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Uncovering Factors Influencing Public Perceptions of Food Biotechnology

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Abstract

Significant divergence exists in public opinions about biotechnology. Although there is broad support for plant biotechnology for health benefits, opinions differ on the issue of animal genetics for pure economic benefits. While some are opposed to it, many are undecided about genetically modified foods. Considerable skepticism exists about scientists, corporations and government which have negative influence on public acceptance of food biotechnology. Consumers' personal attributes have significant influence on their views about various biotechnology issues.

Introduction

The application of biotechnology in the production of food, fiber and pharmaceutical is a major development of the late 20th century. This emerging technology is often viewed as the next revolution which has the potential to fundamentally alter the way the society organizes its production and distribution of food. Billions of dollars have already been invested in biotechnology research and new product development. Science and technology is poised to bring consumers a wide range of genetically modified (GM) products. In fact, many GM products have already entered our food distribution chains. These products have the potential to not only meet our basic needs, but also bring a wide range of economic, environmental and health benefits. Despite its promise to bring significant benefits to society, public acceptance of food biotechnology has been mixed in the U.S. and elsewhere (Einsiedel, 1997; Gamble *et al*., 2000; Hoban, 1999; Kelley, 1995; Macer *et al*., 1997; Hallman *et al*., 2002). Biotechnology advocates emphasize the potential benefits to society via reduction of hunger and malnutrition, prevention and cure of diseases, and promotion of health and general well-being (Isserman, 2001). On the other hand, opponents view its use as a needless interference with nature that may lead to unknown and potentially disastrous consequences (Nelson, 2001).

In the U.S., GM crops entered the grain supply channels without raising major public concern. However, agricultural biotechnology has met considerable opposition in Europe and many developing countries. Responding to apparent public concerns about the perceived risks to humans and the environment, European Union (EU) imposed quite restrictive regulations on all transgenic crops in any portion of the EU food system (Grossman and Endres, 2000). In the U.K., protestors destroyed GM crops on several occasions. Until recently, Brazil and India

refused to approve any GM crop. Due to similar consumer concerns, McDonalds and Frito-Lay have decided not to use GM potato in their products.

Some oppose the use of genetic technologies in agricultural production alleging (perceived) risks to humans and environment, while others oppose it citing moral, ethical and social concerns. Biotechnology is often criticized on the ground that its use in plants and animals, especially gene transfer across species, take us to "realms of God" and against "Law of Nature". Some argue that since genes are naturally occurring entities that can be discovered (not invented), granting patent ownership to genetic findings and processes is morally and ethically untenable.

Public discourse on agricultural biotechnology has also raised some social and political debates. It has been argued that modern genetic technologies may allow developed countries produce commodities that are currently imported from developing countries. Such developments, it is claimed, will have significant negative effects on poverty situation in the Third world and lead to global instability (Junne 1991; Galhardi, 1995). Other researchers, however, maintain the opposite view (e.g., Watanabe, 1985). Another source of concern is that, under the existing arrangements, farmers will eventually become permanently dependent on multinational corporations for their "means of production" which may bring adverse economic, social and political outcomes.

Given the significance of the subject, full understanding of public interests and concerns is needed to arrive at sound private and public decisions pertaining to food biotechnology. However, very few studies have systematically explored the underlying factors influencing the acceptance of food biotechnology among consumers. In a recent study, Moon and Balasubramanian (2001) found that consumer acceptance of biotechnology was significantly related not only to their perceptions of risks and benefits associated with GM products, but also

to their moral and ethical views. Further, public views about multinational corporations, trust in government, and knowledge of science and technology also influenced their attitudes towards biotechnology. Baker and Burnham (2001) found that consumers' cognitive variables (e.g., levels of risk aversion, opinions about GM foods) influenced their acceptance of GM food products, whereas the socio-economic variables did not have significant effects.

Public perceptions of biotechnology have multiple dimensions and are likely to be influenced by multiple forces, preferences and events. For instance, positive benefits (e.g., nutritional benefits from improved and new products, environmental benefits via reduced use of pesticides, etc.) are likely to encourage consumer acceptance of food biotechnology. On the other hand, perceptions of risks to humans and environment are likely to have adverse effects on public acceptance of GM products. Also, factors such as public confidence in government, scientific community and biotechnology companies are expected to influence consumers' attitudes towards this emerging technology. Similarly, people's social, political, religious and moral/ethical views are likely to affect their perceptions of biotechnology and acceptance of GM food products (Hamstra, 1995; Wanskin and Kim, 2001).

This study explores the underlying factors influencing consumer attitudes towards food biotechnology. The objectives of the study are as follows: (i) identify and estimate the relative importance of the factors underlying public acceptance of food biotechnology; (ii) identify distinct consumer segments by the importance they place on various issues relating to biotechnology; (iii) develop a profile of these distinct consumer groups; and (iv) explore the relationship between consumers' socio-economic characteristics and their views about the issues that influence public acceptance of (or resistance to) food biotechnology.

Data and Methodology

This study uses data from a national telephone survey of public attitudes towards various issues pertaining to the use of biotechnology in agriculture. These included subjects such as approval of genetic modifications of plants and animals to develop products that will bring specific health and economic benefits, moral and ethical concerns about plant and animal genetics, perceptions of health and environmental risks associated with biotechnology, and willingness to accept GM food products.

Information was also collected on consumers' socio-economic and value characteristics. These included data on age, education, income, gender, employment status, family size, ethnicity, religious practices, and socio-political views. The survey also elicited respondents' views about scientists and companies involved in biotechnology research, as well as their confidence in the government's ability and willingness to protect public interest. To obtain an objective measure of scientific knowledge, respondents were asked a set of 10 basic questions on science relating to biotechnology. The responses to these questions were evaluated and the number of correct responses was used as measure of their understanding of science.

The survey was conducted in March-April, 2001, by American Opinion Research, a division of Integrated Marketing Services, Princeton, New Jersey, on behalf of the Food Policy Institute at Rutgers University. The targeted sample frame was the non-institutional U.S. adult civilian population (18 years or older). A random proportional probability sample drawn from the more than 97 million telephone households in the U.S. was purchased from Survey Sampling, Inc. The target sample size was set at 1200 to achieve a sampling error rate of +/-3%. Each working telephone number was called a minimum of three times, at different times of the week, to reach people who were infrequently at home. Quotas were set to ensure that representative numbers of

males and females were interviewed. Using a computer-assisted telephone interview (CATI)

system, of 1203 phone surveys were completed which represented a response rate of slightly

over 50 percent. However, after excluding the non-respondents to specific questions relevant for

this study, a total of 737 completed surveys were used for empirical analysis.

A list of 34 questions relating to consumers perceptions of biotechnology and acceptance of GM

food were selected for this analysis. These questions explored how people valued the potential

benefits that biotechnology could bring to society, their perception of risks associated with the

use of genetic modification in plants and animals, as well as their views about private and public

institutions associated with biotechnology development. Respondents were presented with

various issues relating to the use of genetic technologies in food production, and were asked to

rate their agreement or disagreement on a scale of 1 to 4 (1 representing strong disagreement and

4 representing strong agreement). These responses were analyzed to identify the underlying

factors influencing public attitudes towards food biotechnology.

In identifying the various dimensions of public perceptions of food biotechnology, the analysis

was conducted in multiple phases. First, the principal components factor analysis was used to

reduce the 34 questions exploring consumers' views on the subject to a smaller and more

focused set of dimensions. Following a standard latent root equals one and scree test to guide the

first rotation, a number of trial rotations were obtained to compare factor interpretability. Then

confirmatory analysis was undertaken to check for factor stability. Finally, a total of six

underlying dimensions were identified that were stable and easy to interpret. The standardized

factor scores (zero mean and unit variance) for each respondent, obtained from the factor

analysis, were saved for later analysis.

In phase two of the analysis, factor scores identified in phase one were subjected to a two-stage cluster analysis (Punj and Stewart, 1983; Milligan, 1980) to identify groups or clusters of respondents with similar views about food biotechnology. First, a Ward's minimum variance algorithm using squared Euclidean measure of inter-object similarity was used to determine the initial clustering solution, the number of clusters and cluster cetroids. Individual cases were then subjected to non-hierarchical clustering algorithm (Hair *et al*., 1992) to obtain the final clusters. Using criteria of increases in cluster coefficients as clusters merge, interpretability and external validity, the analysis identified five clusters of the respondents based on the weight they placed on the factors underlying their attitudes towards food biotechnology.

The next phase of the analysis involved substantiating the differences across clusters by testing for significant differences in descriptive variables. Specifically, ANOVA and Duncan's multiple range tests of homogeneity (adjusted for unequal cluster size) and the Chi Square test of independence were used to test for inter-cluster heterogeneity in the socioeconomic and value attributes of the respondents.

Finally, standard econometric methods were used to explore the relationship between the dimensions of public perceptions of food biotechnology and the respondents' personal attributes. Specifically, multivariate regression analysis was used to estimate the influence of consumers' socio-economic and value characteristics on the standardized factor scores that reflected their attitudes towards food biotechnology.

Empirical Results

The empirical results and discussions are presented in the following three subsections. First, the factors underlying consumers' attitudes towards food biotechnology are identified and described on the basis of the results of principal component factor analysis. The next subsection

presents the results of a cluster analysis used to identify distinct consumer clusters with similar views on the subject. The regression results relating the personal attributes of the respondents and the dimensions of their views about food biotechnology are discussed in the final subsection.

The mean and standard deviation of responses to the 34 questions about public attitudes towards food biotechnology are presented in Table 1. These summary statistics show a broad public approval of biotechnology in developing new and improved products that will bring specific health and economic benefits. The support is particularly high for its use to bring health and nutritional benefits. However, public acceptance declines considerably when people are confronted with the issue of genetic modifications in animals. The mean scores also reveal public support for regulation of GM products, fear of accidents from genetic manipulations of species, and considerable skepticism about scientists and companies involved in biotechnology research. Although mean score suggest some support for using GM products as part of meals to "other groups", the relatively higher standard deviations suggest lack of strong consensus on the issue. Average scores also indicate public interest to "know more" about various biotechnology issues, as well as lack of confidence in the government's ability to properly regulate GM products.

Dimensions of Public Perceptions of Food Biotechnology

The factor loadings from the principal component factor analysis obtained after a varimax rotation of consumers' responses to the 34 questions relating to their views about biotechnology and attitudes towards GM food are presented in Table 1. Factors are ranked in order according to the proportion of variance explained and are named to reflect the latent stimuli underlying consumers' views about biotechnology and GM foods. The analysis identifies six key factors influencing people's opinions about the subject. These six factors, which account for about 63 percent of the total variance, are summarized as follows.

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Self Protection Attitude (factor 1): This factor reflects respondents' self-protection attitude in the sense that individuals view GM food products with some caution. They are cautious about the potential (unknown) risks associated with GM products. They need to confirm the safety of GM foods by observing the effects of these products on other individuals. This *wait and verify safety* attitude is reflected by the high factor loadings of respondents' approval of GM foods as part of meals served to the homeless people, needy children, military personnel, at hospitals and as aid to foreign countries. This factor accounts for 19.20 percent of the total variance.

Health and Economic Benefits (factor 2): This factor embodies the promise of biotechnology to deliver specific benefits to humans and environment (e.g., health and nutritional benefits, reduced production costs, improved taste and prolonged shelf-life of products, reduced pesticide use, etc.). This is reflected in the high factor loadings associated with consumers' approval of biotechnology to create products that carry various health and economic benefits. These benefits are at the core of public support for food biotechnology. This factor accounts for 18.47 percent of the total variance.

Fear and Skepticism about Biotechnology (factor 3): At the heart of public opposition to biotechnology is the perception of (unknown) risks associated with its use in food production. It reflects not only the public concerns about the safety (for people and the environment) of GM products, but also considerable skepticism about the developers of these products. This is evident in the high factor loadings for questions about environmental risks of biotechnology, willingness to accept GM foods, and skepticism about scientists and corporations involved in genetic research. This factor accounts for about 14 percent of total variance.

Enthusiasm about Biotechnology (factor 4): This factor reflects high enthusiasm among many about biotechnology. Individuals in this group are firm believers in "the wonders of science and

technology." Generally overly optimistic, these individuals are the most ardent advocates of the biotechnology and perhaps will be the first to accept GM foods. This factor accounts for 3.97 percent of the total variance.

Willingness to Learn about Biotechnology (factor 5): This factor reflects an open mindedness among many regard various issues relating to biotechnology and GM food products. The high loadings associated with information gathering activities (e.g., watching television programs and reading about biotechnology, willingness to engage in public debates on biotechnology) suggest that many in society are yet to reach a definitive position on the subject. These individuals are seeking more information on the benefits and risks of biotechnology to make up their minds. This factor accounted for 3.90 percent of the total variance.

Confidence in Government Regulation

This factor represents a lack of confidence among many in the ability of government to protect the interest of the common people. The lack of faith in the government regulatory system is a source of uneasiness among some consumers who have concerns about the safety of GM products. It highlights the need for a credible regulatory system to alleviate public concerns about the safety of GM products. This factor accounts for 3.33 percent of total variance.

Cluster Analysis

The results of cluster analysis of consumers' responses to various questions about biotechnology suggest that the respondents can be classified into five groups (clusters) on the basis of their views about biotechnology. The mean factor scores and the associated standard deviations obtained from the cluster analysis are reported in Table 2, while the distribution of respondents across these clusters is presented in Figure 1. The estimated F-statistics from the ANOVA analysis (Table 2) suggest significant inter-group variations in the importance placed

by respondents on the six factors underlying public attitudes towards biotechnology and GM foods. The five groups (clusters) of respondents are described below and are named to reflect the dominant issue affecting their views about biotechnology, as reflected by the mean factor scores.

Benefit Seekers: The leading issue to the members of this group is the promise of biotechnology to deliver a wide range of benefits. This is reflected by the high score on the health and economic benefit factor (factor 2). About a fifth of the survey participants belong to this group. The factor scores suggest that consumers in this group are willing to learn more about biotechnology issues and have some degree of concern about the safety of this technology.

Self Protectors: About a quarter of the survey respondents belong to this group. Self protection is their highest priority, as is reflected by the high score on the self-protection factor (factor 1). Individuals in this group are unwilling to be the first ones to consuming GM foods. They prefer to verify the safety of biotechnology from the use of GM foods by others. Other factor scores suggest that consumers in this group are also concerned about the government's ability to properly regulate GM products.

Biotechnology Opponents: Respondents in this group are opposed to the use of biotechnology in food production. Their skepticism of and opposition to genetic technologies is reflected by the high score on the fear and skepticism factor (factor 3). Consumers in this group also reveal concern about the government's ability to properly regulate GM products. These are the passionate opponents of biotechnology who are unlikely to accept GM foods. However, with only 13 percent of the respondents, this is the smallest of five groups identified by cluster analysis.

Open Minded Biotechnology Learners: This is the largest of the five groups of respondents classified by the cluster analysis. About 27 percent of the respondents belong to this group.

People in this group are willing to learn more about biotechnology, as is reflected by the high score on the willingness to learn factor (factor 4). Other factor scores reveal some degree of self protection attitude and concern about government's ability to regulate GM products.

Biotechnology Optimists: This group is so named because of the high factor score associated with optimism about biotechnology (factor 6) among these consumers. About 15 percent of the respondents belong to this group. Despite their optimism about biotechnology, consumers in this group place some importance on self protection, and reveal some concern about the safety of this technology and the government's ability to regulate GM products in the best public interest.

Table 3 presents the socio-economic characteristics of the respondents in each of the five groups identified by the cluster analysis. Table 3 shows that relatively more male respondents are biotechnology learners and benefit seekers while more females are skeptics and self protectors. Young consumers (age less than 35 years) are far less skeptical of biotechnology than the middle aged and older individuals. Most of the middle aged respondents are biotechnology learners and self protectors, whereas most of the older consumers are either self protectors or benefit seekers.

More than a third of the college educated respondents belong to biotechnology learner group, whereas only 11 percent of those with a maximum of high school diploma belong to this group. Compared to college educated consumers, almost twice as many individuals with a high school diploma or less are biotechnology skeptics. Also, people with less education are more self protecting than those with higher education. Relatively more consumers from the lowest income group (i.e., annual income less than $35,000) are biotechnology skeptics and are less willing to learn about it. Respondents with higher incomes are mostly biotechnology learners and self protectors. Individuals in the five clusters do not differ significantly in terms of their social/

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political views and place of residence, although there is some indication that liberals are more skeptical and less optimistic about biotechnology.

Relatively more whites (Caucasians) are self protectors and biotechnology learners, whereas relatively more non-whites are benefit seekers and biotechnology optimists. There seems to be no difference across races in terms of their opposition to biotechnology. Religious individuals are more skeptical, more self protecting, less willing to learn and less benefit seeking than those who do not consider themselves as religious. Similarly, people with below average knowledge of science are more skeptical and self protecting, and less benefit seeking and willing to learn about biotechnology than those with above average knowledge of science.

Explaining Factors Driving Public Perceptions of Food Biotechnology

The relationship between the factors underlying public perceptions of food biotechnology and the respondents' personal attributes is explored via standard regression analysis. The dependent variables in the regression equations are the standardized factor scores obtained from the principal component analysis. The explanatory variables used in these models are as follows.

Age: Three dummy variables representing three age groups are defined as follows: (1) *YOUNG* equals 1 if the respondent is younger than 35 years and 0 otherwise; (2) *MIDAGE* equals 1 if the respondent's age is between 35 and 54 years and 0 otherwise; and (3) *MATURE* equals 1 if the individual's age is 55 years or more and 0 otherwise.

Income: Three dummy variables corresponding to three income levels are defined as follows:

(1) *LOWINC* equals 1 if the household annual income is less than $35,000 and 0 otherwise;

(2) *MIDINC* equals 1 if household income is between $35,000 and $75,000 and 0 otherwise; and

(3) *HIGHINC* equals 1 if the annual household income is $75,000 or more and 0 otherwise.

Gender: The variable *MALE* is assigned a value of 1 if the respondent is male and 0 otherwise.

Education: Three dummy variables representing three educational levels are defined as follows: (1) *HISCHOOL* equals 1 if the respondent has a high school diploma or less and 0 otherwise; (2) *COLLEGE* equals 1 if the individual has an associate or a four-year college degree and 0 otherwise; and (3) *GRAD* equals 1 if the respondent has graduate education and 0 otherwise.

Race: The variable *WHITE* is assigned a value of 1 if the respondent is white and 0 otherwise.

Social/Political View: Three dummy variables corresponding to the three self-reported social/ political views are defined as follows: (1) *CONSERVATIVE* equals 1 if the respondent described himself/herself as conservative and 0 otherwise; (2) *LIBERAL* equals 1 if he/she describes himself/herself as liberal and 0 otherwise; and (3) *CENTRIST* equals 1 if the he/she describes himself/herself in between liberal and conservative and 0 otherwise.

Religion: Respondents are classified into two groups on the basis of their attendance at church or other house of worship. Accordingly, the dummy variable *WORSHIP_REG* is assigned a value of 1 if the respondent regularly (at least several times a month) attends church and 0 otherwise.

Trust in Government: The dummy variable *TRST_GVT* is given a value of 1 if the respondent somewhat or strongly agrees with the statement "Government regulators have the best interest of the public in mind" and 0 otherwise.

Knowledge of Science: Respondents are classified into two groups based on their self-reported knowledge of science relating to biotechnology. Hence, the variable *KNOWSC* is given a value of 1 if an individual rated his/her knowledge of science as "excellent" to "good" and 0 otherwise.

Moral View of Biotechnology: An individual's moral view about biotechnology is captured in the dummy variable *GM_MORAL* which is assigned a value of 1 if he/she does not report any moral objection to the use of genetic technologies in plants and animals, and 0 otherwise.

Food Purchase Habit: To capture an individual's carefulness about what he/she purchases, the dummy variable *CHKLABEL* is defined by assigning a value of 1 if the person regularly checks food labels for product contents before buying, and 0 otherwise.

Initially, variables such as family size, employment and marital status, place of residence (i.e., big city or suburban), region were included in the regression equations. The coefficients of these variables were all statistically insignificant in all equations, and consequently, these variables were dropped from the final analysis.

The results of regression of factor scores on the set of explanatory variables discussed above are presented in Table 4. It is evident from Table 4 that respondents' personal attributes are significantly related to the six factors that underlie public opinions about food biotechnology. The estimated coefficients imply that, compared to older respondents (55 years or older), young consumers are less self protecting, less skeptical about biotechnology and less concerned about the government's ability to effectively regulate GM products. They are more enthusiastic about biotechnology, although they are not any different from others in terms of their views about the benefits of this technology and their willingness to learn more about it. Middle aged consumers are generally more self protective and willing to learn, but less enthusiastic about the technology, less concerned about the effectiveness of government regulations.

Male consumers are less self-protecting, less skeptical about biotechnology, and less concerned about the government's ability to regulate GM products compared to females. They place higher importance on the benefits of biotechnology and are more willing to learn about it. White individuals are less skeptical but less excited about this technology relative to non-whites. They put lower significance to the benefits of biotechnology and are less interested in learning

more it. However, there is no racial divide with respect to people's self-protection attitude and their views about government regulations.

Consumers with higher education are less skeptical and more willing to learn about biotechnology. However, education does not influence people's self-protection attitudes. College educated individuals seem to be less confident about government regulations. On the other hand, respondents with graduate education place significantly greater importance on the health and economic benefits of biotechnology. While individuals in the lowest income group are less self-protecting and more interested in learning about biotechnology, there is no difference between people in the middle and upper income groups in terms of their perceptions of biotechnology.

Religious individuals are more skeptical and less excited about biotechnology and place lower importance on the benefits of this technology. However, religion has no effect on people's self-protecting attitude, willingness to learn about biotechnology and confidence on government regulations. Those who have no moral objection to the use of genetic technologies are less skeptical and more optimistic about biotechnology. These respondents place relatively higher value on the benefits of this technology. Relative to the centrists, liberals seem to be more self-protective, more skeptical about biotechnology, less confident about government regulations, and view the benefits of this technology as less important. However, there is no difference between conservatives and centrists in terms of their attitudes toward food biotechnology.

Individuals who trust government are less skeptical and more enthusiastic about biotechnology. They put higher value on the benefits of this technology, and have greater confidence on government regulations. However, they are also more self-protecting. Consumers who regularly check food labels are more self-protecting, more distrustful and less optimistic about biotechnology. However, they are also less excited about the promise of this technology.

Finally, consumers with better scientific knowledge are interested in learning more about biotechnology. However, they are not different from those will weaker knowledge of science in any other aspect of their attitudes toward biotechnology and GM food products.

Conclusions

Despite major scientific progress in the application of biotechnology in agriculture, public attitudes towards biotechnology in general and GM food products in particular remain mixed. On the one hand, the public remains optimistic about the prospect of new and improved food and fiber that can bring a wide range of health and economic benefits. On the other hand, they are concerned about the perceived health, safety and environmental risks often associated with the use of this technology in plants and animals. This study explores the various dimensions of public perceptions of food biotechnology. Results indicate that overall public attitude towards food biotechnology is driven by six underlying factors. These range from excitement about the promise of biotechnology to bring tangible health and economic benefits to fear and distrust of the technology. In between, many people are undecided and are interested in learning more about the issues involved.

The results of cluster analysis suggest that different groups of people place varying importance on the underlying factors influencing public acceptance of food biotechnology. Some highlight the health and economic benefits of biotechnology while others are influenced by fear, distrust and skepticism about the technology. However, public opinions about biotechnology are affected by more than one factor. For example, individuals who exhibit self-protective attitude also reveal some degree of skepticism about biotechnology and lack of confidence about the government's ability to properly regulate GM products. Results also indicate considerable skepticism consumers about scientists and biotechnology companies involved in genetic research. Such

negative images of private and public institutions associated with food biotechnology are likely to have adverse affects on public acceptance of GM food products.

The results of this study also indicate that peoples socio-economic and value attributes influence their views about various issues pertaining to food biotechnology. Age, gender, racial background, education and religious views all influence public opinions about the use of genetic technologies in food production. Similarly, people's social and political views, shopping habits and income affect their perceptions of food biotechnology. Results also indicate that although there is broad public agreement for the use of biotechnology in plants in the interest of health and well-being, people are less comfortable with its use in animals or for purely economic reasons. However, the public seem to be interested in learning more about the issues involved before they arrive at definitive conclusions about the wisdom and desirability of biotechnology in the best interest of the society.

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Table 1. Varimax Rotated Factor Loadings about Perceptions of Biotechnology and Attitudes to GM Foods

	Mean	SD	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Factor 1. Self Protection Attitude								
Approve GM food as Part of:								
Meals to the military	2.49	1.03	0.862					
Meals to the needy children for free lunch	2.44	1.05	0.851					
Meals to the Homeless in the Shelters	2.55	1.03	0.851					
Meals to Hospital patients	2.42	1.06	0.840					
Food Aid to foreign countries	2.62	1.02	0.818					
Meals in restaurants	2.43	1.00	0.803					
Meals to prisoners	2.67	1.03	0.772					
Will serve GM food to friends	2.38	1.07	0.619					
Factor 2. Health and Economic Benefits								
Approve GM technology to create:								
Rice with enhanced vitamin A to prevent blindness	3.18	0.93		0.782				
More nutritious grain to feed people in poor countries	3.36	0.89		0.766				

	Mean	SD	Factor 1
Better tasting fruits and vegetables	2.98	1.03	0.750
Fruits and vegetables that are less expensive	3.03	1.03	0.744
Hormones like insulin that help people with diabetes	3.32	0.91	0.714
Sheep whose milk can be used to produce medicines	3.03	0.99	0.704
New types of grass that don't need to be mown more often	3.12	1.01	0.677
Fruits and vegetables that last longer on store shelf	2.74	1.07	0.663
Hormones to produce beef with less cholesterol	2.45	1.11	0.655
Hormones that enable cows to give more milk	2.68	1.09	0.562

(continued)

Table 1. Continued

	Mean	SD	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Skepticism/Fear about Biotechnology								
Even if GM has advantages, but it is against nature	2.61	1.04		0.698				
GM technology threatens nature	2.62	0.99		0.685				
Leave nature as it is/don't meddle with it	2.66	1.08		0.643				
Regulation is necessary given GM potential dangers	3.05	0.93		0.639				

Buy from grocery that sells only non-GM food	2.61	1.04	0.591		
Companies developing GM crops care more for profit than			0.584		
safety	2.88	0.98			
Serious accidents involving GM foods are bound to happen	3.16	0.86	0.581		
Willing to petition against GM	2.14	1.04	0.572		
Unhappy if served GM food unknowingly in restaurants	2.97	1.07	0.563		
GM products created by scientists are not public demand			0.532		
driven	3.02	0.94			

Optimism about Biotechnology

Scientists know better, only moderate regulation is needed	2.16	1.02		0.691	
GM crops have brighter business future than ordinary crops	2.26	1.00		0.646	
GM risks are exaggerated	2.72	0.92		0.398	

Open Mindedness about Biotechnology

Will participate in GM public debates	2.36	1.07			0.823
Read, watch TV about GM	3.37	0.76			0.721

Confidence in Government regulatory system

Government incapable of properly regulating GM foods	2.79	0.99					0.533
Percentage of Total Variance Explained			**19.20**	**18.47**	**13.96**	**3.97**	**3.90**	**3.33**

Table 2. Characteristics of Five Consumer Groups Identified Through Cluster Analysis

Dimensions of Public Perception of Biotechnology	Benefit Seekers	Self Protectors	Biotechnology Skeptics/ Opponents	Open Minded Biotechnology Learners	Biotechnology Optimists	F-Statistics
Self Protection Attitude	-0.844	0.454	0.342	0.321	0.413	67.52*
(Factor1)	0.935	0.821	0.599	0.789	1.094	
Health & Economic Benefit Potential	0.749	0.028	-1.810	0.251	0.299	240.35*
of Biotechnology (Factor 2)	0.628	0.656	0.727	0.624	0.704	
Fear and Skepticism about	0.275	0.265	0.624	-1.041	0.473	148.75*
Biotechnology (Factor 3)	0.845	0.678	0.906	0.655	0.700	
Optimism about Biotechnology	-0.307	-0.469	-0.082	0.077	1.176	70.57*

(Factor 4)	0.888	0.835	0.957	0.831	0.762	
Willing to Learn about	0.257	-0.908	-0.321	0.482	0.178	73.62*
Biotechnology						
(Factor 5)	0.911	0.704	1.044	0.800	0.867	
Confidence in Government	-0.618	0.312	0.331	0.135	0.357	29.55*
Regulation						
(Factor 6)	0.987	0.969	0.908	0.864	0.920	

Note: Values are mean of standardized factor score with standard deviations in italics. F-statistic is from the ANOVA analysis of inter-cluster differences. Asterisk denotes that the statistic is significant at 0.05 level.

Table 3. Socioeconomic Characteristics and Distribution of Respondents Across Clusters

Socioeconomic Characteristics	Benefit Seekers (%)	Self-Protectors (%)	Biotech Skeptics (%)	Biotech Learners (%)	Biotech Optimists (%)
Gender	**Chi Square = 16.37***				
Male	23.2	20.1	10.4	32.9	13.4
Female	15.7	29.8	19.3	20.6	14.6
Age	**Chi Square = 19.09***				
Below 35 years	24.1	21.6	9.3	25.9	19.1
35 – 54 years	17.5	22.8	15.7	32.0	12.0
55 years and above	22.1	26.2	15.2	17.9	18.6
Education	**Chi Square = 53.53***				
High School or below	24.2	26.7	24.7	11.0	13.4
Above High School	21.3	20.7	12.7	34.1	11.2
Annual Household Income	**Chi Square = 30.38***				
Less than $35,000	18.4	22.4	24.5	20.8	13.9
$35,000 - $75,000	21.3	28.9	12.1	28.6	9.1
$75,000 and above	17.2	22.0	15.0	36.1	9.7
Place of Residence	**Chi Square = 4.72**				
Large City	17.6	27.5	13.1	25.1	16.7
Suburban area	21.2	22.9	14.2	27.5	14.2
Small town and rural areas	19.4	27.9	12.1	28.5	12.1
Social/Political View	**Chi Square = 4.21**				

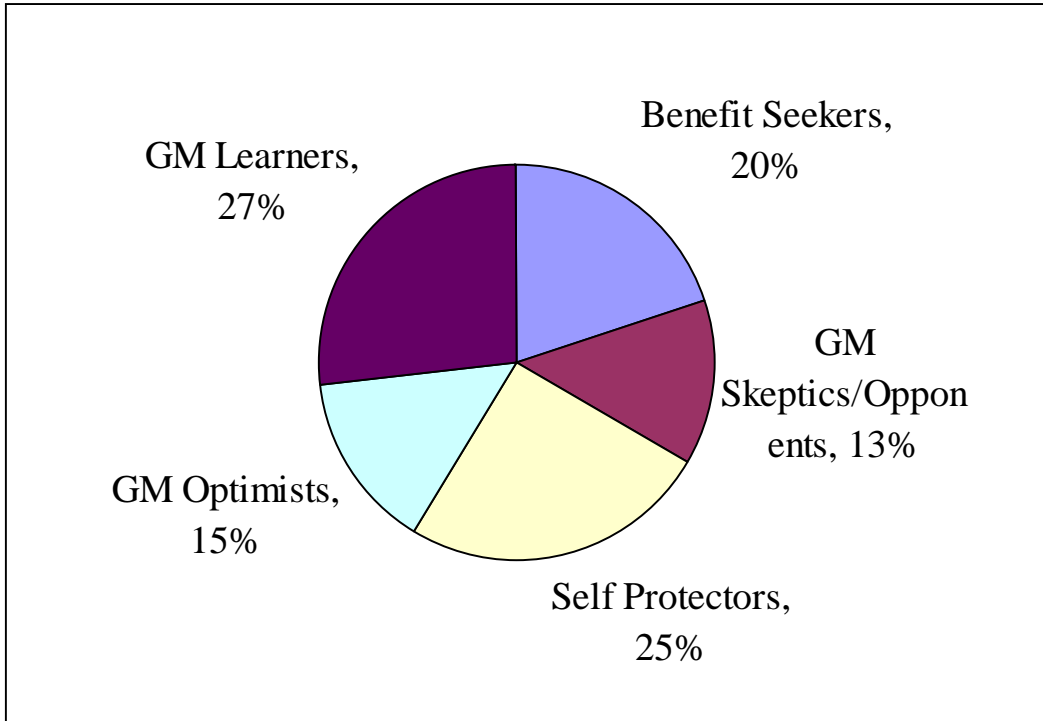|					
Liberal	17.7	25.2	18.3	28.6	10.2
Conservative	16.6	26.1	12.5	30.2	14.6
Centrist	22.5	24.9	13.2	25.4	14.0
Racial Background	**Chi Square = 30.02***				
White (Caucasian)	17.7	28.0	13.3	29.3	11.7
Other races	26.1	16.6	13.4	19.1	24.8
Religious Practice	**Chi Square = 7.07**				
Regular about religion	21.8	25.3	11.9	24.1	16.9
Not regular about religion	18.0	25.3	14.6	29.8	12.3
Opinion about Food Labeling	**Chi Square = 48.92***				
GM foods should be labeled	10.6	26.7	29.6	22.9	10.2
No need for GM food label	23.7	16.4	2.7	40.3	16.9
Scientific Knowledge	**Chi Square = 36.18***				
Below average	21.8	29.8	19.2	12.8	16.4
Above average	19.2	22.8	12.5	32.5	13

Note: The Chi Square test is for association between the respective variables and cluster

membership. The symbol asterisk denotes that the test statistic is significant at 0.05 level.

Table 4. Socioeconomic Variables and Factors Affecting Public Perceptions of Food Biotechnology

	Factors Affecting Public Perception of Biotechnology					
	Self Protection	Benefit	Skepticism	Biotech Enthusiasm	Biotech Learning	Confidence in Government
Constant	-0.634 (-3.11)	-0.427 (-2.15)	0.771 (3.25)	0.886 (3.67)	-0.355 (-1.44)	0.208 (1.16)
Young (age less than 35 yrs.)	-0.326* (-3.10)	0.110 (0.66)	-0.144** (-1.93)	0.216* (2.05)	-0.087 (-1.10)	-0.338* (-3.03)
Middle Age (age 35–54 yrs.)	0.212* (2.24)	-0.072 (-0.76)	-0.121 (-1.36)	-0.187* (-2.26)	0.244* (2.44)	-0.288* (-2.78)
Male	-0.182* (-2.33)	0.126** (1.85)	-0.158* (-2.09)	0.084 (0.63)	0.214* (2.72)	-0.168** (-1.92)
White	0.119 (1.26)	-0.112* (-2.10)	-0.168* (-1.99)	-0.285* (-2.68)	-0.147** (-1.76)	0.078 (0.85)
College Education (2-yr or 4-Year College)	-0.142 (-1.32)	-0.111 (-1.30)	-0.322* (-4.07)	0.138* (2.01)	0.143** (1.86)	0.211* (2.01)
Graduate Education	0.085 (0.88)	-0.320* (-2.63)	-0.486* (-4.28)	0.314* (2.88)	0.322* (2.26)	0.112 (1.15)
Low Income (Less than $35,000)	-0.212* (-2.20)	0.129 (1.44)	0.163 (0.82)	-0.104 (-0.89)	0.158** (1.76)	-0.122 (-1.11)
Middle Income ($35,000-$75,000)	0.141 (1.41)	0.123 (1.05)	0.125 (1.22)	-0.204 (-2.21)	-0.078 (-1.08)	0.108 (0.98)
Check Food Label	0.342* (4.30)	-0.266* (-3.07)	0.491* (5.67)	-0.188* (-2.22)	0.082 (0.88)	0.088 (1.21)

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Attend Church Regularly	-0.126 (-0.84)	-0.122** (-1.73)	0.198* (2.13)	-0.201* (-2.29)	-0.098 (-0.58)	-0.788 (-0.99)
No Moral Problem with Biotechnology	0.123 (1.10)	0.628* (6.52)	-0.324* (-2.85)	0.186* (2.46)	-0.122 (-1.51)	0.125 (1.45)
Trust Government	0.203** (1.83)	0.219* (2.44)	-0.168* (-2.44)	0.266* (2.78)	0.098 (0.85)	-0.285* (-3.52)
Liberal	0.223** (1.88)	-0.118** (-1.72)	0.185* (2.10)	0.102 (0.88)	0.113 (1.00)	0.201** (1.92)
Conservative	0.112 (1.11)	0.088 (1.01)	0.100 (0.89)	0.114 (1.11)	0.098 (0.82)	0.111 (1.44)
Knowledge of Science & Technology	0.042 (0.68)	0.102 (1.21)	-0.108 (-1.19)	0.155 (1.44)	0.285* (2.88)	-0.102 (-1.16)
Adjusted R^2	0.14	0.19	0.24	0.14	0.08	0.07
Model F-Statistics	9.82	11.28	15.36	8.76	6.65	5.88

Note: Single asterisk denotes that the variable is significant at 0.05 level and double asterisk denotes that the variable is significant at 0.10 level.

GM Learners, 27%

Benefit Seekers, 20%

GM Skeptics/Opponents, 13%

GM Optimists, 15%

Self Protectors, 25%

Figure 1.

Proportion of Respondents in Each Cluster