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Public Perception of Food Biotechnology: Uncovering Factors Driving Consumer Acceptance of Genetically Modified Food

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This study uses multivariate statistical procedures to explore the factors underlying public attitudes toward food biotechnology. Our analysis finds public acceptance of genetically food is influenced by multiple latent stimuli that include the desire for new and improved products, concerns over the safety of these products, and distrust of government and biotechnology companies. Cluster analysis identified distinct consumer groups on the basis of the importance they place on various biotechnology issues. Respondents belonging to distinct consumer groups vary considerably in terms of their personal attributes.

The application of biotechnology in agriculture has raised major controversy in the U.S. and elsewhere. Despite its promise to bring significant benefits to the society, public acceptance of this technology has been mixed (Gamble et al. 2000; Hallman et al. 2002). Biotechnology advocates highlight its potential to improve social welfare via improved nutrition, prevention and cure of diseases, and promotion of health (Isserman 2001). Opponents view its use as a needless interference with nature that may lead to potentially disastrous consequences (Nelson 2001).

Public discourse on biotechnology has raised other social, political, and ethical debates. It is often argued that genetic manipulation of plants and animals, especially gene transfer across species, takes us to the “realm of God.” Since genes are discovered rather than invented, some find patent ownership of genetic findings and processes ethically untenable. Some are concerned about the potential social consequences of the permanent dependence of farmers on biotechnology companies for their “means of production.” Others are afraid that this technology will benefit the developed countries at the expense of developing countries (Galhardi, 1995).

Various studies have found that public perceptions of biotechnology are not necessarily based on scientific facts, as most people have little or no knowledge about this technology. In our survey, which forms the basis for this study, we find that while most Americans are optimistic about the benefits of biotechnology, they are also concerned about the unforeseen consequences of its use. Consistent with other studies, we find that public support for biotechnology depends on whether plants or animals are involved (Hamstra 1998; Hallman et al. 2002) and the purpose for its use. There is greater support for its use for specific health or economic benefits than when it is presented in the abstract. Also, public views on this subject are related to trust and confidence in scientists, regulators, and companies associated with this technology.

These findings suggest that public acceptance of biotechnology has multiple dimensions and is influenced by multiple factors. For instance, while consumer benefits are likely to promote the acceptance of this technology, perceptions of risks to humans and the environment are likely to discourage its acceptance. Similarly, acceptance of food biotechnology is likely to be related consumers’ social, political, and religious views (Wanskin and Kim 2001).

This study uses multivariate statistical analysis to explore the factors underlying public acceptance of biotechnology. The objectives of this study are to identify and estimate the relative importance of the factors underlying public acceptance of biotechnology, to identify distinct consumer according to their views on biotechnology, and to explore the relation between the dimensions of consumer

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attitudes towards biotechnology and consumers' personal attributes.

Data and Methodology

Data for this study comes from a national telephone survey of public perceptions of and attitudes toward various biotechnology issues. The survey was completed in March-April, 2001 by a professional polling firm on behalf of the Food Policy Institute, Rutgers University. The survey collected information on respondents' knowledge and awareness of various biotechnology issues, their perceptions of the risks and benefits of this technology, their views about institutions associated with it, and the socioeconomic and value characteristics of the respondents.

The survey targeted the non-institutional U.S. adult civilian population. A random sample was drawn from the more than 97 million telephone households. The target sample size was set at 1200 to achieve a sampling error rate of $\pm 3\%$. Quotas were set to ensure that representative numbers of males and females were interviewed. Using a computer-assisted telephone-interview system, a total of 1203 phone surveys were completed with a response rate of slightly over 50%. Analysis of the survey data indicated that the sample was representative of the U.S. population. In cases where some respondents did not answer some questions (there were between 20 and 40 such cases), their missing responses were replaced by the mean response to that specific question.

The analysis is based on the responses to 30 questions relating to public attitudes toward biotechnology. Respondents were asked to rate their agreement or disagreement, on a scale of 1 to 4 (where 1 = strong disagreement and 4 = strong agreement) with various statements on the use biotechnology. Principal-components factor analysis was used to reduce the responses to the 30 questions to a smaller set of dimensions. Next, using a two-stage cluster analysis (Hair et al. 1992), we identified clusters of respondents with similar views on biotechnology. Finally, ANOVA and chi-square tests of independence were used to examine inter-cluster heterogeneity in terms of respondents' personal attributes.

Empirical Results

Table 1 presents the mean, standard deviation, and factor loadings from the principal-component factor analysis (using a varimax rotation) of responses to the 30 questions used in the analysis. The factors are ranked in order of the proportion of variance explained and are named to reflect the latent stimuli underlying public perceptions of biotechnology.

The estimated means (≥ 3.0) and standard deviations (≤ 1.0) of the responses reveal a broad consensus for the use biotechnology to develop products that provide health and economic benefits. The principal-component analysis identified 6 factors underlying public opinions about biotechnology. These factors, which accounted for 62% of the variance, are described below.

Health and Economic Benefits (Factor 1): This factor account for 20.58% of the error variance. It reflects public recognition of the potential of biotechnology to bring tangible benefits to the society. This is reflected in the high factor loadings for questions about GM products that bring material benefits to consumers, which are at the core of public support for biotechnology.

Self-Protection Attitude (Factor 2): This factor reflects a self-protection attitude in the sense that people are cautiously optimistic about GM foods. They want to verify the safety of GM foods through the use of these foods by other. This "wait and verify safety" attitude is reflected in the high factor loadings for the approval of GM foods to be consumed by "someone else." This factor accounts for 17.31% of the error variance.

Opposition to Biotechnology (Factor 3): This factor reflects public anxiety about the (unknown) risks associated biotechnology, which is at the heart of public opposition. This is reflected in the high factor loadings for questions about the implications of this technology for the environment and people's acceptance of GM foods. This factor accounts for about 10% of the error variance.

Lack of Trust in Government Regulation and Biotechnology Companies (Factor 4): Some in society share a rather negative image of biotechnology companies and are quite skeptical of government's ability to properly regulate GM products (Hallman et al. 2002). For this reason they are uneasy with the use of this technology. This factor

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. Health and Economic Benefits								
Approve GM technology to create:								
Better-tasting fruits and vegetables	2.94	1.04		0.748				
Rice with enhanced vitamin A to prevent blindness	3.17	0.95		0.748				
More-nutritious grain to feed people in poor countries	3.33	0.91		0.766				
Fruits and vegetables that are less expensive	3.03	1.04		0.736				
Hormones to produce beef with less cholesterol	2.64	1.09		0.713				
Hormones like insulin that help people with diabetes	3.31	0.92		0.701				
Sheep whose milk can be used to produce medicines	3.03	0.98		0.680				
Fruits and vegetables that last longer on store shelf	2.74	1.08		0.666				
New types of grass that don't need to be mown more often	3.13	1.01		0.629				
Hormones that enable cows to give more milk	2.41	1.11		0.614				
Factor 2. Self-Protection Attitude								
Approve GM food as Part of:								
Meals to the Homeless in the Shelters	2.52	1.02	0.856					
Meals to the military	2.44	1.03	0.853					
Meals to needy children for free lunch	2.40	1.05	0.838					
Food Aid to foreign countries	2.59	1.02	0.818					
Meals to Hospital patients	2.34	1.05	0.818					
Meals to prisoners	2.62	1.02	0.779					
Factor 3. Fear About and Opposition to Biotechnology								
GM technology threatens nature	2.64	0.96			0.708			
Willing to petition against GM	2.11	1.01			0.683			
GM products not necessary	2.49	0.98			0.637			
Will pay more for non-GM products	2.45	1.04			0.580			
Regulation is necessary given GM potential dangers	3.11	0.91			0.530			
Serious accidents involving GM foods are bound to happen	3.10	0.96			0.528			
Factor 4. Skepticism about Government Regulation and Biotech Companies								
Government incapable of properly regulating GM foods	2.82	0.96				0.726		
Biotech companies more interested in profit than safety	2.91	0.98				0.520		
Factor 5. Open-Mindedness about Biotechnology								
Will participate in GM public debates	2.31	1.06					0.776	
Read, watch TV about GM	3.39	0.76					0.763	
Factor 6. Optimism about Biotechnology								
Risk from GM can be avoided if we want to	2.85	0.96						0.730
GM risks are exaggerated	2.70	0.89						0.564
GM crops have brighter business future than ordinary crops	2.25	0.98						0.510
Percentage of Total Variance Explained			20.58	17.31	9.96	4.81	4.54	4.44

Note: The mean is the average of raw scores of each question, reported on a 1–4 scale with 1 = strong disagreement and 4 = strong agreement. For better readability of the table, factor loadings below 0.4 are not reported.

accounts for 4.81% of the error variance.

Open-Mindedness about Biotechnology (Factor 5): This factor reflects an open mind among many on biotechnology issues. This is reflected by the high loadings for activities relating to obtaining additional information on the subject. It suggests a rather fluid state of mind among many on GM issues. These individuals are seeking more information to reach a definitive position. This factor accounts for 4.54% of the error variance.

Optimism about Biotechnology (Factor 6): This factor reflects high enthusiasm about genetic technology among many in society who are firm believers in “the wonders of science and technology.” Generally overly optimistic, they are the most ardent advocates of and perhaps the early acceptors of GM foods. This factor accounts for 4.44% of the error variance.

Cluster Analysis

The means and standard deviations of the standardized factor scores and the number of respondents in each cluster are reported in Table 2. The analysis identified five consumer clusters on the basis of the importance placed by the respondents on the factors identified in the principal component factor analysis. ANOVA-based F-tests suggest significant inter-group variations in the importance of the factors underlying public attitudes towards biotechnology. These five clusters are described below and are named to reflect the dominant factor characterizing each group.

Biotechnology Opponents: Consumers in this group are opposed to food biotechnology (note the high mean score for factor 3). They downplay the potential benefits of biotechnology and are unlikely to accept GM foods. They are skeptical of the technology, biotechnology companies and government regulators (note the large negative scores on Factors 1, 5, and 6). However, with only 12% of the respondents, this is the smallest of the five groups identified by cluster analysis.

Self-Protectors: About one-fifth of the respondents belong to this group. Self-protection is their highest priority (note the high mean score for Factor 2). These consumers are interested in GM foods but prefer to verify the safety of these products (note the mean scores for Factors 1 and 5).

Skeptics about Government and Biotechnol-

ogy Companies: This group comprises about 15% of the respondents, who are highly skeptical of biotechnology companies and government regulators (note the high mean scores for Factor 4, positive mean score for Factor 3, and negative mean score for Factor 6). They are generally opposed to and are unlikely to GM foods.

Benefit Seekers: Consumers in this group (about 28% of the respondents) place high importance on the benefits of biotechnology, as reflected in the high mean score for Factor 1. Although they share optimism about biotechnology (note the mean score for Factor 6) and are open to its use (note the mean score for Factor 5), they are also concerned about the safety of GM products, which is reflected in the reasonably high mean score for the self-protection factor (Factor 3).

Biotechnology Optimists: These consumers (about one-quarter of the respondents) are enthusiastic supporters of biotechnology. They place high importance on the benefits of biotechnology (note the mean score for Factor 1) and hold positive views of companies developing this technology as well as of government regulators (note the negative mean score for Factor 4). However, they also reveal some degree of self-protection attitude (see mean score for Factor 2).

Table 3 reports the personal attributes of respondents in various clusters. Chi-square tests reject the null of no association between respondents' views of biotechnology and their personal attributes. Table 3 shows that men are relatively more optimistic about biotechnology and are less self-protecting and less opposed to GM foods. Relatively more women are skeptical about government and biotechnology companies. Older consumers are self-protecting and skeptical of government and biotechnology companies. More young people are in the benefit-seeking group, while more middle-age consumers are in the biotechnology optimistic camp.

More educated people belong to the biotechnology optimist group, while fewer among them are distrustful of biotechnology companies and the government. Suburbanites are more self-protecting and opposed to biotechnology. Residents of large cities are most skeptical of government and biotechnology companies. Peoples' social and political views do not seem to have a large influence on their opinions on GM issues. Fewer whites are self-

Table 2. Consumer Groups Identified by Average Standardized Factor Scores from Cluster Analysis.

Dimensions of Public Perceptions of Biotechnology	Biotech Opponents	Self Protectors	Skeptics of Government and Biotech Companies	Benefit Seekers	Biotechnology Optimists	F-Statistics
No. of Observations	141	228	187	335	312	
Health & Economic Benefits of GM (Factor 1)	-1.715 (0.75)	0.493 (0.85)	-0.204 (0.95)	0.863 (0.68)	0.455 (0.69)	311.36*
Self-Protection Attitude of Biotechnology (Factor 2)	-0.376 (0.63)	1.134 (0.59)	0.097 (0.97)	0.573 (0.62)	0.376 (0.67)	142.67*
Opposition to Biotechnology Biotechnology (Factor 3)	1.059 (0.85)	-0.089 (0.95)	0.522 (0.88)	-0.225 (0.80)	-0.753 (0.81)	141.05*
Skepticism about Govt. & Biotech Co. (Factor 4)	0.497 (0.78)	0.224 (1.02)	0.713 (0.75)	-0.071 (0.85)	-0.471 (0.92)	41.37*
Open-Mindedness to Biotechnology (Factor 5)	-0.404 (0.61)	0.598 (0.67)	-0.073 (0.94)	0.713 (0.78)	-0.580 (0.72)	114.21*
Biotechnology Optimists (Factor 6)	-0.653 (0.94)	0.122 (0.89)	-1.276 (0.79)	0.432 (0.74)	0.856 (0.59)	164.96*

Note: Values are mean of standardized factor scores with standard deviations in parentheses. F-statistic is from the ANOVA analysis of inter-cluster differences. Asterisks denote significance at 0.05 level.

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

Socioeconomic Characteristics	Biotech Opponents	Self Protectors	Skeptics of Govt. & Biotech Co.	Benefit Seekers	Biotech Optimists
Gender Chi Square = 39.75*					
Male 9.7 16.6	11.6	28.9	33.2		
Female 13.5	21.1	19.0	26.9	19.5	
Age Chi Square = 22.32*					
Below 35 years	11.0	15.8	13.2	33.5	26.5
35 – 54 years	12.9	18.7	14.7	24.3	29.4
55 years and above	11.6	23.6	18.5	26.7	19.5
Education Chi Square = 29.34*					
High School or below	10.4	19.5	20.4	30.8	19.0
Above High School	12.8	19.0	12.0	26.0	30.2
Place of Residence Chi Square = 13.57*					
Large City 9.2	18.7	18.4	26.1	27.6	
Suburban area	15.7	21.3	11.6	24.9	26.5
Small town and rural areas	12.1	18.2	14.8	30.3	24.5
Social/Political View Chi Square = 9.28*					
Liberal 13.7	19.8	13.7	24.1	28.8	
Conservative	14.0	15.6	17.8	27.3	25.4
Centrist 10.3	21.0	14.6	27.8	26.3	
Racial Background Chi Square = 16.72*					
White (Caucasian)	12.6	17.2	14.2	16.6	27.5
Other races 9.6	25.4	19.7	25.9	19.3	
Religious Practice Chi Square = 24.03*					
Regular about religion	20.4	18.0	19.1	24.4	18.1
Not regular about religion	11.6	19.1	11.6	26.9	30.7
Opinion about Food Labeling Chi Square = 79.40*					
GM foods should be labeled	12.7	20.7	16.3	28.3	22.0
No need for GM food label	4.2	4.2	10.9	22.7	58.0

Note: The chi-square statistic tests the null hypothesis of no association between the each variable and cluster membership. Asterisks denote significance at 0.05 level.

protecting and skeptical of government and companies; relatively few of them are benefit-seekers, although more among them are optimistic. More religious individuals are more opposed to biotech-

nology, distrustful of government and companies, and less optimistic about GM technology. Those who support labeling of GM foods are more self-protecting and opposed to biotechnology. They are more skeptical of government and companies, and

less optimistic about biotechnology itself.

Conclusions

Scientific challenges notwithstanding, public acceptance of genetically modified products is critically important for the future of food biotechnology. The evidence thus far is decidedly mixed; public perceptions of food biotechnology are characterized by ongoing tension between opposing forces. On the one hand the public remains optimistic about the prospect of new and improved products that will bring a wide range of health and economic benefits, while on the other hand they are concerned about the potential health, safety, and environmental risks from the use of this technology. Underlying public perceptions of biotechnology are six core factors that range from excitement about the promise of health and economic benefits from GM products to fear and distrust of the technology. In between, many people are undecided, trying to learn more about the issues to reach a definitive position.

We find considerable anxiety among many about the safety of biotechnology, which is a major obstacle to its widespread acceptance. Lack of confidence in government regulations and negative perceptions of biotechnology companies work as additional impediments. This highlights the importance of the credibility of private and public institutions responsible for certifying the safety of GM foods and implementing necessary regulatory controls on GM processes and products. We also find that consumer priorities regarding various biotechnology issues are related to their personal attributes. This suggests that, at least in the near term, there will be considerable divergence within society in terms of acceptance of food biotechnology.

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