Consumer Attitudes Toward GMOs: The Ohio Experience

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ABSTRACT: Data were collected from 902 rural and urban residents of Ohio during the winter of 2003 to assess attitudes toward the production of genetically modified (GM) plants and animals. Attitudes were assessed using likert-type attitude statements. The theoretical perspective used in the investigation was developed from diffusion and risk perception theories. Regression modeling demonstrated that the theoretical model was very good for predicting variability in attitudes toward GM plants and animals. Approximately 61% of the variance in the dependent variable was explained by the statistical model. The findings are discussed in the context of the social acceptability of GM food and fiber products among Ohio residents.

Keywords: genetically modified organisms, risk, rural, urban, attitudes, media

Introduction

One of the most significant scientific innovations in history is the ability of human beings to manipulate genetic structure through modern techniques of molecular biology, often called biotechnology or bioengineering. Although pharmaceuticals and vaccines produced through biotechnology have been widely accepted throughout the world, people in many societies have expressed concern about the use of the same technologies to produce agricultural products (Braun 2002). Basic changes in plants and animals can now be accomplished in a few months rather than decades of selective breeding. Food products, ingredients, and microorganisms produced through modern biotechnology techniques are commonly called transgenic, or genetically modified (GM).

Modification of genetic structures of plants and animals is deliberately carried out for specific, predetermined purposes to improve or otherwise alter the physical composition of plants and animals so that they are better able to survive in a broader range of physical conditions (Uzogara 2000). Genetically modified plants and animals often are better able to resist disease and/or pests and can be engineered to produce food and fiber products that are different from the parent organisms.

To date, GM-plants have been created that produce proteins that protect them from insect pests. Others have been developed that are more adaptable to a variety of physical environmental conditions. Still other GM-plants have been formulated to make them more resistant to pesticides. It is highly likely that future GM plants will be even more astounding in terms of their contribution to the resolution of human problems than those developed to date.

Although many of the biotechnology practices presently used to produce GM-products have been developed in recent years, plants and animals used for agricultural purposes have been subject to genetic manipulation for centuries via selective breeding. Although the process of selective breeding often takes many years to achieve desired outcomes, agriculture as an industry has become much more productive over time because of the variations in plants and animals that have been developed.

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Several agricultural GM-products presently in existence have been shown to contribute extensively to human well-being, and the technology used to produce them has the potential to create even more innovative food and fiber products in the future. Among the most notable benefits of biotechnology is the ability to develop crop varieties that are more tolerant to drought and temperature variability (Borlaug 2000). Such progress could signal a major step in helping to feed the world's growing population, particularly in developing countries where soils and agronomic conditions make agriculture difficult (NCB 1999; Royal Society 2000). Reclaiming damaged soils and improving productivity of farm land in extremely hot or dry regions would also help protect fragile lands and forests, which would contribute to the protection of natural resources and biodiversity for future generations (Bonny 2000).

Additional benefits from biotechnology accrue for both farmers and consumers in the form of less reliance on pesticides, possible improvement of soils, higher crop yields, increased choices for control of damaging plant diseases and insects, and enhancement of food quality and nutrition (Bright and others 1996; Wolfenbarger and Phifer 2000; AgBioWorld 2003; Royal Society 2003).

Scientists, food processors, and agricultural interest groups have tended to support research and development of GM products on the basis of the benefits afforded to society; however, a number of opposition groups have emerged to question the legitimacy of their efforts. These groups have raised a number of legitimate questions and concerns globally about ethical and safety issues associated with pursuing a future dominated by genetic engineering (Reiss and Straughan 1996; Hoban 1998; Loader and Henson 1998; Franks 1999; Gaskell 2000; Macer and Ng 2000; NIF 2000; Bishop and others 2001; Chern and Rickertsen 2001; Blaine and others 2002). Although consensus has not been achieved on issues associated with GM-products, it is widely agreed that the creation of modern biotechnology techniques has revolutionized the manner in which contemporary agricultural production systems are perceived in many societies.

The concern expressed within many societies is that genetic change can be achieved in such a short period of time that undesirable social and environmental consequences cannot be anticipated and/or controlled. Opponents of GM food and fiber products argue that the impacts on human and animal health and the environment cannot be ignored (Lomax 2000). It has been observed that GM microorganisms are living organisms that can disperse to other habitats and multiply (Seidler and others 1998). Other critics suggest that it is not ethical for human beings to manipulate basic genetic structure and that "natural" evolution is superior to human-engineered plants and animals (Frewer and Shepard 1998; Straughan 1998; Moseley 1999).

A large body of research has been developed in response to concerns about the safety of GM products and practices. Studies have been conducted to assess the potential for transgenic plants to become more competitive in natural habitats and therefore to become pests; to study and assess the likelihood of gene transfer between genetically engineered plants and nontarget plants that could result in unintended new plant species or weeds; and to assess the potential for allergic reactions and other adverse health effects in human beings who consume GM products (Bright and others 1996; Seidler and others 1998). While research is ongoing, the overwhelming consensus of the scientific community is that biotechnology does not pose significant risks to either the environment or to human health. Studies to date show that the likelihood of plants becoming weeds is no higher for transgenic plants than for those produced by conventional breeding methods and that gene transfer is also highly unlikely to occur if proper management procedures are observed (Bright and others 1996; Scriber 2001; Ritala and others 2002; Royal Society 2003). Much research has also been conducted in response to concerns that GM food products could have negative effects on human health. Evidence to date strongly suggests that GM food products pose no greater risk than conventionally produced food products (OECD 1993; FAO 1996; NCB 1999; Royal Society 1999, 2001, 2002, 2003; Borlaug 2000; Uzogara 2000; WHO 2000; CSPI 2001). Gasson and Burke (2001) argue that GM foods have been subjected to far more rigorous evaluations than those applied to foods produced by conventional plant breeding, and the empirical results refute assertions that GM food products pose a threat to humans or the physical environment.

It is generally agreed that the resolution of ethical issues associated with genetic modification of plants and animals will occur at the public policy level within and between societies. The future of GM products will be influenced by how they are perceived by members of society. If a significant portion of society perceives GM products as introducing unacceptable levels of risk into their lives and if the processes used to produce them are defined as being unethical, it is quite possible that public policies will be developed and implemented that will act as barriers to future research and development of GM products. The purpose of this article is to discuss the findings of a study designed to assess how rural and urban people living in Ohio perceive GM plants and animals and to identify factors that explain the variability in attitudes toward such innovations. Study findings are discussed in the context of social acceptability of GM food and fiber products among Ohio residents and the implications for future public policy regarding GM products.

Theoretical Modeling

The theoretical perspective used to guide the investigation was developed from selected components of the classical diffusion model (Napier and others 1988, 2000; Rogers 1995; Napier and Bridges 2002; Robinson and Napier 2002) and risk perception theory (Slovic 1986; Tucker and Napier 1998, 2001, 2002).

Classical diffusion theory basically posits that potential adopters must be made aware of innovations and must become knowledgeable of the benefits and costs associated with innovations so they can make informed adoption decisions. Once potential adopters become knowledgeable of specific innovations, they will develop attitudes toward the innovation and make adoption decisions consistent with those attitudes. The model asserts that factors affecting access to knowledge about an innovation will be significantly associated with attitudes toward innovations being assessed.

Diffusion theory also argues that human beings are risk averse and that certainty of outcomes associated with adoption of innovations affects adoption decisions. Some innovations have a low level of risk associated with adoption because expected outcomes are almost certain to occur or the consequences of failure of the innovation to achieved expected outcomes is of no consequence to the adopter. Other innovations have a high level of risk associated with them because expected outcomes may not be realized or the consequences of failure are very high for the adopter. This is especially true for technological innovations that have not been subject to testing over extended periods of time and under a variety of environmental, social, economic and political situations. Diffusion theory suggests that higher levels of perceived risk associated with adoption of a specific innovation will result in more negative attitudes toward the innovation and lower probability of adoption (Rogers 1995).

Risk perception theory argues that innovations are assessed in the context of whether or not potential consequences of adoption are familiar and controllable (Slovic 1986; Covello and Johnson 1987; Tucker and Napier 2001). The theory asserts that involuntary exposure to risk and perceived lack of control over outcomes will result in higher levels of perceived risk (Pidgeon and Beattie 1998). If potential adopters are familiar with an innovation and are aware of threats associated with adoption, they can elect to avoid the threat, assuming there is some means of doing so. When the level of risk associated with an innovation is unknown, human beings tend to be cautious and express fear of the unknown. If potential adopters are familiar with a specific innovation, they tend to perceive less risk attached to adoption because they would perceive more control of outcomes. Individuals may be very willing to adopt innovations that have high levels of risk attached to them if the potential adopter believes that he/she can control the outcomes to the extent risks are reduced to an acceptable level. Risk perception theory suggests that factors affecting familiarity and controllability will be significantly related to attitudes toward innovations. Higher levels of perceived familiarity and controllability will increase the probability that attitudes toward innovations will be more positive.

Application of the Theoretical Model

Perception of risk

Although research to date strongly suggests that GM products are safe, such products have the *potential* to disrupt environmental ecosystems, generate economic change within and between societies, and to introduce higher levels of perceived risk into the lives of potential adopters (Seidler and others 1998). If potential adopters perceive GM products as posing a risk to themselves or to significant others, they should develop negative attitudes toward the innovation being assessed and reject such products. It is hypothesized that level of perceived risk will be significantly related to attitudes toward GM products. Individuals who perceive higher levels of risk will exhibit more negative attitudes toward GM products.

Information/education/familiarity factors

Because human beings seek to reduce uncertainties to levels of probability, potential adopters will seek information about technological innovations and assess them in the context of perceived risk (Slovic 1986). Assuming that amplification of risk (Kasperson and others 1988) does not obscure scientific information from being disseminated to various publics,[1] access to information about an innovation should provide potential adopters with greater awareness of the risks associated with specific innovations and aid in the development of attitudes toward the innovations being assessed.

Mass media have been shown to serve as a primary source of consumer information about science topics (Mountcastle-Shah and others 2003). Information disseminated via printed and electronic channels of communication should be more objective and factual than interpersonal communication channels because such channels are subject to public scrutiny (Boone and others 2000). Scientific research can be summarized and the public informed of the various issues associated with debates about specific innovations. To date, no definitive statement can be made about the level of risk associated with specific GM products; however, evidence suggests that health and environmental risks are probably quite low. Although mass media coverage of biotechnology tends to focus on its possible negative effects (IFIC 2002; Bonny 2003), consumers should be able to gain a more complete picture of GM product safety by actively pursuing additional sources of biotechnology information. Exposure to multiple channels of communication about the risks associated with GM products should demonstrate that such products generate numerous benefits to society while producing few environmental and health threats. Under these circumstances, consumers would be expected to express less fear about the production and consumption of GM products, which should result in the reduction of negative attitudes toward such products. It is hypothesized that importance placed on printed and electronic information channels to secure information about GM products will be significantly related to attitudes toward GM products. Individuals who place higher importance on multiple electronic and printed channels of communication will exhibit less negative attitudes toward GM products.

Educational achievement should affect attitudes toward GM products (Hoban 1998) because individuals who have been exposed to more learning experiences should have a greater probability of being exposed to scientific evidence indicating that GM products produce many benefits for society and have a low probability of harming the environment or endangering human and animal health. Once people are made aware that GM products do not pose a threat, perceptions should become more positive. It is hypothesized that educational achievement level will be significantly related to attitudes toward GM products. Individuals who have achieved higher levels of education will exhibit less negative attitudes toward GM products.

Age should affect attitudes toward GM products because older people were educated in an era when genetically altered organisms were produced by selective breeding, which was slow and the outcomes predictable. Potential impacts on society and the environment from unanticipated outcomes associated with selective breeding were relatively inconsequential. Given the present controversy about the risk levels associated with the production and consumption of GM food and fiber products, older people probably do not have access to information systems and educational experiences that would reduce concerns expressed about this new technology. Without exposure to scientific information about GM products, older people should perceive higher levels of potential threat associated with these products. It is hypothesized that age will be significantly related to attitudes toward GM products. Older individuals will exhibit more negative attitudes toward GM products.

Family income should affect attitudes toward GM products (Hoban 1998) because financial resources will affect access to learning opportunities and to education. Individuals who have higher incomes will have a greater opportunity to access information sources that provide scientific information about GM products and will be exposed to information that suggests that GM products pose a minor threat to the environment and human health. Greater disposable income should also increase the opportunity for varying food purchases and for modifying diets. It is hypothesized that income will be significantly related to attitudes toward GM products. Individuals who have higher incomes will exhibit less negative attitudes toward GM products.

Controllability factors

Farming status should affect attitudes toward GM products because agriculturalists have greater control over GM products than do other occupational groups. Although farmers cannot control GM ingredients in food and fiber products they consume, they do have control over the production of GM agricultural products on their farm. Farmers may view production of GM products as an extension of traditional selective breeding techniques and have little fear of biotechnological approaches to modification of plants and animals. Farmers also have a higher probability of being aware of the low health and environmental risks associated with producing GM products. It is hypothesized that farming status will be significantly related to attitudes toward GM products. Farmers will exhibit less negative attitudes toward GM products than nonfarmers.

Gender should affect attitudes toward GM products because males tend to perceive themselves to have more control over situations affecting their lives than females (Everson and others 2000). If males perceive they have more control over things that affect them, they should perceive greater control over threats posed by GM products. It is hypothesized that gender will be significantly related to attitudes toward GM products. Females will exhibit more negative attitudes than males toward GM products.

Percent food purchase should affect attitudes toward GM products because individuals who regularly make food purchases can seek information about the contents of the food being consumed within the household. Due to the higher level of awareness produced by information seeking, individuals making regular food-purchase decisions will become more knowledgeable about current research that suggests GM food products pose little threat to human health. It is hypothesized that the percentage of household food purchases will be significantly related to attitudes toward GM products. Individuals who have greater responsibility for food purchasing within the household will exhibit less negative attitudes toward GM products.

The number of children in a household should affect attitudes toward GM products because parents are concerned about protecting the health and well-being of their children (Dosman and others 2001). Parents will seek to control access of their children to GM food and fiber products that could *potentially* harm them. It is hypothesized that the number of children in the household will be significantly related to attitudes toward GM products. Individuals with more children living at home will exhibit more negative attitudes toward GM products.

Methods

Sample selection

Data were collected from adult residents living in 902 Ohio households. An urban sample and a rural sample were drawn from existing lists of known populations. The urban portion of the study sample was drawn from the telephone directory of Columbus, Ohio. The rural portion of the study sample was drawn from the membership list of the Ohio Farm Bureau that is purported to contain the names and addresses of approximately 80% of all agriculturalists in the state. Individuals on the list who indicated they were not involved in some type of agricultural production were eliminated from the sampling frame. A systematic random sample was drawn from the list of members who were farmers. In an attempt to secure an equal number of respondents from each population source, a systematic random sampling approach was developed to select approximately equal numbers from each list. Using this approach, 1365 urban subjects and 1086 rural subjects were selected (2451 total). Twenty-one names and addresses in the Columbus sample were eliminated from the study group because they were businesses. The final study sample was composed of 2430 households.

Questionnaires were mailed to both the urban and rural samples in the early winter of 2003. A cover letter explaining the purpose of the study and a stamped, self-addressed return envelope were also included in the mailing. Approximately 3 wk after the initial mailing, a second wave of mailing to nonrespondents was initiated. A 3rd mailing was posted to nonrespondents approximately 3 wk later. A total of 1276 questionnaires were returned from the 3 mailings, which constitutes 52.5% of all households included in the initial sampling. Such a percentage for a mailed questionnaire survey is considered to be quite good using contemporary social science research standards. A total of 902 returned questionnaires were sufficiently completed for use in statistical modeling.

Table 1—Characteristics of study respondents (n = 902)

Characteristic	Descriptive data	
Age	Mean = 54.0 y	S.D. = 14.7 y
Education	Mean = 14.5 y	S.D. = 2.9 y
Gender	Male = 72.7%	Female = 27.3%
Number of children under 18 living at home	Mean = 0.6	S.D. = 1.0
Children less than 3 y of age living at home	Yes = 7.2%	No = 92.8%
Nonfarm income:		
Less than $20000	16.2%	
20001 to 30000	12.8%	
30001 to 40000	10.3%	
40001 to 50000	11.6%	
50001 to 60000	8.5%	
60001 to 70000	6.9%	
70001 to 80000	6.3%	
80001 to 90000	3.1%	
90001 to 100000	4.7%	
100001 to 110000	3.7%	
110001 to 120000	2.4%	
More than 120000	7.3%	
Missing data	6.2%	
Engaged in farming	Yes = 43.7%	No = 56.3%

Data collection instrument

Data were collected using a structured questionnaire that was designed to secure information about the attitudes of respondents toward production of GM plants and animals, perceived risks associated with GM products, and personal characteristics of respondents. Factors included in the statistical modeling to examine the merits of the theoretical perspective used to guide the investigation were measured in the following manner.

Dependent variable

Attitude toward GM products was chosen as the dependent variable for this study and was measured using 8 Likert-type (Edwards 1957; Nunnally 1978) attitude scale items. The possible responses ranged from "strongly agree" to "strongly disagree" and were weighted 1 to 5. The possible range of scale scores was from 8 to 40, with higher scale scores representing more negative attitudes toward GM products. The 8 attitude items assessed ethics associated with use of GM food and fiber products, socioeconomic impacts of GM products, and the right of humans to develop GM products. Item analysis of responses to the scale items produced an alpha coefficient of reliability of 0.92 (Cronbach 1951). Such a high alpha indicates the 8 items composing the scale are highly intercorrelated and can be legitimately summed to form a composite scale score.

Independent variables

Nine variables were chosen to represent various elements of the theoretical perspective used to guide the investigation. The factors chosen were as follows: attitude toward perceived risk, importance of information channels, education, age, income, farming status, gender, percent food purchases, and number of children less than 18 living at home.

Level of perceived risk

Perceived risk was assessed by asking respondents to rate the level of risk, with 9 possible outcomes, associated with production and consumption of GM plants and animals. The possible responses ranged from "no risk" (weighted 0) to "high risk" (weighted 10). The range of possible scale scores was from 0 to 90 with higher scale scores representing higher levels of perceived risk. The 9 outcomes evaluated were impacts on human and animal health, the environment, the economy, and pests. Item analysis produced an alpha coefficient of reliability (Cronbach 1951) of 0.96, which means the items are very highly correlated and that the weighting values can be legitimately summed to form a composite scale score.

Importance of information channels

The importance of printed and electronic channels for accessing information about GM products was measured by asking respondents to circle a number along a continuum with responses ranging from 0 (no importance) to 10 (high importance). The media assessed were as follows: television news reports, radio, magazines, and newspapers. Item analysis produced an alpha coefficient of reliability of 0.90, which means the items are very highly correlated and that the weighting values can be legitimately summed to form a composite scale score.

Education. Education was measured as the highest year of education completed by the respondent.

Age. Age was measured as the age of the respondent at last birthday.

Income. Income was measured as the total nonfarm family income for the 2001 tax year. Twelve categories of income were provided that ranged from less than $20000 to more than $120000. The categories were weighted 1 to 12 and used for statistical analysis.

Farming status. Farming status was measured as a dummy variable with a value of 1 representing farmers and a value of 2 for nonfarmers.

Gender. Gender was measured as a dummy variable with males receiving a value of 1 and females a value of 2.

Percent food purchase. Percent food purchase was measured by asking respondents to indicate the percent of responsibility they have for making food purchasing decision for the household. The range of possible responses was from 0% to 100%.

Number of children in household. The number of children in the household was measured as the number of children under 18 y of age who were living at home at the time of the data collection.

Statistical analysis. Descriptive statistics were used to examine

Table 2—Attitudes toward genetically modified organisms, presented in percentages (n = 902)[a]

Statement	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Mean	S.D.
	Possible response						
It is ethically acceptable to genetically modify animals[b]	9.0	21.5	21.9	26.6	21.0	3.3	1.3
Farmers should be encouraged to produce GMO agricultural products[b]	8.9	21.3	36.3	19.4	14.1	3.1	1.1
Economic benefits of GMOs outweigh environmental risks posed by them[b]	12.3	23.8	30.7	21.1	12.1	3.0	1.2
No one has the right to prevent farmers from producing GMO products[b]	17.9	34.6	20.6	18.1	8.8	2.7	1.2
The government should ban experiments that produce GMOs[c]	11.5	14.7	23.4	30.6	19.8	2.7	1.3
It is ethically acceptable to genetically modify plants[b]	17.1	41.1	18.1	13.5	10.2	2.6	1.2
Research to develop GMO plants should be encouraged[b]	19.4	37.8	19.8	13.5	9.4	2.6	1.2
Human beings have the right to modify the basic genetic structure of plants[b]	14.8	40.3	22.9	12.9	9.2	2.6	1.2

[a]Percentages may not sum to 100.0 due to rounding error. Alpha for scale = 0.92; Scale mean = 22.4; S.D. = 7.7.
[b]Responses weighted 1 to 5 with "strongly agree" receiving a 1 and "strongly disagree" receiving a 5.
[c]Responses weighted 5 to 1 with "strongly agree" receiving a 5 and "strongly disagree" receiving a 1.

Table 3—Perceived level of risk associated with production and consumption of genetically modified organisms presented in percentages (n = 902)[a]

	Level of risk													
	No risk		Little risk	Some risk			Considerable risk			High risk				
Possible outcome	0	1	2	3	4	5	6	7	8	9	10	MD	Mean	SD
Creation of pesticide-resistant weeds	3.2	4.3	6.0	7.1	8.3	18.1	9.7	10.0	11.1	5.2	14.1	2.9	5.8	2.8
Creation of pesticide-resistant insects	3.3	4.4	7.7	8.0	7.8	20.5	9.7	9.4	10.5	4.9	13.7	0.1	5.7	2.8
Destruction of beneficial insects	4.4	5.5	8.3	8.5	10.2	19.0	8.2	7.8	9.4	4.9	13.5	0.1	5.4	2.9
Loss of global markets for U.S. agric. products	3.8	2.6	10.2	9.9	8.8	20.2	8.9	9.4	7.3	3.9	12.1	3.0	5.4	2.7
Harm to wildlife	9.4	8.5	11.4	10.7	8.3	13.9	5.7	5.9	5.9	5.5	12.3	2.4	4.7	3.2
Human health problems	8.3	5.5	15.3	11.9	7.8	16.9	5.7	5.5	8.2	2.6	10.0	2.3	4.6	2.9
Animal health problems	8.5	6.8	14.2	11.8	7.7	16.8	5.4	6.4	6.7	3.2	10.1	2.4	4.6	3.0
Environmental damage	11.5	8.5	15.0	11.0	7.9	12.8	5.6	5.7	6.5	3.2	9.7	2.7	4.1	2.9
Loss of agricultural productivity	10.5	9.5	15.4	14.0	7.1	15.0	4.8	4.9	5.4	2.3	8.2	2.8	4.1	2.9

[a]Percentages may not sum to 100.0 because of rounding error. Alpha for scale = 0.959; scale mean = 44.6; SD = 22.8.
MD = missing data.

general trends in the data set, whereas linear regression (Pedhazur 1982) was used to assess the merits of the theoretical modeling for predicting variability in attitudes toward the production and consumption of GM products. Missing data were attributed to the variable mean (Donner 1982), which has been demonstrated to be the best means of salvaging cases when the sample size is large, when missing data constitute a small percentage of the total data set, and when the correlations[2] are moderate to low. All of these conditions were satisfied within the data set.

Results

Descriptive findings

Characteristics of the study sample are presented in Table 1. Respondents tended to be well-educated, middle-aged males who reported moderate incomes. Relatively few children under the age of 18 remained in respondent households. Approximately 44% of the respondents indicated that some member of the household was engaged in farming.

Descriptive findings for attitudes toward GM products are presented in Table 2 and demonstrate that respondents perceived these products in a slightly positive manner.

Respondents believed that it is ethically acceptable to modify plants but not animals. Respondents were neither positive nor negative about encouraging farmers to produce GM food and fiber products and about the economic benefits of GM products compared with environmental costs. Respondents believed that no one has the right to prevent farmers from producing GM products and were opposed to government suppression of GM product experimentation. Respondents were most positive about the ethical acceptability of genetically modifying plants and for humans to engage in research and development of GM products. The mean scale value for attitude toward GM products was 22.4, which is lower than the median possible score of 24. This finding indicates the group was slightly positive toward GM products.

Descriptive findings for perceived level of risk associated with possible outcomes of producing GM food and fiber are presented in Table 3. Findings demonstrated that respondents believed there are some risks associated with adoption of GM products. Study participants were most concerned about the creation of pesticide-resistant weeds and insects. They were least concerned about loss of agricultural productivity and environmental damage.

Multivariate findings

Multiple linear regression analysis was used to assess the merits of the theoretical hypotheses. The regression findings are presented in standardized regression coefficient form and the variables shown to be significant beyond the 0.05 level are identified with an asterisk.

$$Y = 0.744X_1^* - 0.087X_2^* + 0.086X_3^* + 0.071X_4^* - 0.038X_5 - 0.031X_6 + 0.029X_7 - 0.028X_8 - 0.006X_9$$

where Y = attitude toward GM products; X_1 = level of perceived risk; X_2 = importance of information channels; X_3 = gender; X_4 = farming status; X_5 = nonfarm income; X_6 = education; X_7 = age; X_8 = percent of food purchase; X_9 = number of children in household.

The coefficient of determination of the regression model was 0.606, which means that 60.6% of the variance in the dependent variable was explained. Such a level of explained variance is considered to be very high using contemporary social science research standards.

Four variables were shown to be significant in reducing the unexplained variance in attitudes toward GM products. The significant variables are "level of perceived risk," "importance of information channels," "gender," and "farming status." As the level of perceived risk associated with production of GM products increased, there was a concomitant increase in negative attitudes toward GM products. As importance of printed and electronic channels for securing information about GM products increased, attitudes toward GM products became less negative. Females exhibited a slightly more negative attitude than males toward GM products. Nonfarm respondents exhibited a slightly more negative attitude toward GM products than people with family members engaged in farming. All of the significant relationships were consistent with research hypotheses.

Conclusions

Study findings indicate that respondents held slightly positive attitudes toward GM products as measured in this study. However, respondents perceived some risk associated with their production. These findings are consistent with those of Kaneko and Chern (2003) and Hoban (1998).

Regression findings revealed the theoretical model to be very good for predicting attitudes toward the production of GM products. The findings for the 4 factors shown to be significant beyond the 0.05 level were consistent with the theoretical perspective used to guide the study. It is concluded that the theoretical perspective developed to assess attitudes toward GM products as it was operationalized in this study was very useful for that purpose.

Regression findings indicate the strongest explanatory factor is level of perceived risk. The perceived risk variable explained practically all of the total variance in the statistical model (55.4% of the total variance explained). Individuals who perceived higher levels of risk exhibited more negative attitudes toward GM products. This finding indicates that attitudes toward GM products are very strongly influenced by perceived consequences associated with adoption of the innovation. If individuals perceive that GM products pose a significant risk to human health, animal health, and the environment, then perceptions of GM products will be more negative. It is highly probable that the inclusion of additional factors assessing consequences associated with adoption of GM products will improve the statistical model.

The policy implication of the risk finding is that GM products will not be widely accepted unless potential adopters become convinced that risks associated with adoption are within acceptable levels. One means of reducing perceived risk associated with GM products is through public investment in research, which was supported by respondents to this study (see "Research to develop GMO plants should be encouraged," Table 2). Expanded public investment in biotechnology research and carefully coordinated dissemination of research findings could substantially reduce the level of perceived risk associated with the production and consumption of GM products. Information provided to society should emphasize how consumers benefit from biotechnology research and provide data to demonstrate the impacts of GM products on human health and environmental quality.

The information channels finding provides insight relative to how to deliver messages about GM products to potential adopters. The importance placed on printed and electronic media channels demonstrated that individuals who placed greater importance on such delivery systems held more positive attitudes toward GM products.[3] This is probably due to more objective presentation of information about GM products via these channels. It could also be a partial function of increasing familiarity with the GM product debate that has occurred over the past 10 years. Research has been generated that shows GM products to have little negative impact on the environment and human health. This familiarity with outcomes apparently has produced more favorable attitudes toward GM products. Research findings about the consequences of adopting GM products should be disseminated via all communication channels; these findings suggest that printed and electronic channels appear to have significant impact on potential adopters.

Gender findings indicate that females exhibited a slightly more negative attitude toward GM products, which is consistent with previous research (Bonny 2003). Scientific research findings focused on the consequences associated with adoption of GM products should be directed specifically to females. Targeting this specific group of potential adopters with findings about the consequences of producing GM products could provide females with more information for making informed adoption decisions. This is especially important because females tend to assume more responsibility for making food purchases.

The farming status finding adds credibility to the concept of controllability in the decision-making process about adopting GM products. Farmers can exhibit control over the production of GM food and fiber products, and as a result they are less negative toward GM products.

Greater effort should be made in the public policy arena to provide potential adopters with more control over the production and consumption of GM products. One means of doing so is via product labeling, which has triggered controversy and debate within the United States and other countries (Bonny 2003). Although labeling of GM foods is currently not required in the United States, its supporters contend that consumers have a right to be informed if GM ingredients are in their food products. Opponents maintain that GM foods do not differ substantially from conventional foods and that labeling of such food products will create unwarranted apprehension on the part of consumers. Recent research conducted by Tegene and others (2003) confirms that labeling does have a significant impact on consumer acceptance of GM foods. Using an experimental research design, the authors found that the presence of GM food labeling reduced the amount consumers were willing to pay for various products by an average of 14%. However, it is possible that public perceptions of GM products might become more positive in the future as genetically engineered foods are introduced that have more obvious benefits to consumers, such as enhanced taste (NCB 1999).

Among the significant challenges facing proponents of labeling are the cost and bureaucratic difficulties in implementing such a system (Uzogara 2000). Doerfert and others (2003) point out that consumer fears of higher product costs and bureaucratic involvement in the marketing system were major reasons that Oregon voters rejected a state referendum in 2002 that would have required labeling of GM foods. Despite these difficulties, it is possible that benefits associated with empowering producers and consumers with the ability to elect not to produce and not to consume such products could result in wider acceptance of GM products. Individuals could elect to avoid GM products, while simultaneously supporting the right of others to produce and consume GM products.

Additional research is needed to assess the costs and benefits of labeling and its appropriateness for different types of GM products.

Evidence produced via this study strongly suggests that level of perceived risk is the critical factor affecting attitudes about the production and consumption of GM products. Research needs to be initiated on other types of perceived consequences associated with adoption of GM products. It is highly probable that other measures of risk will be shown to be useful predictors of attitudes toward GM products. Risk analyses and other modes of social scientific research may add additional insight to what types of public policies will be required in the future to bring the contemporary controversy about the threat posed by GM products to a closure. A major contribution of such research is not in dictating whether GM products should or should not be produced and marketed, but in aiding scientists and policymakers to better understand the basis of public opinion and consumer sentiment that could encourage or hinder adoption of such products. There will probably never be consensus on the level of risk associated with GM products; however, public policies will be in place that will govern how and when such products can be released for public consumption and who assumes the responsibility for any unanticipated consequences associated with their production and consumption..

Endnotes

[1]It should be noted that a number of difficulties and weaknesses have been identified in science reporting. For instance, media are limited in the amount of space or time that can be devoted to complex science topics, and reporters often lack adequate science training. Treise and Weigold (2002) found that science writers acknowledged that publicity and hype are common elements of current science communication that threaten the quality of information received by the public. Gunter and others (1999) found that both scientists and journalists questioned the quality of reporting on biotechnology issues. Content analyses conducted by the Intl. Food Information Council (2002) indicate that media coverage of biotechnology tends to focus heavily on alleged dangers and possible risks to human health, whereas far less attention is paid to the benefits of biotechnology. One conclusion is that consumers may not be receiving enough information to make judgments about food safety.

[2]Before regression modeling, a correlation matrix was computed to assess the level of intercorrelations among the independent variables. Little multicollinearity among the independent variables was observed. Therefore, all of the independent variables were included in the regression modeling.

[3]The findings for importance of channels reported in this study are not consistent with those reported by Loges (1994) and Coleman (1993). Previous research focused on the role of information channels and perceptions suggests that use of electronic and printed media channels frequently results in an increase in concern about health and other risk situations. Research should be initiated to assess how information channels have affected the public debate over GM products.

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