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Perceived Risks of Agro-Biotechnology and Organic Food Purchases in the United States

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This study examines the role of consumers' perceived risks and benefits of agro-biotechnology in shaping purchase patterns for organic food among U.S. consumers. Perceived risks and benefits of biotechnology, general purchase behavior, knowledge of GM technology, and socio-demographic variables are examined in relation to their impact on organic food purchases. Consumers who are concerned about negative attributes of agro-biotechnology, including long-term health and environmental hazards, inequity in the distribution of benefits from the technology, and adverse effects to small and medium farms, are the potential organic food consumers. Growth in the organic food market is largely dependent on continued reinforcement of consumers' belief that organic foods are safer than conventional foods.

Consumption of organic food products has grown significantly throughout the industrialized world. Sales of organic foods in Europe, North America, Australia, and Japan exceed \$114.5 billion per year (Makatouni 2002). In the United States, organic products are available in nearly 20,000 natural foods stores and are sold in 73 percent of all conventional grocery stores (Dimitri and Greene 2002).

Studies have shown that consumers' selections of foods are influenced by many factors including health concern (Rimal, Fletcher, and McWatters 2000; Steenkamp 1997), convenience (Kinsey and Senaur 1996), and environment (Van Ravenswaay 1986). Recent incidences of foot-and-mouth disease and mad cow disease have further increased consumers' food-safety consideration when selecting food items (Verdurme, Gellynck, and Viaene 2002). In a separate study, more than 54 percent of the respondents in the state of Georgia perceived pesticide residues to be a serious or extremely serious food-safety threat (Rimal et al. 2001). Growth hormones, animal drug residues, bacteria, food additives, irradiation, and naturally occurring toxins followed pesticide residues as perceived threats.

The application of biotechnology in agriculture and medicine has produced a growing number of organisms and products. Along with the increasing commercial success of application of biotechnology, a widespread debate focusing on the ecological, human health, and socio-economic effects of biotechnology is taking place at the national and

international level. Controversy over GMOs originated in the European Union (EU), which responded to negative consumer sentiment of GM foods by imposing a moratorium in 1998 that precluded approval of new GM varieties. However, evidence available thus far does not support alleged health or environmental hazards attributed to GMOs. Furthermore, the U.S. and other countries announced in May, 2003 that they would file a formal WTO dispute to abolish the moratorium which they believe distorts agricultural and food trade.

Although American consumers have been largely supportive of the application of biotechnology in food production (Moon and Balasubramanian 2001), increasing public concerns of food-safety issues including the use of genetically modified (GM) organisms and hormones and pesticide residues are likely to affect markets for foods produced by alternative practices such as organic farming. Previous research elicited willingness-to-pay (WTP) as a measure of behavioral intentions with respect to non-GM foods (Noussair, Robin, and Ruffleux 2004; Moon and Balasubramanian 2003; Chern et al. 2003; Burton et al. 2001). These studies presented some insight into consumers' preferences about GM and non-GM food that could be useful in estimating the size of market for non-GM food. However, eliciting willingness-to-pay for non-GM food is not sufficient in determining whether and to what degree GM food is substitutable with non-GM versions, including traditional food and organic food. Knowledge about such substitutability is the key to determining the strength consumers' aversion for GM food in enhancing the market for organic foods.

This study investigates whether consumers' perceived risks and benefits of agro-biotechnol-

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ogy has any influence on the decision to purchase organic food. In addition, consumers' general purchase behavior, knowledge of GM technology, and socio-demographic variables are examined in relation to their impact on organic food purchases. Findings from this study will be useful for the organic food industry and the biotechnology industry in designing and implementing programs. The identification and comparison of factors influencing the purchase of organic foods provide valuable information in targeting specific segments of the population. Many studies have cited reasons why consumers purchase organic food products. For example, Kuchler, Ralston, and Tomerlin (2000) reported that organic food consumers differed from conventional consumers based on the importance attached to the specific attributes of organic foods. Are the perceived risks of agro-biotechnology powerful enough that marketers of organic foods can use the risks to attract more consumers?

Materials and Methods

Data Collection

A survey instrument was designed to evaluate the relationship between organic food consumption and perceived risks and benefits of agro-biotechnology. The data collected from survey were therefore based on the perceptions of survey respondents rather than on actual safety or nutritional attributes of organic or GM foods. The surveys were administered by mail in the U.S. using household panels maintained by the National Panel Diary (NPD) group, a marketing consulting firm specializing research on consumer behavior and food marketing. Survey methods that use an established panel are called "permission-based surveys" and are increasingly used in exploring various aspects of consumer behavior for academic or commercial purposes (Moon and Balasubramanian 2001). Questionnaires were distributed to 5,200 households (a sub-sample of the NPD panel), selected across the U.S. by random sampling. The U.S. sample was stratified by geographic regions, head of household age, education, and income, consistent with the U.S. census for adults. There were 3,060 usable observations, an effective return rate of 59 percent.

The data were analyzed in two ways. First, a descriptive analysis of important variables was conducted using frequency analysis. Second, the

association of organic food purchase with perceived risks and benefits of agro-biotechnology was analyzed using a regression analysis.

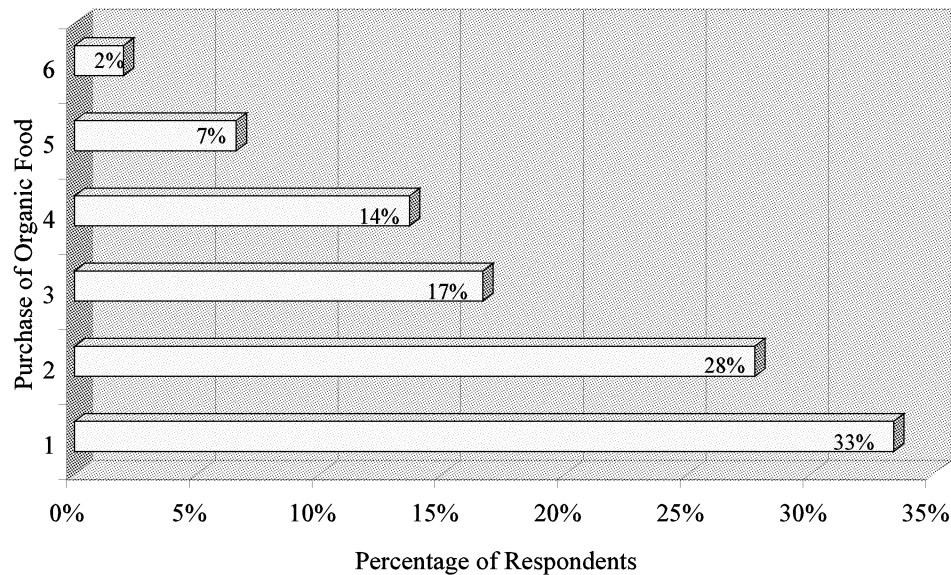
Results

Purchase of Organic Food

Respondents were asked, "How often do you purchase organically grown produce or other organic food products to reduce potential health risks?" Responses were recorded on a variable scale ranging from "1 = Never" to "6 = All the time." Figure 1 shows that only two percent of the respondents purchased organic foods all the time, while 33 percent never purchased organic food. Responses were re-grouped into two categories, the first group representing consumers who were generally unlikely to purchase organic food (responses 1 to 3), and the second group representing consumers who were likely to purchase organic food (responses 4 through 6). Only about 23 percent of the respondents fell in the group of likely purchasers of organic food.

Risks and Benefits of Agro-Biotechnology

Those who oppose the application of biotechnology in food production argue that using this technology in crop production has significant negative consequences. They fear that inserted genes could be allergenic or harmful to human health (Moon and Balasubramanian 2003; Hansen 2001). Examples of such fear included a possibility of new genes inadvertently causing plants to produce toxins at higher levels than are present naturally, which could create long-term negative health consequences. Furthermore, genes from genetically modified plants may escape into the environment through cross-fertilization, posing risks to the natural ecosystem (Caplan 2001). Moral issues about biotechnology focus on the belief that it is immoral to alter God's creations using genetic-engineering techniques. Others concerns have pointed to the inequitable distribution of the economic benefits of agro-biotechnology (Wohl 1998). For example, many believe that multinational biotech corporations are the main beneficiaries of agro-biotechnology, while consumers assume most of the risks involved. Furthermore, increasing control of multinational corporations over small-scale family farming and the gradual disappearance of small farms are some of the negative attributes of



Note: scale ranges from 1=never to 6=all the time.

Figure 1. Distribution of Organic Food Purchase Pattern in the United States.

agro-biotechnology.

Supporters of agro-biotechnology argue that the application of biotechnology to crop production will bring substantial benefits to societies while revolutionizing the way crops are produced (Moon and Balasubramanian 2003). Some of the specific benefits of agro-biotechnology include improved environmental quality (e.g., less soil erosion and infertility) by reducing the use of pesticides and herbicides in crop production (Magnusson and Hursti 2002; Pinstrip-Anderson and Schioler 2000) and improved nutritional value of foods (e.g., rice with improved quantities of Vitamin A; soybeans with fatty acid). More importantly, supporters of biotechnology believe that biotechnology will mitigate food shortages in developing nations by increasing yields with crops resistant to various pests, insects, or drought (Moon and Balasubramanian 2003).

Based on the above discussions, respondents were asked eight questions dealing with perceived risks and benefits of the application of biotechnology in crop production. The five questions related to perceived risks of GM technology dealt with health risks, environmental risks, moral considerations, the image of multinational corporations as the primary beneficiaries of biotechnology, and the growing control of multinational corporations over farming. The three questions relating to benefits of

GM technology dealt with reduced use of chemicals in crop production, improved nutritional content, and increased yields.

Table 1 shows the responses to the eight questions. A majority of the consumers agreed that corporations were the main beneficiaries of the agro-biotechnology (53.3 percent) and that the development and use of genetically modified seeds will negatively impact family farms by putting more control of the food supply into the hands of multinational corporations (51.6 percent). Consumer acceptance of agro-biotechnology is determined by several factors, including the distribution of benefits from the technology. If consumers perceive that there are no obvious benefits to them, the acceptability of the GM technology will be low, as was found among European consumers (Moon and Balasubramanian 2001; Grove-White et al. 1997). More consumers disagreed that agro-biotechnology posed health hazards (30.5 percent) than agreed (25.6 percent). However, the percentages reversed when it came to eco-hazards. More consumers agreed that agro-biotechnology posed ecological hazards (30.3 percent) than disagreed (22.7 percent).

The main perceived benefit of agro-biotechnology was its ability to potentially reduce world food shortages by increasing yields (47.4 percent), followed by its ability to improve environmental

Table 1. Perceived Risks and Benefits of Agro-Biotechnology (%).¹

	Disagree	Agree	Don't Know
Perceived risks of agro-biotechnology			
HEALTH RISKS: Foods based on genetically modified crops pose health hazards to consumers.	30.5	25.6	43.9
ECO HAZARDS: Use of biotechnology in crop production pose hazards to natural ecosystem.	22.7	30.3	47.0
MORALLY WRONG: I believe it is morally and ethically wrong to use genetically modified ingredients to make food products.	43.1	31.5	25.4
CORPORATION: Corporations are the main beneficiaries from agricultural biotechnology, while consumers assume most risk.	22.1	53.3	24.6
CONTROL: The development and use of genetically modified seeds will negatively impact family farms by putting more control of the food supply into the hands of multinational corporations.	17.8	51.6	29.7
Perceived benefits of agro-biotechnology			
REDUCE SHORTAGE: The application of biotechnology to crop production will potentially reduce world food shortages by increasing yields.	14.8	47.4	37.8
IMPROVE ENVIRONMENT: The application of biotechnology to crop production will contribute to improving environmental quality by reducing the use of chemicals in agricultural production.	16.2	42.3	40.6
NUTRITION: Agricultural biotechnology enhances the value of foods by improving the nutritional composition.	21.2	29.1	48.8

¹ Risks and benefits were rated on a six-point scale ranging from 1 = Disagree completely to 6 = Agree completely. "Disagree" was an aggregation of 1 to 3 while "Agree" was of 4 to 6.

quality by reducing the use of chemicals in agricultural production (42.3 percent). Almost half of the respondents answered "don't know" when asked about the contribution of agro-biotechnology in improving the nutritional value of food (48.8 percent). Only 29 percent agreed that agro-biotechnology enhances the nutritional value of foods.

A Regression Analysis to Evaluate the Factors Influencing Organic Food Purchasing Decisions

In order to measure the relationship between organic food purchase patterns and respondents' perceived risks and benefits of agricultural biotechnology, an ordered probit regression model was selected.

The reported organic food purchase pattern was the dependent variable in the model. Explanatory variables included socio-economic and behavioral variables and variables representing perceived risks and benefits of agricultural biotechnology. The choice of regression model was based on the characteristics of the dependent variable. The purchase pattern was measured using a scale (1 to 6) that allowed for the ranking of the outcomes. The empirical model was defined as

$$(1) Y^*_t = \beta'X_t + \varepsilon_t,$$

where Y^*_t is an unobserved purchase pattern for organic food; X_t is a vector of variables related to

risks and benefits of agro-biotechnology, general food-related attitude and purchase behavior, and socio-demographics (Table 1); β is the vector of unknown parameters; and ε_i is the independently and identically normally distributed error term. While Y_i^* was unobserved, respondents actually reported purchase history by selecting one of the six categories (Y_i) representing likelihood of buying organic food. Values for Y_i were 1, 2, 3, 4, 5, and 6, where 1 represented consumers who said that they "never" bought organic food and 6 represented consumers who said that they bought organic food "all the time." The unknown-parameter vector β in Equation (1) was estimated using LIMDEP software.

Independent Variables

The first group of independent variables included consumers' general food-related attitude and purchase behavior (Table 2). These attitudes and behaviors are likely to influence food-purchase patterns. Consumers were asked questions relating to their perception of the safety of the food supply and the influence of food prices and food safety on their food-purchase decisions. This set of independent variables included the perceived safety of food available in the grocery stores (SAFE_FOOD), the attitude toward the government's role in safety of the food supply (FOOD_SUPPLY), and the importance of food safety (FOOD_SAFETY) and prices of food (FOOD_PRICE) in food-purchasing decisions.

High correlations were found among the variables measuring consumers' perceived risks and benefits of agro-biotechnology (Table 1). The correlation coefficients ranged from 0.43 to 0.66 among the perceived risks and 0.42 to 0.56 among perceived benefits. It therefore would be difficult in the regression model to isolate the impact of each of the factors on organic food purchase patterns. To cope with potential multi-collinearity problems in estimating the empirical models, an index of perceived risks (RISKS) was constructed by adding consumer responses to the five questions describing the negative attributes and dividing by the number of questions. Theoretically, the index could range from 1 (representing complete disagreement with the risk aspects of agro-biotechnology) to 6 (representing complete agreement). Similarly, a benefit index (BENEFIT) was created using consumer re-

sponses to three questions relating to the benefits of agro-biotechnology. The benefit index could range from 1 (representing complete disagreement with the positive aspects of agro-biotechnology) to 6 (representing complete agreement). It is anticipated that perceived benefits of agro-biotechnology will negatively impact the likelihood of purchasing organic food. Consumers who perceived that GM food products were beneficial were less likely to purchase organic foods. Similarly, consumers who strongly agreed that applications of biotechnology in food production had many risks were likely to buy organic food more often.

As discussed above, consumers' level of awareness and concern about biotechnology was measured by asking how much they had read or heard about GMOs (HEAR_GM) and whether they were upset about the existing practices of labeling GM food (UPSET). Previous studies have shown that a higher level of awareness about GM issues translated into negative attitude toward GM food (Hursti and Magnusson 2003; *Nature* 1997). Hursti and Magnusson (2003) showed that higher level of knowledge about gene technology among Swedish consumers translated into a negative attitude toward GM foods and a positive attitude toward organic foods. Similarly, it is expected that consumers who are generally upset over existing labeling practices are likely to purchase organic food more often.

Demographic characteristics of consumers were likely to influence their organic food-purchase patterns in two ways: through their perceptions and attitudes about biotechnology, or directly. Surveys showed that gender and level of education have made a significant difference in explaining public acceptance of biotech foods. Males and respondents with higher education were more likely to accept biotech foods (Moon and Balasubramanian 2003; *Nature of Science* 2000). Heiman, Just, and Zilberman (2000) also showed that education had a significant role in explaining consumers' attitudes toward biotech foods. Hence, gender, age, income, and education were also included in the set of independent variables. The education variable represented those with a college degree, or otherwise. The demographic characteristics of the study sample compared well with the census data. According to the 2000 census, the percentage of females in the total U.S. population was 51 percent, compared to 53 percent in this study. The Caucasian population was 75 percent of the census,

Table 2. Descriptive Statistics of the Variables Used in the Analysis.

Variable	Explanation	Mean	Standard Deviation
Organic	How often do you purchase organically grown produce or other organic food products to reduce potential health risks associated with pesticides residues. 1 = never; 6 = all the time (dependent variable used in the regression model)	2.38	1.35
Index of perceived risks and benefits of application of bio-technology:			
RISKS	Index of perceived risks of agro-biotechnology (1 to 6)	3.71	0.99
BENEFITS	Index of perceived benefits of agro-biotechnology (1 to 6)	3.76	0.83
General food related attitude and purchase behavior:			
SAFE_FOOD	I feel that foods available at grocery stores are safe to eat. 1 = disagree completely; 6 = agree completely	4.48	1.08
FOOD_SUPPLY	The government ensures safety of the food supply. 1 = disagree completely; 6 = agree completely	4.29	1.16
FOOD_SAFETY	Safety is an important consideration in food purchasing. 1 = disagree completely; 6 = agree completely	5.01	1.19
FOOD_PRICE	Price is an important consideration in food purchasing. 1 = disagree completely; 6 = agree completely	5.02	1.11
Awareness about GM and concern among the respondents:			
HEAR_GM	How much heard about genetically modified organism (GMOs). 1 = nothing; 6 = a great deal	2.46	1.32
UPSET	How do you feel about the fact that conventional foods are currently not labeled differently than the genetically modified foods in the grocery stores? 1 = not bothered; 6 = extremely bothered	3.05	1.47
Demographic characteristics of the respondents:			
GENDER	Female = 1; Male = 0	0.53	0.50
AGE	Actual age of the respondents	45.48	12.54
INCOME	Household income in '000 U.S. dollars	52.36	40.70
COLLEGE	1 = college education; 0 otherwise	0.47	0.50
WHITE	1 = white; 0 = otherwise	0.85	0.35

compared to 85 percent in this study. The mean household income of the U.S. in the census was \$42,000 (in 1999 dollars) compared to \$52,000 in this study. There was a slight overrepresentation of white and higher-income households in the sample for the study.

Discussion of Regression Results

Results from the ordered probit model for consumers' purchase patterns of organic food are reported in Table 3. The chi-square statistics for the model indicated that the null hypothesis that all parameters were jointly zero was rejected at 0.01 level. Based on the collinearity diagnostic tests (Belsy, Kuh, and Welsch 1980), no collinearity problems were detected in the analyses.

Consumers' purchase of organic food was influenced by perceived risks of agro-biotechnology, general food-purchase behaviors, level of awareness of GM technology, concern that GM foods are not differently labeled than traditional foods, and age of the respondents.

Perceptions about the risks of agro-biotechnology as represented by RISK were statistically significant ($\beta = 0.0530$; P-value = 0.0375) in determining overall purchase patterns of organic food. Perceived risks of agro-biotechnology caused consumers to buy organic food more often. In a separate study of UK consumers, Burton et al. (2001) reported that infrequent consumers of organic food were willing to increase their food bill to avoid animal and plant GM technology. In this study, consumers who perceived that agro-biotechnology generally

Table 3. Organic Food Consumption: Maximum Likelihood Estimates of Ordered Probit Model.

Variables	Estimated Parameter	P-value
Constant	-0.4801*	0.0278
RISKS	0.0530*	0.0375
BENEFITS	0.0336	0.1814
SAFE_FOOD	-0.1504*	0.0000
GOVT_ROLE	-0.0167	0.4206
FOOD_SAFETY	0.2002*	0.0000
FOOD_PRICE	-0.0252	0.1722
HEAR_ALL	0.1797*	0.0000
UPSET	0.0917*	0.0000
FEMALE	-0.0231	0.5741
AGE	-0.0038*	0.0215
INCOME	-0.0005	0.3715
COLLEGE	-0.0524	0.2165
WHITE	0.0166	0.7576
Threshold parameters for Index		
Mu (1)	0.77728*	0.0000
Mu (2)	1.31111*	0.0000
Mu (3)	1.99304*	0.0000
Mu (4)	2.76484*	0.0000
Log likelihood Restricted	-4297.04	
Log likelihood Unrestricted	-4543.24	
Chi-squared (degree of freedom = 13)	492.40*	

*Significant at < 5 percent

possessed zero risk would not be inclined to buy organic food. Perception of benefits did not have a statistically significant impact on the likelihood of purchasing organic food.

Consumers who perceived that the foods available at the grocery stores were generally safe to eat were likely to buy organic food less often ($\beta = -0.1504$; $P\text{-value} < 0.0001$) than were those who thought that food available at the grocery stores is generally unsafe to eat. However, those who were concerned about the safety of food while making food-purchase decisions were likely to buy organic food more often ($\beta = 0.2002$; $P\text{-value} < 0.0001$). Interestingly, price considerations while purchasing food did not have any effect on the likelihood of purchasing organic food. Magnusson et al. (2001) reported that although consumers were concerned about organic food being more expensive than the conventional food, many organic consumers never refrained from buying organic foods because of the price. Kuchler, Ralston, and Tomerlin (2000) reported that the perceived benefits of organic food products are sufficient to cover the existing price premium for organic foods. Results in the current study are consistent with the fact that organic food consumers are least susceptible to price premiums. The impact of prices was the least in terms of magnitude and statistical significance among several variables dealing with food-purchase behavior. The results showed that consumers' consideration of food safety while making food-purchase decisions and safety of food at the grocery stores were the most influential factors in determining organic food-purchase patterns.

Consumers who had read or heard a great deal about the GM technology were likely to buy organic food more often than those who were not knowledgeable about GMOs. This result reinforces the earlier discussions about the role of information and education in shaping perceptions of risks and benefits of agro-biotechnology. Consumers who were upset that labeling of GM foods was not different from labeling of traditional foods ($\beta = 0.0917$; $P\text{-value} < 0.0001$) were likely to purchase organic foods more often. Trijp, Steenkamp, and Candel (1997) demonstrated the importance of clear and unmistakable labeling as an important condition for buying food items including organic foods.

Among the socio-demographic variables, age of the respondents was the only variable that had a statistically significant impact on organic food-

purchase patterns ($\beta = -0.0038$; $P\text{-value} = 0.0215$). Older respondents were less likely to buy organic foods than were younger respondents. This result is consistent with the results reported by Govindaswamy and Italia (1997) showing that younger individuals were more likely to pay a premium for organically-grown fresh produce than were older individuals. Prices of organic foods may have indirectly influenced older consumers' purchase intentions for organic food. Many older consumers have a limited disposable income. Although this finding is not directly evident in this study, Davies, Titterton, and Cochrane (1995) found a relationship between the amount of disposable income available and the extent of purchase of organic foods which agrees with our findings.

Summary and Conclusions

The perception of risks and benefits determines consumer acceptance of food products including organic and GM foods. This study explores the role of perceived risks and benefits of agro-biotechnology in shaping consumers' purchase patterns for organic products. The sample data indicate that one-fourth of the consumers bought organic products at least sometimes. Only two percent of the consumers bought organic food very often. However, as perceived risks of GM technology dominated the perceived benefits, consumers were increasingly likely to look for alternative food sources, including organic foods. The results suggest that as consumers' perceived risks of agro-biotechnology increase, they are more likely to buy organic foods. Consumers who are concerned about negative attributes of agro-biotechnology, including long-term health and environmental hazards, inequity in the distribution of benefits from the technology, and adverse effects to small and medium farms, are the potential organic food consumers.

Due to high correlations among the attributes of agro-biotechnology, the study is unable to delineate the effect of each individual attribute. However, knowledge about the linkage between perceived risks of agro-biotechnology and organic food consumption is important, considering the debate in regulatory circles on whether the definition of organic food should include absence of GM ingredients. Demonstrating that perceived risks of GM food have an impact on organic food-purchase decisions, our results suggest that organic

foods need to be free from GM ingredients. In fact, GM opponents in the European Union (EU) argue that GM crops cannot co-exist with organic crops (*Doane's Agricultural Report* 2004). Instead of resisting GM crops based on potential health and environmental hazards, these opponents are now attempting to separate the organic food market from GM technology.

The importance of food safety while making food-purchase decisions and consumers' trust in the ability of grocery stores to supply safe food are other important factors in determining purchase patterns for organic foods. In this study, prices of food products do not play an important role in determining purchase patterns for organic foods. As long as organic food marketers are successful in assuring food safety, consumers are willing to pay a premium price for organic foods. Growth in the organic food market largely depends on continued reinforcement of consumers' belief that organic foods are safer than conventional foods.

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