Consumer Knowledge of Food Biotechnology

A Descriptive Study of U.S. Residents

Brian J. Schilling
William K. Hallman
Adesoji O. Adelaja
Lucas J. Marxen*

Food Policy Institute
ASB III, 3 Rutgers Plaza
New Brunswick, NJ 08901
Tel: (732) 932-1966
FAX: (732) 932-9544
schilling@aesop.rutgers.edu

June 2002

* Brian Schilling is Assistant Director of Research, Food Policy Institute. William Hallman is Associate Director for the Food Biotechnology Program, Food Policy Institute and Associate Professor in the Department of Human Ecology. Adesoji Adelaja is the Director of the Food Policy Institute and Dean/Director of Research at Cook College and the New Jersey Agricultural Experiment Station. Lucas Marxen is a graduate research assistant. This is Food Policy Institute Publication No. RR-0502-002.

Consumer Knowledge of Food Biotechnology
A Descriptive Study of U.S. Residents

Brian J. Schilling, William K. Hallman, Adesoji O. Adelaja, and Lucas Marxen

Abstract

A national survey conducted by the Food Policy Institute demonstrates the lack of knowledge and awareness most Americans have of genetically modified foods. The paper provides insight into public perceptions of food biotechnology's risks and benefits and a preliminary examination of consumers' stated preferences for genetically modified functional foods.

Key Words: agricultural biotechnology, genetically modified food, public perceptions, nutraceuticals.

Introduction

The role of biotechnology in the future of agriculture and food is becoming increasingly important. Billions of dollars are being spent to develop new and improved foods, feeds, fibers, pharmaceuticals, and nutraceuticals. With specific regard to genetically modified (GM) foods, consumer reception has been mixed. In many parts of Europe GM foods have been met with strong caution, if not outright opposition (Gaskell et. al. 1999). In the U.S. there appears to be a polarization between proponents and opponents of GM foods, however, the majority of Americans remain relatively unaware or ambivalent about food biotechnology (see, for example, IFIC 2000; Gallup 2001; Hallman et. al. 2002).

The future direction of food biotechnology will be established by the decisions of policy makers, regulators, consumers, farmers, food firms, and the biotechnology industry. These decisions will have far reaching implications for American society as they pervade the economic, environmental, and public health arenas. It is clear that not just scientific evidence, but also public opinion will influence the future of GM foods (Hallman and Metcalfe 1994). It is therefore important to develop a deeper understanding of the basis, strength, and persistence of consumers' opinions of GM foods.

This paper is a descriptive study of consumers' self-reported knowledge, assumptions, and acceptance of food biotechnology in the U.S.[1] The study is based upon a national survey conducted in April 2001 by the Food Policy Institute at Rutgers University. Findings demonstrate the relative lack of thought the typical American has given to agricultural biotechnology and the consequent lack of knowledge and awareness most Americans have of GM foods. This paper

[1] The terms food biotechnology, agricultural biotechnology, and genetically modified (or GM) foods are used interchangeably in this paper.

provides insight into public perceptions of the risks and benefits of food biotechnology. A preliminary examination of differentials in acceptance rates when GM foods are presented in abstract terms vis-a-vis as identifiable products developed from specific technologies with tangible benefits is also provided.

What is Biotechnology?

Gregor Mendel is recognized for his pioneering work with pea plants in the mid-1800s that provided the foundation of our understanding of genetics and heredity, and much of the basis for more deliberate and informed efforts to breed crops and livestock. In the last half century, scientists have come a long way in their knowledge of the genetic structure of organisms, including how genes express various attributes. Scientists now know how to regulate genes to produce specific proteins that control targeted characteristics in the host organism.

Agricultural biotechnology enables the hybridization of plants and animals with desired characteristics by isolating and removing a targeted gene from an organism and splicing it into the DNA of another organism. This very generalized process is known as recombinant DNA technology. A key departure from traditional cross-breeding, however, lies in the fact that through the use of recombinant DNA technology the manipulation of genetic traits can now be achieved without sexual reproduction, thus enabling the sharing of attributes (genes) across different species of organisms. Proponents argue that this is a more refined extension of traditional cross-breeding techniques that have been employed for many centuries to selectively breed crops and livestock.

Methods

This study is based on a national (U.S.) survey of public perceptions, awareness, and acceptance of food biotechnology conducted by the Food Policy Institute. Prior to the development of the survey, the Institute solicited input from more than 50 representatives of academia, government, food and agricultural companies, consumer groups, and biotechnology firms to identify important topics and issues of interest to various stakeholder groups. The survey was also developed to provide comparability to the 1999 Eurobarometer, a broad-based public opinion poll administered in 15 European countries, as well as a previous survey of New Jersey residents conducted by Hallman and Metcalfe in 1993.

Significant thought went into the selection of the appropriate terminology used in the questionnaire. For example, while generally viewed as synonymous, the use of the terms 'genetic modification', 'biotechnology', and 'genetic engineering' do in fact result in significantly different response patterns when used in public polling (Hallman et. al. 2002). 'Genetic modification' was the descriptive term adopted for use in this study due to its increasing common use and the fact that the terminology more accurately reflects the application of recombinant DNA technologies to create new varieties of agricultural products.[2]

The sample frame was the non-institutionalized U.S. adult civilian population. A sample was selected using random proportional sampling from the more than 97 million telephone households in the U.S. The Food Policy Institute commissioned American Opinion Research, the polling division of Integrated Marketing Services in Princeton, New Jersey, to implement the questionnaire using a computer-assisted telephone interview (CATI) system. The survey was in the field for the

[2] 'Biotechnology' is actually an encompassing term, referring to a broad range of technologies including, for example, the development of medicines and pharmaceuticals, recombinant DNA technologies, and cloning. This term is, however, adopted in specific segments of the questionnaire where direct comparability to the Eurobarometer was desired.

period of March 15, 2001 to April 4, 2001. A total 1203 interviews were completed, providing a sampling error rate of ± 3 percent.[3] The average survey time was 24.5 minutes.

Sample Demographics

The geographic coverage of the survey was commensurate with the state population estimates published by the U.S. Census Bureau. A summary of other selected demographics follows:

- 47 percent of respondents were male, 53 percent were female;
- the age of respondents ranged from 18 to 91 years (median: 43 years);
- 76.0 percent of respondents identified themselves as White, 9.5 percent as African-American, 1.6 percent as Asian or Pacific Islander, 1.8 percent as Native American, and 4.5 percent as 'Other' (6.7 percent did not specify race);
- 54.9 percent of respondents were married, 22.4 percent were single, 7.4 percent were separated/divorced, 5.8 percent were widowed, and 4.6 percent were unmarried but living with a partner (4.8 respond did not specify marital status);
- 8.7 percent of respondents had less than a high school education, 28.1 percent were high school graduates, 26.4 percent completed 'some' college, 20.8 percent completed a four-year college degree, and 11.7 percent held a post-graduate degree (4.3 percent did not specify educational level);
- 41.3 percent of respondents reported a household income of under $50,000, 20 percent $50,000 to $75,000, and 21.1 percent over $75,000 (17.0 percent did not specify household income);
- 72.1 percent of respondents attend a house of worship (34.8 percent attend at least once per week); and,
- 33.4 percent of respondents identify themselves as having (or leaning toward) a liberal ideology, 47.9 percent report having (or leaning toward) a conservative ideology, and 10.8 percent identify themselves as moderates (7.9 percent did not indicate a political ideology).

---

[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 up to ensure that representative numbers of males and females were interviewed. Random selection of which adult in the household was to be interviewed was accomplished by asking to interview the person aged 18 or over whose birthday had occurred most recently.

To better represent the population, the data was weighted to adjust for race, ethnicity, and education. Weighting factors were derived from comparison data from the 2000 U.S. Census. Except for the reported sample demographics, all of the univariate results reported are estimates of the distribution of responses within the United States and are derived from the weighted data. However, to avoid analytical errors caused by altering the variance and apparent degrees of freedom through the weighting process, the results of all inferential statistics reported are based on analyses using the unweighted data.

What Do Consumers (Think They) Know About Genetically Modified Foods?

The American public has not given much thought to the issue of genetically modified foods. Consistent with other recent surveys on consumer awareness of food biotechnology (i.e., IFIC 2000; Gallup 2001), most respondents of the Food Policy Institute's survey indicate that they have heard relatively little about this technology. For example, only 13 percent of Americans report having heard or read "a great deal" about genetic modification. Another 47 percent report having heard/read "some" information on the subject while the balance (40 percent) report having heard/read little or nothing. This finding is supported by the fact that only two-in-five (41 percent) of Americans agree with the statement "I feel that I am adequately informed about biotechnology."

Americans do tend to believe they are relatively well-informed about the process of food production in the U.S.; three-quarters, in fact, rate their basic understanding of how food is grown and produced as at least "good." Knowledge of food production appears, however, to be overestimated. In illustration, half of those interviewed said they had never heard about traditional crossbreeding when the technique was described in simple terms. In fact, 61 percent of

respondents report that they have never eaten a fruit or vegetable created through traditional crossbreeding (another 11 percent were unsure).

Americans were less optimistic about their understanding of science and technology, with about two-thirds (66 percent) rating their basic understanding of science and technology as "good" or better. This self-assessment of knowledge, too, seems to be overestimated. Survey participants were presented with a nine-question true-false "quiz" to determine actual knowledge of basic biological facts and principles. Among the findings of the exercise:

- 34 percent of Americans incorrectly believe "genetically modified foods are created using radiation to create genetic mutations" (another 20 percent was not sure if this statement was true or false);
- 33 percent of Americans incorrectly believe "it is impossible to transfer animal genes to plants" (another 16 percent was unsure);
- 24 percent of Americans incorrectly believe "ordinary tomatoes do not contain genes, while genetically modified tomatoes do" (another 19 percent was unsure);
- 30 percent of Americans incorrectly believe "genetically modified animals are always larger than ordinary animals" (another 11 percent was unsure);
- 27 percent of Americans failed to agree with the statement "the father's genes determine whether the child is a girl" (another 9 percent was unsure);
- 22 percent of Americans incorrectly believe "tomatoes genetically modified with genes from catfish would probably taste 'fishy'" (another 10 percent was unsure);
- 21 percent of Americans incorrectly believe "if a person eats a genetically modified fruit, their genes could be modified as a result"(another 11 percent was unsure);
- 19 percent of Americans failed to agree with the statement "the yeast used to make beer contains living organisms" (another 11 percent was unsure); and,
- 4 percent of Americans failed to agree with the statement "there are some bacteria which live on waste water" (another 2 percent was unsure).

Seven of the quiz questions posed to American consumers in the Food Policy Institute survey were originally asked in the 1999 Eurobarometer, enabling an international comparison. As summarized in Table 1, American consumers appear to be more knowledgeable about some basic

facts related to food biotechnology than their European counterparts. However, as noted by Hallman et. al. (2002), despite the generally better performance by American consumers "there is little cause for boasting." Only two-in-five Americans correctly answered more than 6 of the questions correctly to receive a "passing grade."[4]

Table 1: Comparative Analysis of Biotechnology Quiz Results.

	U.S. Results (2001)			*EU Results (1999)*		
Question	**True (%)**	**False (%)**	**Don't Know (%)**	**True (%)**	**False (%)**	**Don't Know (%)**
There are some bacteria which live on waste water. (True)	94	4	2	83	4	13
Ordinary tomatoes do not contain genes, while genetically modified tomatoes do. (False)	24	57	19	35	35	30
If a person eats a genetically modified fruit, their genes could be modified as a result. (False)	21	68	11	24	42	34
The father's genes determine whether the child is a girl. (True)	64	27	9	44	29	26
The yeast used to make beer contains living organisms. (True)	70	19	11	66	12	23
Genetically modified animals are always larger than ordinary animals. (False)	30	59	11	28	34	38
It is impossible to transfer animal genes into plants. (False)	33	51	16	27	26	47
Tomatoes genetically modified with genes from catfish would probably taste "fishy." (False)	22	67	10	Not asked in 1999 Eurobarometer.		
Genetically modified foods are created using radiation to create genetic mutations. (False)	34	46	20	Not asked in 1999 Eurobarometer.		

* Correct responses are shaded.

These findings combine to demonstrate that the American public is not ready to make

[4] Hallman, Adelaja, Schilling and Lang also note that self-assessments of food production/science and technology are poor predictors of actual knowledge (as measured by quiz performance). The correlation between self-rated understanding of food production and quiz score was 0.09 (at $p<.01$). Similarly, the correlation between self-rated understanding of science and technology and quiz score was 0.18 (at $p<.01$).

decisions about GM foods based upon an evaluation of scientific information. This is a particularly important point as efforts to communicate with the public about food biotechnology have typically hinged upon scientific messaging. But, as Hallman (2000) notes

> the place to start is to recognize that decisions concerning the acceptability of biotechnology have long passed the point of being the sole province of experts or of the scientific community and have entered the realms of public policy and public opinion. Failure to recognize the nature of the differences between experts and consumers in knowledge and perspective regarding biotechnology...can lead to poor strategies for providing information to consumers.

To be effective in communicating with the public about food biotechnology, it is important to have an accurate picture of what consumers actually know and understand about the technology, what they want to know, and their perceptions and concerns.

Public Perceptions of the Risks of Genetic Modification

The American perspective on genetic modification exists in a state of schizophrenic tension, with the majority of people simultaneously expressing optimism about the potential benefits of GM technology and concern about the unforeseen consequences of its use. The majority (58 percent) of the American public appears to believe that genetic modification will improve quality of life and nearly two-thirds (62 percent) acknowledge that GM food *will benefit many people*. A little more than half (58 percent) of those surveyed actually believe that *the risks of GM have been greatly exaggerated*.

On the other hand, 56 percent of Americans report that the *idea of genetically modified food causes* [them] *great concern*. Many have reservations about the potential for unintended and unforeseen consequences of the technology. Nearly three-quarters (74 percent) of Americans believe that *the potential danger from genetic modification is so great that strict*

regulations are necessary. Due to human fallibility, 80 percent of respondents believed that *serious accidents involving genetically modified foods are bound to happen*. In fact, half (49 percent) believe that if something did go wrong with GM food, it would be a global disaster. Only one-third of those surveyed feel that genetically modified food *presents no danger for future generations*.

The disruption of the ecological balance emerges as one concern Americans have with respect to genetic modification. For example:

- 58 percent of Americans believe "we have no business meddling with nature";
- 74 percent believe "nature is so complex it is impossible to predict what will happen with GM crops"; and,
- 54 percent feel that "even if genetically modified food has advantages, it is basically against nature";

Concern has been expressed that the introduction of GM plants and animals (created to grow more quickly, be more resistant to pests or drought, etc.) into the environment could lead to a displacement of native species. Fears about ecosystem destablization came to the fore when salmon were genetically modified to mature and grow more rapidly. Similarly, the highly publicized lab study linking pollen from corn genetically modified to express the Bt toxin to Monarch butterfly larvae mortality raised significant concern among environmentalists. Another concern associated with Bt toxin expression in crops is the possible selection of insect pest species that have resistance to the toxin, thus diminishing its effectiveness as a insecticide.

Other concerns Americans express over the genetic modification of food include the potential for adverse human health impacts (i.e., allergenicity or the unintended introduction of undesired compounds into food), the concentration of corporate control of the food supply, and

the immorality of "playing God" with living organisms.[5]

Who Can the Public Trust?

Despite having reservations, Americans do not seem inclined to turn back the clock on food biotechnology. Fewer than one-third (32 percent) report that they would sign a petition against biotechnology and only 35 percent believe it would be better if *we did not know how to do genetic modification at all*. Public trust, however, weighs heavily in the debate over GM foods. While three-quarters of Americans agree that regulation of genetic modification is needed, 59 percent believe the government is not equipped to properly regulate GM foods. Public confidence in the scientific community's ability to self-regulate themselves is similarly low. Only 38 percent of Americans agreed with the statement *scientists in this country know what they are doing, so only moderate regulations on genetic modification are probably necessary*. Further, almost three-quarters (73 percent) feel that *most GM foods were created because scientists were able to make them, not because the public wanted them*. The belief that regulations are needed is also reflected in the fact that two-thirds (68 percent) believe that *companies involved in creating GM crops believe profits are more important than safety*.

Insistence on the Right to Know

Nine-of-ten Americans believe foods created through the use of genetic modification should have special labels. Interestingly, only slightly more than half (53 percent) of those responding to the survey say they would actually take the time to look for fruits or vegetables that were not

---

[5] See Hallman (2000) for a more detailed review of consumer concerns about agricultural biotechnology.

genetically modified. Further, more than one-third (37 percent) say that seeing a label on fresh produce indicating it had been produced using genetic modification would not make a difference in their purchase decision, while about 48 percent would be less willing to buy the produce.

Irrespective of whether label information is used and acted upon (or even read), the public mindset is that "more information is better." The public wants to know that information on the food items on supermarket shelves or in restaurants is available to them and that they have personal control over their consumption decisions (Hallman 2000; Thomson 1997). For example, nearly 70 percent of Americans indicate that they would be unhappy if they were served GM food in a restaurant without their knowledge.

Consumer Acceptance of Genetically Modified Foods

The American public's position on the acceptability of genetically modified food products is, in a word, undecided. The American mindset is uncrystallized on the issue with most people not having an entrenched viewpoint. Further, pinpointing public sentiment on the issue is challenging due to the sensitivity of responses to the wording of questions and terminology. For example, in both the 1996 and 1999 Eurobarometers, perceptions of the impact of various technologies on Europeans way of life were assessed. In the case of biotechnology a split ballot was used, whereby half of respondents were presented with the term "biotechnology" and half were presented with the term "genetic engineering." In both years, the use of the term "biotechnology" resulted in a 7 to 8 percentage point difference in public response (Table 2).

Table 2: Influence of Terminology on Public Response.

	Percentage of Europeans Saying that their way of life will improve in the next 20 years due to the technology	
Term Used	**1996 Eurobarometer**	**1999 Eurobarometer**
Biotechnology	50%	45%
Genetic Engineering	43%	37%

Source: INRA Europe, 2000.

What is further evident, is that the public has decidedly different responses to the presentation of genetic modification in abstract, non-contextualized terms versus specific applications of genetic modification (i.e., specific products with defined attributes). This is not surprising since the typical consumer has not yet been presented with any tangible benefits of agricultural biotechnology. To date, most agricultural biotechnology has been oriented toward providing producer benefits (input traits) such as greater pest resistance (and, hence, reduced chemical inputs), herbicide resistance, drought tolerance, and higher yield (Riley and Hoffman 1999).[6] Specific examples include GM corn containing the Bt (*Bacillus thuringiensis*) pesticide, channel catfish with greater resistance to enteric septicemia, and salmon that grow more rapidly (and are thus less expensive to raise) than their non-GM counterparts (Pew Initiative on Food and Biotechnology 2001).

The "second wave" of food biotechnology promises to yield products oriented more toward output traits, or benefits valued by end users. Examples range from more drought-tolerant turf grass to crops with greater nutritional value, cow's milk with reduced lactose, and even crop or livestock-based vaccines or hormones. A notable and often cited genetically modified food that

[6] As an example, the Hawaiian papaya industry was devastated by the papaya ringspot virus in the 1950s. The successful development of a genetically modified variety of papaya resistant to the virus was field tested in the early 1990s and approved for commercialization in 1997. The GM papaya was modified to incorporate the coat protein gene of the virus (see Gonsalves et. al. 1998).

was unsuccessfully presented to consumers is the *Flav Savr* tomato developed by Calgene, Inc. Marketed in 1994, the tomato was genetically modified to ripen longer on the vine (resulting in better flavor) and remain firm after harvest.

Some authors (Riley and Hoffman 1999; Feldman et. al. 2000; Adelaja and Schilling 1999; Pew Initiative 2001) note potential opportunity in the development of nutraceuticals or "functional" food items that convey greater health through the use of biotechnology.[7] What is unclear, however, is the direction consumers will go when presented for the first time with a food product with defined health (or other) benefits that was derived via modern agricultural biotechnology.

Plant Versus Animal GM

While not resoundingly supportive of the technology, Americans clearly demonstrate greater support for the genetic modification of plants than they do for animals. Overall, 58 percent of survey respondents say they approve (16 percent strongly) of creating hybrid plants via genetic modification (Table 3). Only 28 percent of Americans say they approve (7 percent strongly) of the creation of animal hybrids through the use of genetic modification. Conversely, 22 percent of Americans believe the use of plant GM technologies is *morally wrong* (Table 4). A much greater percentage (55 percent) believe the genetic modification of animals is morally objectionable.[8]

When asked directly, however, whether the technology of genetic modification would make

---

[7] Nutraceuticals may be generally defined as foods or parts of foods that confer health or medicinal value, including the prevention and/or treatment of disease.

[8] As a point of reference, it should be noted that consumer acceptance of traditional crossbreeding techniques is only 63 percent for plants and 31 percent for animals. The percentage of Americans finding such practices morally wrong is 19 and 50 percent for plants and animals, respectively.

the quality of life for people better or worse, 58 percent of Americans responded "better" (14 percent "much better"). In contrast, only 26 percent of Americans believe genetic modification will make the quality of their lives worse (17 percent "much worse").

Table 3: Consumer Acceptance of Plant and Animal Genetic Modification.

	Do you approve or disapprove of creating hybrid plants/animals using GM? *Frequency (%)*				
	Strongly Approve	**Somewhat Approve**	**Somewhat Disapprove**	**Strongly Disapprove**	**No Answer**
GM Hybrid Plants	16.0	41.8	18.9	17.7	5.5
GM Hybrid Animals	7.0	20.7	24.7	42.8	4.8

Table 4: Moral Status of Plant and Animal Genetic Modification.

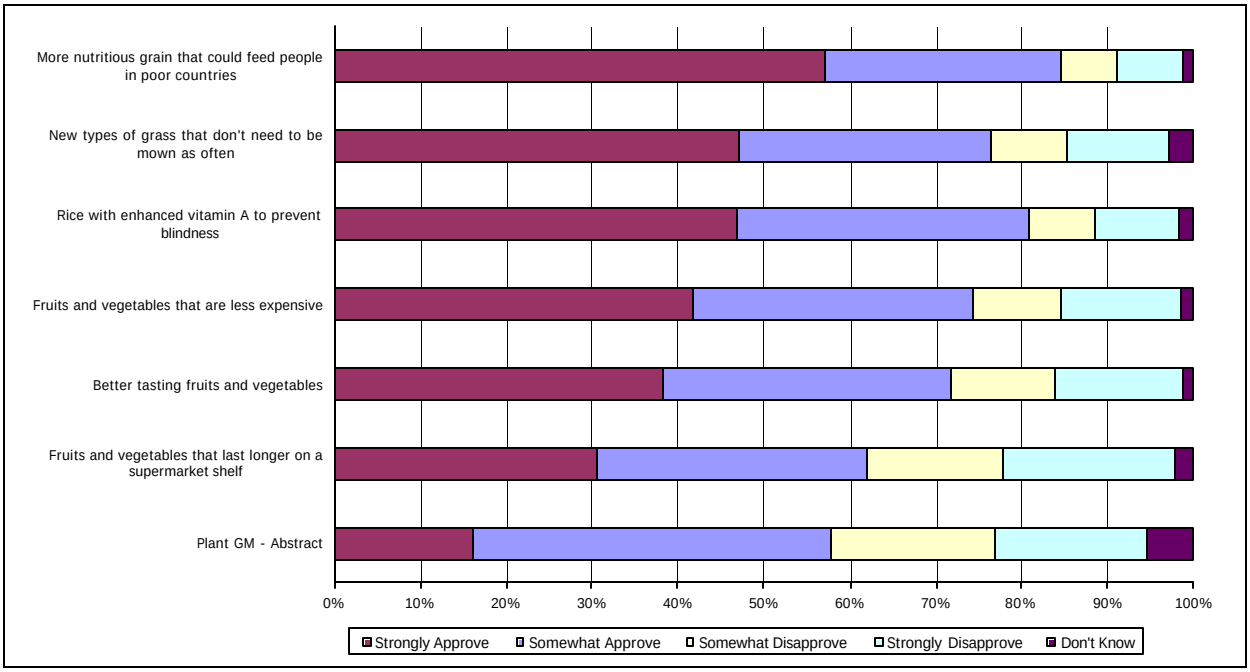
	Is the creation of hybrid plants/animals morally wrong or not? *Frequency (%)*			
	Morally Wrong	**Not Wrong**	**It Depends**	**No Answer**
GM Hybrid Plants	22.0	70.0	2.5	5.5
GM Hybrid Animals	55.1	36.7	4.0	4.2

Tangible Benefit Versus Abstract Concept

As shown in Figure 1, approval for identifiable plant products with specified benefits is significantly higher than it is for the abstract concept of plant genetic modification. For example, while only 58 percent of Americans reported approval for plant genetic modification (presented in the abstract), more than three-quarters approve (47 percent strongly) of genetically modified grass that requires less frequent mowing. Figure 2 reveals a similar pattern for animal-based

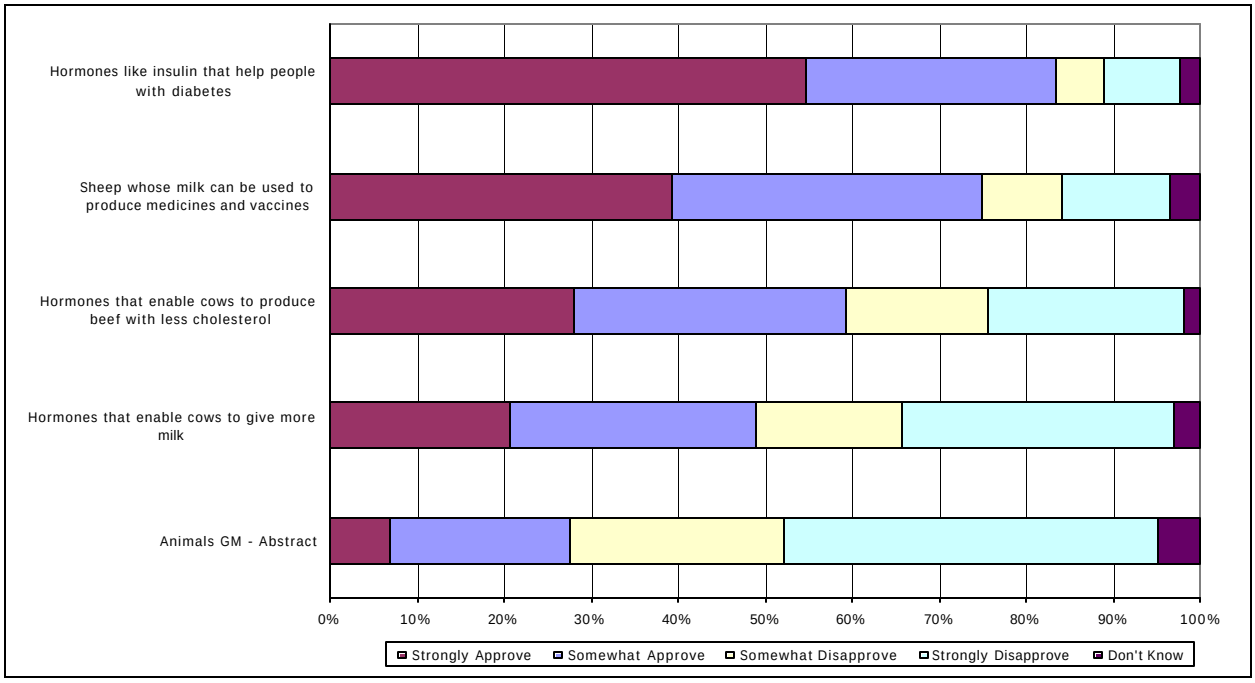
genetic

Figure 1: Consumer Approval of Specific Applications of Plant GM.



modification. Whereas only 28 percent of Americans approve of creating genetically modified hybrid animals, 59 percent approve of using genetic modification to create sheep whose milk can be used to produce medicines and vaccines.

Figure 2: Consumer Approval of Specific Applications of Animal GM.



***Technology Versus Benefit: A Preliminary Look at Consumer Preferences for GM* Functional Foods**

The market for nutraceuticals, including functional foods, dietary supplements, and natural/organic foods, is among the most rapidly growing segments of the food industry (Adelaja and Schilling 1999).[9] The emergence of the U.S. nutraceuticals market is supported by a number of social, economic, and demographic factors including an aging population, rising expense of traditional healthcare, increasing knowledge of diet-disease relationships, and greater receptivity to alternative medical practices. A primary goal of this study is to gain insight on the nature of the interplay between consumer attributes and product attributes (specifically the nature of product health benefits and the use or non-use of genetic modification) and consumer acceptance of various products.

[9] A precise definition of the nutraceuticals market remains elusive. Generally accepted components of the nutraceuticals or nutrition industry, however, include functional foods ($17.2 billion), dietary supplements ($16.7 billion), and natural/organic foods ($11.8 billion). (Market estimates are based on Nutrition Business International's 2000 estimates).

The national survey provided data on consumer willingness to consume three different base products (orange juice, breakfast cereal from grain, and hamburger from beef) with varying levels of health benefits that were derived with and without the use of genetic modification. In total, seven product health benefits were presented. The following benefits were selected with the *a priori* expectation that consumer approval for products would rise as benefits moved from nutritive to preventative to performance enhancing:

- added calcium for healthy teeth and bones (nutritive);
- added vitamins and minerals for better nutrition (nutritive);
- added omega compounds to lower cholesterol and prevent heart disease (preventative);
- added zinc to prevent the common cold (preventative);
- added anti-oxidants to slow the aging process (preventative);
- added compounds to improve memory and concentration (performance enhancing); and,
- added vitamin A to improve eyesight (performance enhancing).

Similarly, three possible technologies for creating the product benefit were evaluated:

- genetic modification involving the introduction of plant DNA;
- genetic modification involving the introduction of animal DNA; and,
- traditional cross-breeding technologies (non-genetic modification).

From the above, a matrix of 21 (7x3) technology/benefit combinations was constructed for each base product. For the purposes of evaluating consumer preferences for these products, the sample was trisected, with a given respondent evaluating their willingness to consume one given base product with a combination of 21 different benefit/technology combinations.[10] Examples of these combinations are:

- orange juice genetically modified with carrot DNA to have added vitamin A to improve eyesight;

[10] The sample sizes for each base product are: orange juice (n=402), breakfast cereal from grain (n=401), and hamburger from beef (n=400).

or,

- orange juice with added calcium for healthy teeth and bones; or,
- beef (hamburger) genetically modified with carrot DNA with added omega compounds to lower cholesterol to prevent heart disease.

Consumer willingness to consume each product permutation was evaluated using a 10-point scale (10 = completely willing to consume, 1 = completely unwilling to consume). The questions were sequenced to first establish consumer preferences for the various product-benefit combinations (with no mention of the technology employed), and then establish preferences for various product-benefit-technology combinations. These questions took the form of:

> Using a scale of 10 to 1 (where 10 means *completely willing* and 1 means *completely unwilling*), how willing would you be to consume (PRODUCT) if it tasted and cost the same as regular (PRODUCT) but had (BENEFIT)?

> Using a scale of 10 to 1 (where 10 means *completely willing* and 1 means *completely unwilling*), how willing would you be to consume (PRODUCT) if it tasted and cost the same as regular (PRODUCT) but was genetically modified using (SOURCE OF DNA) to have (BENEFIT)?

Preliminary Findings

In general, consumers expressed a greater willingness to consume the plant-based products (orange juice and cereal) than the animal-based product (beef hamburger) when they were modified to have specified health benefits, regardless of the technology employed. Empirical results of the consumer preference analysis for one of the three products examined, orange juice, are presented in Table 5. Simple descriptive statistics are presented herein, however, the next phase of analysis involves the decomposition of willingness to consume each of the three products by econometrically isolating the effects of consumer characteristics, product choice, product health benefits, and technology usage.

Results were not consistent with the *a priori* expectation that consumer willingness to

consume orange juice products would increase as the nature of the health benefit shifted from nutritive to preventative to performance enhancing. In fact, orange juice with added calcium for healthy teeth and bones and orange juice with added vitamins and minerals for better nutrition were the most highly rated products (mean = 8.02/10 and 7.85/10, respectively). The ranking of the remaining product-benefit combinations was as follows:

- orange juice with added vitamin A to improve eyesight was ranked 3rd (7.72/10);
- orange juice with added omega compounds to lower cholesterol and prevent heart disease ranked 4th (7.64/10);
- orange juice with added zinc to prevent the common cold ranked 5th (7.51/10);
- orange juice with added anti-oxidants to slow the aging process ranked 6th (7.05/10); and,
- orange juice with added compounds to improve memory and concentration ranked 7th (7.03/10).

The use of genetic modification to derive orange juice with the specified benefits, in all cases, resulted in lower consumer willingness to consume. Consumer acceptance of the products fell more significantly when animal DNA was introduced into the orange. The next step in the analysis will provide insight into the relative importance of both consumer and product attributes on consumer willingness to consume genetically modified food products, allowing for greater understanding of the market segmentation for biotechnology-derived functional food products.

Table 5: Impact of Added Benefits and Technology on Consumer Willingness to Consume Orange Juice.

	Technology Employed					
	No GM		**Plant GM**		**Animal GM**	
Benefit	Mean*	S.D.	Mean*	S.D.	Mean*	S.D.
calcium for healthy teeth and bones	8.02	2.64	6.74	3.21	5.46	3.45
omega compounds to lower cholesterol	7.64	2.83	6.77	3.14	5.39	3.49

vitamins and minerals for better nutrition	7.85	2.63	6.68	3.07	5.31	3.42
zinc to prevent the common cold	7.51	2.85	6.64	3.16	5.18	3.41
anti-oxidants to slow aging process	7.05	3.09	6.40	3.25	4.99	3.38
compounds for memory and concentration	7.03	3.04	6.46	3.12	5.11	3.37
vitamin A to improve eyesight	7.72	2.74	6.74	3.13	5.18	3.41

* Based on a scale of 1 (completely unwilling to consume) to 10 (completely willing to consume).

Conclusions

Proponents of GM technology argue that, in addition to producer benefits (input traits), modern biotechnology is poised to bring useful new products to the market with consumer or end-user benefits (output traits) such as enhanced nutritive or health value. Opponents of biotechnology counter that the risks of genetic modification are not fully known and that unintended human health, ecological, or other adverse effects are possible. As the use of genetic modification of foods proceeds, it is becoming increasingly necessary to gain a better understanding of public perception and acceptance of these products. Substantial investments are being made in biotechnology within the agricultural and food industries despite the lack of clarity on the future direction of public sentiment.

Genetically modified foods (or food production in general, for that matter) is not a front-runner among issues the typical American tends to think about today. It follows that most Americans have not made any significant effort to learn about the technology or its applications and are thus relatively unaware of its use in food production. When forced to think about genetically modified foods, Americans respond with both optimism as well as caution. For the majority of Americans with no entrenched viewpoint in favor or against GM foods, opinions tend to be held with little conviction and are subject to change. Indeed, pinpointing public sentiment on

the issue is challenging due to technical reasons (i.e., sensitivity to terminology used and the context within which the technology is presented.) as well as the fact that viewpoints are uncrystallized and malleable. While the majority of Americans are not inclined to dismiss the potential value of food biotechnology, most are similarly convinced that the full range of potential impacts of genetic modification is not known and oversight and regulation of GM practices is necessary.

The Food Policy Institute has initiated a major four year study of American public perceptions, attitudes, and acceptance of genetically modified foods. The project is both multi-functional (integrating research, outreach, and teaching) and multi-disciplinary, engaging agricultural economists, psychologists, risk assessment experts, communication specialists, marketing specialists, plant/biotechnology scientists, and extension faculty. More than 20 participating investigators have been convened from Rutgers University, Penn State University, Texas A&M University, Saint Joseph's University, and the University of Dusseldorf (Germany). Anyone wishing to learn more about the initiative is invited to contact the authors.

References

Adelaja, A. and B. Schilling. 1999. "Nutraceuticals: Blurring the Line Between Food and Drugs in the 21st Century". Millennium Issue of *Choices* (December issue): 35-39.

Feldmann, M. P., M. L. Morris, and D. Hoisington. 2000. "Genetically Modified Organisms: Why All the Controversy?" *Choices* (First Quarter):8-12.

Gallup News Service. 2001. "Gallup Poll Analyses - Biotech Food Remains Fairly Obscure to Most Americans." Gallup Organization, Princeton, New Jersey.

Gaskell, G., M. Bauer, J. Durant, and N. Allum. 1999. "Worlds Apart? The Reception of Genetically Modified Foods in Europe and the U.S." *Science*, Vol. 285:384-387.

Gonsalves, D., S. Ferreira, R. Manshardt, M. Fitch, and J. Slightom. 1998. "Transgenic Virus Resistant Papaya: New Hope for Controlling Papaya Ringspot Virus in Hawaii." American Phytopathological Society. Available at: http://www.apsnet.org/education/feature/papaya/Top.htm

Hallman, W. K., A. O. Adelaja, B. J. Schilling and J. Lang. 2002. "Public Perceptions of Genetically Modified Foods: Americans Know Not What They Eat." Food Policy Institute Publication No. RR-0302-001.

Hallman, W. K. 2000. "Consumer Concerns About Biotechnology: International Comparisons." Food Policy Institute Publication No. ####.

Hallman, W. K. and J. Metcalfe. 1994. "Public Perceptions of Agricultural Biotechnology: A Survey of New Jersey Residents." EcoPolicy Center Report, Rutgers University.

INRA Europe. 2000. Eurobarometer 52.1. The Europeans and Biotechnology Report by INRA (Europe) - ECOSA. Report on behalf of Directorate-General for Research, Directorate.

International Food Information Council. "Consumer Attitudes Toward Food Biotechnology." Available at: http://ificinfo.health.org/foodbiotech/survey.htm.

Nutrition Business International. *Nutrition Business Journal*. Vol 6(5/6):1-7.

Pew Initiative on Food and Biotechnology. 2001. "Harvest on the Horizon: Future Uses of Agricultural Biotechnology.

Riley, P. and L. Hoffman. 1999. "Value-Enhanced Crops: Biotechnology's Next Stage." *Agricultural Outlook* (March 1999): 18-23.

Thomson, P. 1997. "Food Biotechnology's Challenge to Cultural Integrity and Individual Consent." Hastings Center Report 27(4):34-39.