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U.S Public Awareness and Knowledge of and Interest in Biotechnology: A Principal Component Factor Analysis

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Unlike earlier surveys based studies on public attitudes and perceptions of biotechnology, this study investigates the importance of consumers' awareness and knowledge of and interest in biotechnology. Results suggest that Americans are largely unaware of both of the presence in their lives of GM food and of its wide application in food production. In view of this, many Americans would like to see more GM media coverage. Additionally, most Americans are unfamiliar with the laws and safety testing regarding GM food.

Unlike earlier survey based studies on public attitudes and perceptions toward biotechnology, this study investigates the importance consumers' awareness, knowledge and interest towards biotechnology. The study attempts to relate such concerns and issues with biotechnology acceptance. The survey elicited public opinions on what they would like to know, which areas have informational gaps, and which topics are of interest relating to GM foods and the technology.

To date, the negative and indecisive public attitude toward genetic modification has generally been attributed to lack of biotechnology information. This has polarized the public into opponents and proponents of GM. Despite this divide, majority of Americans have remained relatively unaware or ambivalent toward the concept of genetically modified foods (Hallman et al. 2002, 2003, 2004). In a recent study, Hallman, et al. (2004) found that between 60% and 70% of processed foods in American supermarkets include at least a fragment of a GM crop, yet most consumers are not aware of this.

Although the future of biotechnology rests on consumer acceptance, a number of consumer concerns need to be addressed. These concerns include long-term safety of the technology for human health and the environment, lack of biotechnology information, and mistrust of the institutions dealing with biotechnology, notably the regulatory and private agencies. Regardless of these concerns, the American public remains optimistic about benefits

of biotechnology. Findings by Onyango and Nayga (2004) indicate that the U.S. public generally approves of genetic modification when the product delivers tangible health benefits or product-specific benefits, such as GM breakfast cereal with antioxidants.

This study explores the importance of public awareness and knowledge of, interest in, and skepticism toward biotechnology and its acceptance. This study identifies and estimates the relative importance of public perceptions of biotechnology issues and concerns, characterizes public perceptions into distinct groupings based on GM issues and concerns, and analyzes the relationships between consumers' socioeconomic and value characteristics and the principal issues and concerns. This study contributes by informing policy makers and the biotech industry about what is important from the consumers' point of view as it relates to GM foods.

Data and Methodology

A survey instrument developed by the Food Policy Institute, Rutgers University, was used to collect data for this study. The Food Policy Institute contracted the opinion polling firm Schulman, Ronca, and Bucuvalas, Inc. to conduct 1,201 telephone interviews using computer-assisted telephone interview (CATI) technology. The survey collected information on core questions related to American awareness and knowledge of GM food, willingness to purchase GM products, attitudes toward risks and benefits, opinions on mandatory product labeling, and overall approval of the transgenic technique as it relates to animal and plant biotechnology. Additional information on socio-demographic characteristics and social, political, moral, and religious

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views of the respondents was also collected.

The interviews were conducted between May 4, 2004 and June 14, 2004. Interviewers were consistently monitored throughout the field period. To reduce interview time, two versions of the survey were used, with the same core questions but with different supplemental questions. Version A had 601 respondents and an average interview time of 19.5 minutes, and Version B had 600 respondents and an average interview time of 21.9 minutes. All interviews were conducted in English. Potential respondents were selected using national random-digit dialing across all 50 states. U.S. Census Bureau population estimates determined the distribution necessary for proportionate geographic coverage. The CATI program guided a random but balanced selection process to ensure that representative numbers of males and females were interviewed.

Many of the telephone numbers originally selected as part of the sampling frame were excluded as non-residential or non-working numbers. Only 25% of the numbers selected at random yielded completed interviews. However, calls to 66% of the working residential numbers resulted in completed interviews.¹ When weighted, the 1,201 completed interviews have a sampling error rate of $\pm 3\%$. For those questions asked of only half the sample (the adjusted N will be indicated in text and tables where appropriate), the sampling error rate increases to $\pm 4\%$. After completing the telephone survey, the 1,201 respondents were asked to receive a mail questionnaire.

This analysis is based on responses to 15 questions relating to public perceptions of biotechnology. These questions explored consumer awareness of and interest in certain topics relating to GM foods and perceptions of risks from biotechnology. In one set of the questions, respondents were asked to state whether they agreed or disagreed with a statement; in the other set, they were asked to rate their interest in hypothetical GM topics to be televised. The last set of questions sought responses about particular

issues such as awareness of government testing of GM for human and environmental safety. For purposes of this analysis, the responses were coded as 1 for those disagreeing and 2 for those agreeing with a statement. A similar approach was adapted for yes or no responses. The questions answered with "not sure" were rescaled with "not sure" = 0, "No" = 1, and "Yes" = 2. No rescaling was done on the questions relating to the respondent's rating of interest of GM topics to be televised. The row coding on a scale of a 1 to 10 was retained without undermining the metric scaling.

Principal component factor analysis (PCA) was used to reduce the 15 questions exploring public views on the issues and concerns to a smaller set of dimensions (factors). A standard latent root equal to one and a scree test were used to establish the number of factors to retain, followed by a confirmatory analysis to ensure internal reliability of the factors. Next, a two-stage cluster analysis (Punj and Stewart, 1993; Hair et al., 1992) was used to identify clusters of issues with similar running themes on biotechnology. ANOVA and chi-square tests were applied to examine inter-cluster heterogeneity in terms of the socioeconomic attributes of the respondents.

Empirical Results

Dimensions of Public Perceptions of GM Issues, Concerns, and Topics of Interest

Table 1 presents the means, standard deviations, and factor loadings² from the principal component factor analysis obtained after a Varimax rotation of consumer responses to the 15 questions exploring public views on GM issues, concerns, and topics of interest. Factors are ranked in order of the proportion of variance explained and labeled to reflect the latent stimuli underlying GM public opinions. The estimated means of (>7) on rating hypothetical GM topics to be televised, (<1) on whether government tests GM foods for human healthy and environmental safety, (>2) on perceived GM risks, and (~ 2) for labeling of GM food, and (>1) for awareness of biotechnology suggest relevance of the variables in defining the latent dimensions on the GM issues explored. These statistics reveal a broad consensus

¹To achieve the maximum response rate, many working numbers were attempted 16 or more times. Numbers were dialed on different days of the week and at varying times of day in an effort to reach elusive respondents. For households that used call-blocking systems, the research company allowed identifying information to be displayed. If an answering machine picked up three times in a row on any given number, interviewers left messages identifying the research company and the purpose of the call.

²Factor loadings represent both how the variables are weighted for each factor and the correlation between the variables and the factor.

Table 1. Varimax-Rotated Factor Loadings: Attitudes toward and Perceptions of GM Foods.

Issue, concerns, and topics of interest	Mean	SD	Interest in GM media coverage	Low awareness about GM	Health & environmental safety GM tests	Perceived GM risks and labeling
TV show: who regulates and monitors genetically modified foods	8.04	2.41	0.7652			
TV show: which foods or brands of food contain genetically modified ingredients	7.94	2.55	0.7250			
TV show: the potential benefits of eating genetically modified foods for your health and your family's health	7.95	2.60	0.7343			
TV show: whether the genetic modification affects the farmers' cost of producing food	7.47	2.62	0.7228			
TV show: whether genetically modified food will affect world hunger	8.07	2.46	0.7718			
TV show: the companies involved in the production of genetically modified foods	7.36	2.70	0.7574			
TV show: likelihood that something bad will happen as a result of genetically modified foods	8.02	2.62	0.6635			
Before this interview, were you aware that these methods of genetically modifying food existed?	1.78	0.42	0.8367			
How much would you say you've heard or read about genetically modified foods?	2.52	0.93		0.8422		
Before this interview, have you ever discussed genetically modified food with anyone?	1.37	0.48		0.6991		
As far as you know, has the government tested genetically modified food products for human safety?	0.73	0.87			0.8628	
As far as you know, has the government tested genetically modified food products for environmental safety?	0.63	0.83			0.8855	
I would pay more for food that was not genetically modified.	2.78	1.06				0.7447
Growing genetically modified crops will be harmful to the environment.	2.47	0.91				0.7653
Do you think that genetically modified foods should be required to be labeled?	1.91	0.28				0.4999
Percentage of total variance explained			25.48	12.99	11.02	10.77

about the issues on awareness of, topics of interest regarding, and perceived risks of biotechnology. The analysis identified four core GM issues and concerns that, taken together, accounted for about 60 percent of the variance, as summarized below.

Interest in GM Media Coverage (Factor 1): This factor relates to public desire to know more about biotechnology. The hypothetical GM topics to be televised were rated highly in total. Americans say they are interested in topics relating to human health, GM regulation and government oversight, the range of foods containing GM ingredients, GM-food impact on alleviating human hunger, its effect on farmers' cost of production, corporations involved in GM production, and the unknown consequences of GM food. The high factor loadings are indicative of a strong relationship between the variables and the public interest in such topics. This is the largest factor, accounting for about 26 percent of the error variance.

Low Levels of Public Awareness of GM (Factor 2): The public's low level of awareness about biotechnology accounts for 13 percent of the error variance. Although the U.S. public has been open to genetic transformations, they are uninformed about the science. Lack of awareness is reflected by the high factor loadings for lack of knowledge, prior discussions, or reading about the existence of such methods. A common result is aversion, reflected by high loading for paying more to avoid GM foods.

Testing of GM for Human Health and Environmental Safety (Factor 3): Questions about whether effects of GM technology have been sufficiently tested for human and environmental safety indicate consumers' concern over the government's ability to properly regulate GM products. This concern is not unique to the U.S.—the Eurobarometer poll found that only 30 percent of Europeans believe that “the industry developing new products through the use of biotechnology does a good work for society” (Hallman et al. 2002). This factor accounts for about 11 percent of the error variance.

Perceived GM Risks and GM Labeling (Factor 4): This factor reflects the broad public concern about the (unknown) risks associated biotechnology. Perception of biotechnology risks for human health and environmental safety is at the heart of public opposition to biotechnology (Hossain et al. 2003). This is demonstrated by the high factor loadings for questions about environmental risks of biotechnology and respondents' support of labeling

of GM foods. This factor accounts for about 11 percent of the error variance.

Cluster Analysis

Applying a non-hierarchical cluster analysis to the standardized factor scores (obtained from factor analysis), three groupings of issues were identified based on similarity of dimensions of concern about biotechnology (described above). The mean and standard deviation of the standardized factor scores and the number of respondents in each cluster are reported in Table 2. The F-statistics from the ANOVA analysis (Table 2 and Figure 1) suggest significant inter-issue variations in the importance placed on the four dimensions on public views towards biotechnology. The three clusters are described below.

Interest in GM Media Coverage: About 39% of the survey respondents are interested in having GM topical issues televised (note the high mean score for Factor 1). This may seem to be motivated by views they hold on perceived risks associated with biotechnology therefore seeking for guidance. Reinforcing this group's interest is the fact that they may have heard little about government testing of GM foods.

Low Awareness Levels about Biotechnology: About 34% of the survey participants lacked information about biotechnology (reflected by high mean score for Factor 2). This lack of information about biotechnology may partially explain the negative views of the perceived risks. People in this cluster will need assurance that GM foods are tested to ensure human health and environmental safety. People in this cluster also favor televising various topical issues on the technology.

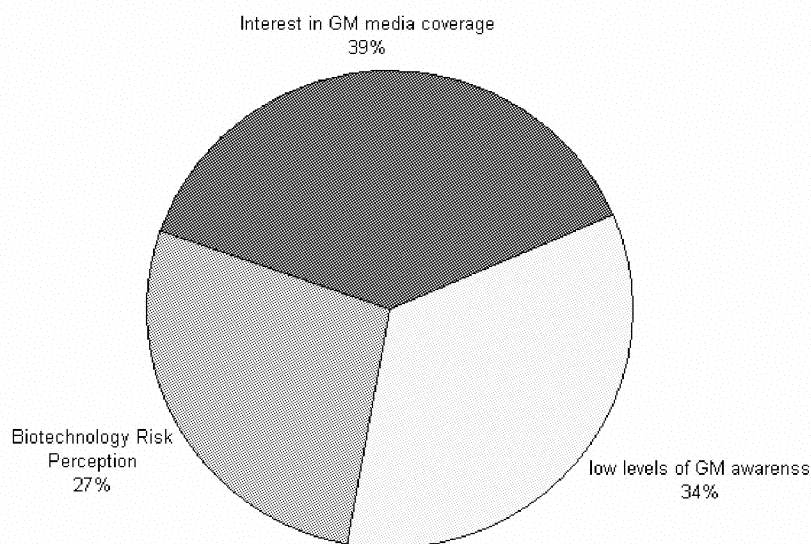
Perceived Biotechnology Risks: This dimension reflects uncertainties about biotechnology, resulting in opposition to the use of biotechnology in food production (note the high mean score for Factor 4). Individuals in this group place little importance in biotechnology and are less concerned as to whether the government has tested GM foods to ensure human health and environmental safety (note the high negative coefficient). On the other hand, respondents in this group may wish to know more about biotechnology. This is the smallest cluster, accounting for 27 percent of the respondents.

Table 3 reports the personal attributes of respondents in various clusters. Chi-square tests

Table 2. Characteristics of the GM Issues Groupings Identified through Cluster Analysis.

Observations	321 (27%)	461 (38%)	411 (34%)	
Dimensions: GM areas of concern	Biotechnology risk perception	Interest in GM media coverage	Low levels of GM awareness	F-statistic
Factor 1: GM Topics of great interest	-1.163 (0.851)	0.590 (0.550)	0.176 (0.749)	610.20*
Factor 2: Biotechnology General Awareness	0.089 (0.922)	-0.486 (1.042)	0.540 (0.649)	145.52*
Factor 3: Testing GM For Health/ Environmental safety	0.109 (0.944)	-0.328 (1.090)	0.326 (0.777)	53.90*
Factor 4: Perceived Biotechnology Risks	0.534 (0.840)	0.333 (0.730)	-0.839 (0.868)	324.16*

Note: values are mean of standardized factor scores with standard deviation in parenthesis. F-statistics are from ANOVA of inter-cluster differences. Asterisks denote the statistic is significant at 5% or better level.

**Figure 1. Cluster Membership.**

reject the null of no association between respondents' views on the areas of concern or views about biotechnology and their personal attributes. Men are less concerned about the perceived risks associated with biotechnology; however, more men have low levels of awareness about biotechnology. Women are more eager for GM-related topics to be televised. Almost equal numbers of women are concerned about risks posed by biotechnology and have low levels of awareness on the subject. The results also show that a majority of respondents with high school or less education have low awareness of biotechnology, while those with education above the high school level are more interested in topics related to biotechnology. More Caucasians are interested in seeing GM media coverage, with few being concerned about perceived biotechnology risks. Interestingly, respondents with incomes above \$100,000 are the least informed about biotechnology, yet few of them are concerned about its risks. Those with incomes below \$25,000 and those with incomes between \$25,000 and \$50,000 desire more GM media coverage, as do respondents with children aged 5–17 years. Respondents who are unmarried but living with a partner have the lowest levels of biotechnology awareness and are the least concerned about the perceived risks posed by biotechnology. Separated respondents have low levels of awareness; this group is also the most interested in GM media coverage. Those employed part-time desire more GM topics in the media. The unemployed also are interested in GM media coverage, and a substantial number of them are less aware of biotechnology.

Conclusions

Results from factor and cluster analysis show that Americans are largely unaware of GM food, both of its presence in their lives and of its wide application in food production. In view of this, Americans would like to see more GM-related issues televised. Americans report interest in a variety of topics related to GM food and say they would watch television shows about the topics. Still, Americans register opposition on the technology because they are uncertain about the impact of genetic modification on their health and on the environment. In addition, most Americans have little understand-

ing of general facts about transgenic technology, as demonstrated by their low levels of awareness. Americans are unfamiliar with the laws and safety testing regarding GM food.

These results demonstrate the need for developing strong outreach and educational programs to inform the public about biotechnology. Policy makers also should develop a communication strategy to alleviate fears of the perceived risks. It is hoped that such efforts will go along way in assisting Americans reach informed decisions on the need for and rationale behind biotechnology.

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Table 3. Socioeconomic Characteristics and Distribution of respondents Across Clusters (%).

Socioeconomic characteristics	Biotechnology risk perception	Interest in GM media coverage	Low levels of GM awareness
Gender		Chi square=11.30*	
Male	24.8	37.6	37.6
Female	26.9	44.5	28.6
Age		Chi square=5.51	
Below 35 years	27.1	40.4	32.45
35–54 years	22.2	44.0	33.76
55 years and above	28.7	38.2	33.14
Education		Chi square=47.18*	
High school or below	27.8	32.2	40.0
Above high school	23.4	51.2	25.4
Social/political leanings		Chi square=8.71**	
Liberal	29.5	33.2	37.4
Conservative	27.8	41.6	30.6
Centrists	22.7	42.7	34.6
Racial background		Chi square=5.82*	
White (Caucasian)	21.7	47.5	30.8
Other races	26.2	39.4	34.5
Income		Chi square=33.95*	
Below \$25,000	23.7	55.6	20.7
\$25,000–\$49,999	23.6	40.5	35.9
\$50,000–\$99,999	26.9	38.2	34.9
\$100,000 and above	26.7	29.3	44.0
Children 5–17 years		Chi square=18.66*	
No	29.4	38.8	31.8
Yes	17.6	45.9	36.5
Marital status		Chi square=18.81*	
Single	28.3	42.3	29.4
Married	26.6	38.7	34.7
Unmarried but living with a partner	18.2	37.9	43.9
Separated	20.7	65.5	13.8
Divorced	18.5	47.7	33.8
Widowed	21.9	46.9	31.3
Employment		Chi square=10.72*	
Employed full-time	26.0	37.2	36.8
Employed part-time	27.9	44.9	27.2
Unemployed/retired	24.3	45.6	30.1

Note: The chi-square statistic tests the null hypothesis of no association between each variable and cluster memberships.

* = significance below 5% level, ** = significance at 10% level.