.4 %	
3.	1 in 10,000	13.4 %	AVERAGE = 3.3
4.	1 in 1,000	15.6 %	
5.	1 in 100	12.1 %	
6.	1 in 10	5.1 %	
7.	1 in 5	3.2 %	
8.	1 in 2	1.0 %	
9.	Certain to happen	4.4 %	
	NO ANSWER	5.2 %	

Source: van Ravenswaay and Hoehn, 1991b, p. 11.

Table 9

What do YOU think the chances are that someone in your household will have one of the following health problems someday because of the current level of pesticide residues in their food?

0.	No chance	5.	1 in 100
1.	1 in a Million	6.	1 in 10
2.	1 in 100,000	7.	1 in 5
3.	1 in 10,000	8.	1 in 2
4.	1 in 1,000	9.	Certain to happen

N = 906 U.S. Households

SCORE:	0	1	2	3	4	5	6	7	8	9
Cancer					3.8					
Allergies					3.6					
ALL HEALTH PROBLEMS					3.3					
Heart disease				2.8						
Nervous system disorders				2.7						
Impaired immune system				2.5						
Impaired child development			2.1							
Birth defects			2.0							
Mental Illness			1.8							

Source: van Ravenswaay and Hoehn, 1991b, p. 12.

Table 10

Which, if any, of the following things do you do regularly to avoid pesticide residues in the <u>fresh produce</u> you buy?

N = 906 U.S Households

ITEM	PERCENT
Do Nothing	5.1 %
Rinse fresh produce with water	90.8
Grow my own fresh produce	29.8
Avoid imported produce	23.0
Wash produce with soap and water	11.0
Buy foods tested for pesticide residues	11.1
Buy organic food	10.7
Other	5.0
No answer	1.2

Source: van Ravenswaay and Hoehn, 1991b, p. 11.

Table 11

Suppose all foods you bought were tested and certified to have (SEE LABELS BELOW). How much do you think that would REDUCE the chances your household will have health problems someday because of pesticide residues?

0. Not at all (0%)
1. A little (10-20%)
2. About a third (30-40%)
3. About half (50%)
4. About two-thirds (60-70%)
5. A lot (80-90%)
6. Totally (100%)

N = 906 U.S. Households

LABELS:	0	1	2	3	4	5	6	N/A	AVG SCORE
	%	%	%	%	%	%	%	%	
No Pesticide Residues	7.7	16.1	8.1	9.9	8.6	28.8	18.4	2.3	3.6
No Detectable Pesticide Residues	7.7	17.2	10.2	15.6	13.1	28.8	5.3	2.1	3.2
No Residues Above Federal Limits	8.7	23.8	18.0	19.5	11.8	13.1	3.1	1.9	2.6
OWN ACTIONS*	4.5	31.3	17.1	17.7	8.1	15.8	0.8	4.7	2.5

*The question here was: How much do you think the actions you take reduce the pesticide residues in the fresh produce you buy?

Source: van Ravenswaay and Hoehn, 1991b, p. 12.

Table 12

ADDED WILLINGNESS TO PAY FOR CERTIFIED AND TESTED APPLES

N = 681 Households

Apples Certified and Tested to Have:	Added Price per Pound in Cents
No Pesticide Residues	37.5
No Detectable Pesticide Residues	23.6
No Residues Above Federal Limits	23.6

PROBABILITY OF APPLE PURCHASE

PRICE	NO LABEL	FEDERAL LIMIT LABEL	NO RESIDUE LABEL
.39	.7439	.8222	.8580
.49	.7079	.7926	.8323
.59	.6698	.7604	.8038
.69	.6297	.7256	.7725
.79	.5883	.6884	.7386
.89	.5458	.6493	.7023
.99	.5028	.6085	.6638
1.09	.4597	.5664	.6236
1.19	.4171	.5236	.5819
1.29	.3755	.4805	.5393
1.39	.3352	.4376	.4962
1.49	.2968	.3954	.4532

Source: van Ravenswaay and Hoehn, 1991b, p. 13.

Table 13

WILLINGNESS TO ACCEPT PEST DAMAGE ON CERTIFIED AND TESTED APPLES

N = 681 Households

Apples Certified and Tested to Have:	% of Apple in Photo With Pest Damage
No Pesticide Residues	11.9%
No Detectable Pesticide Residues	7.5
No Residues Above Federal Limits	7.5

Source: van Ravenswaay and Hoehn, 1991b, p. 13.

Table 14

Percent of Respondents Willing to Buy Cosmetically Imperfect Oranges Prior to and Following Information about Reduced Pesticide Use (N=229)

Willingness to Buy	Level 1 Damage		Level 2 Damage	
	Before	After	Before	After
Much Less	43	10	62	17
Less	35	15	25	17
Same	16	12	9	9
More	3	27	2	28
Much More	3	36	3	30
χ^2 (d.f.)	176.9 (4)***		164.2 (4)***	

***p < .001

Source: Bunn, Feenstra, Lynch and Sommer, 1990, p. 273.

Figure 1

Percentage Change in the Consumer Price Index for Food and Beverages by Chemical Use Reduction Scenario, 1987-94

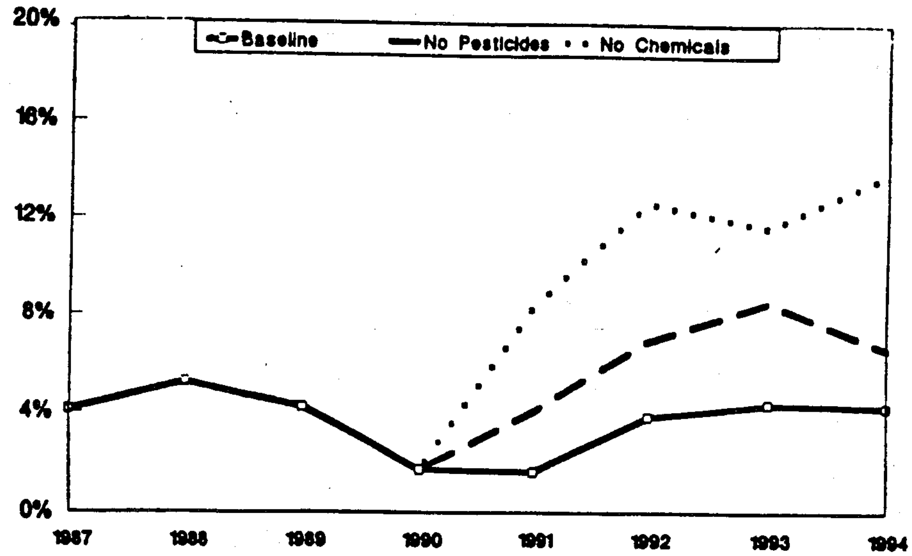
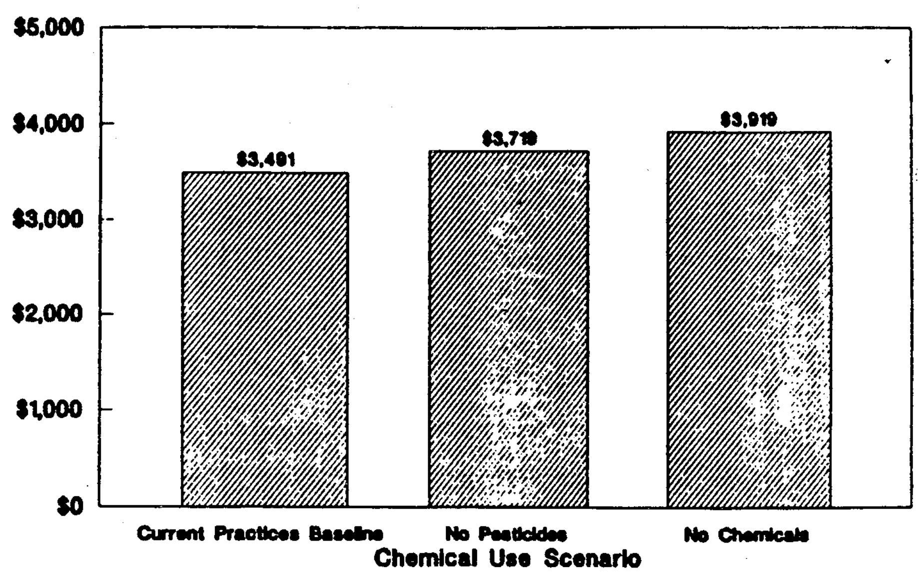


Figure 2

Annual Food Expenditures Per Household by Chemical Use Scenario, 1995-98

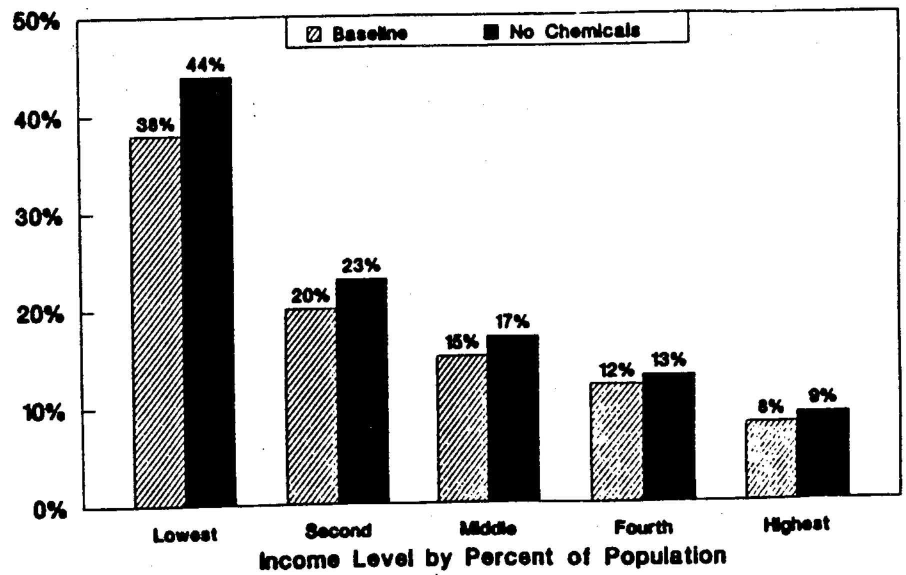
Real Prices 1989 = 100



Source: Knutson, Taylor, Penson, and Smith, 1990a, p.3.

Figure 3

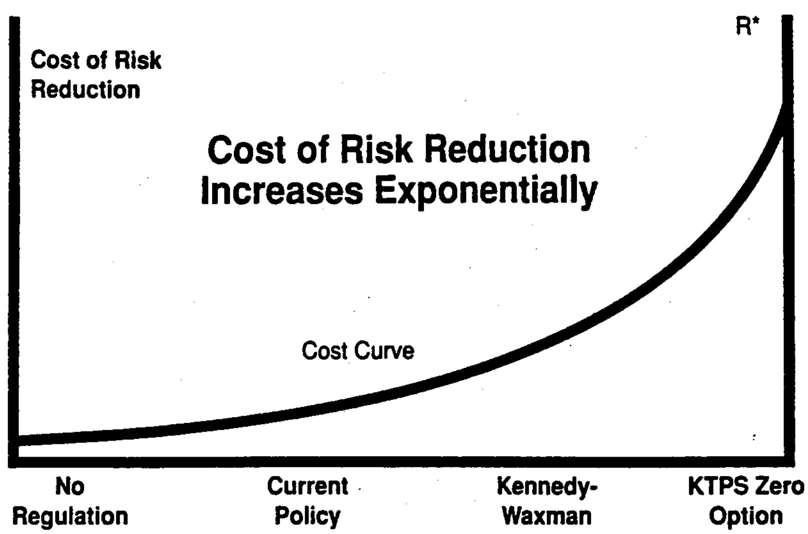
Percent of Income Spent on Food by Level of Household Income and Chemical Use Reduction Scenario, 1995-98



Source: Knutson, Taylor, Penson, and Smith, 1990a, p.42.

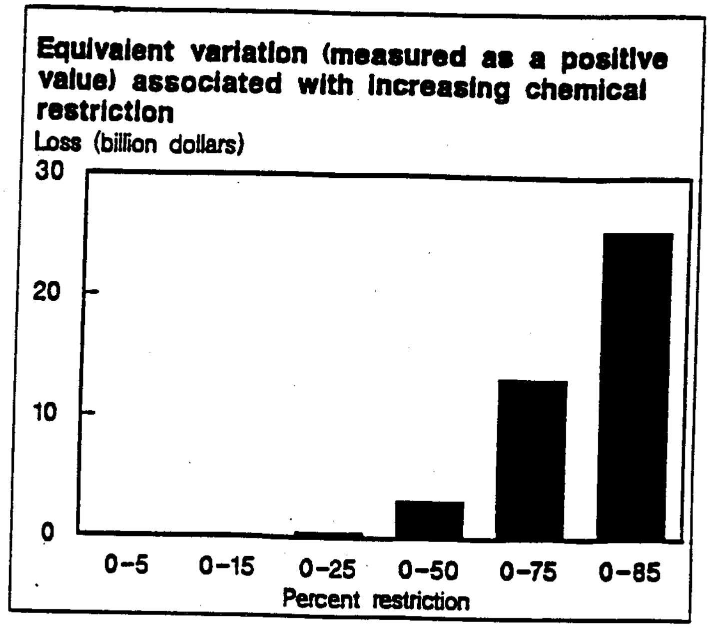
Figure 4

The Cost of Agricultural Chemical Use Reduction



Source: Ayer and Conklin, 1990, p.28.

Figure 5



Source: Rendelman, 1991, p.5.

Figure 6

Trade-off Between Benefits and Chemical Use Reduction