An Application of Choice modeling To Measure U.S. Consumer Preferences for Genetically Modified Foods

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Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Denver, Colorado, August 1-4, 2004

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Abstract

Food biotechnology promises to deliver a wide range of enhanced consumer benefits. This study models consumer's willingness to trade-off the potential risks of GM foods with the possibility of extracting significant benefits. It estimates the marginal effects and relationships between product characteristics and consumer attributes on acceptance of GM foods.

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Introduction

The commercial potential of biotechnology emerged as a new reality in the agricultural and food industries in the 1990s. The use of food biotechnology offers the promise of delivering foods with a wide range of enhanced consumer benefits. Despite their promise, genetically modified (GM) products have received mixed regulatory and consumer approval in the U.S. and elsewhere (Gaskell *et al.*, 1999; Hallman *et al*., 2002). Controversy exists about the possibility and extent of externality costs resulting from unanticipated health, and environmental impacts, as well as the moral and ethical acceptability of the use of biotechnology in the food system.

Billions of research dollars are being expended on R&D to develop GM products with output traits that bring tangible consumer benefits. These potential benefits include longer shelf stability, enhanced sensory appeal, reduced allergenicity and nutritional or wellness attributes (Dunahay, 1999; Riley and Hoffman, 1999; Feldman *et al*., 2000). Another promising use of biotechnology is potential to develop organisms that produce pharmaceuticals such as vaccines and hormones (Hallman *et al*., 2002). These distinct consumer benefits of the GM food products (which are not available in the non-GM products) are likely to be critically important for broad consumer acceptance of bioengineered foods (House *et al*., 2001). As GM food products with enhanced and functional attributes appear in the marketplace, consumers will be faced with the choice between GM products that bring tangible benefits (but may carry unknown risks) and the traditional non-GM products that do not provide these distinct benefits.

It is vital that researchers contribute to the ongoing debate over the benefits and risks of biotechnology by providing scientifically credible information on how consumers value various food attributes, including process attributes such as genetic modification. This is especially true given that food consumption in the U.S. and other developed countries is driven by factors other than pure physiological needs. Majority of consumers in these countries want foods that are not only safe, but that also promote good health and overall well-being (Senauer, 2001). As Antle (1999) rightfully argues, the analysis of food consumption demand needs to go beyond its traditional setting to incorporate consumer characteristics as well as non-price attributes of foods such as nutritional content, safety and convenience attributes, how the product is produced, environmental impacts of production, the use of pesticides, irradiation and GM organisms.

This study contributes to the ongoing debate over food biotechnology by explicitly modeling how consumers trade-off the potential or perceived risks of GM foods with the possibility of extracting significant benefits from GM foods. Specifically, this study estimates the marginal effects of, and relationships between, specific product characteristics and consumer attributes on consumer acceptance of GM food products. Consumer choice of food attributes will be analyzed within the choice-modeling framework (Louviere *et al*., 2000).

In particular, this study will analyze (i) how consumers value the attributes embodied in food products (e.g., technology of production, product benefit content); (ii) how consumer valuation of these attributes vary across product-types (whether it is consumed as a fresh product or it is a processed product or it is an animal-based product); and (iii) how the preference over product-attribute and product-type combinations are related to observed consumer characteristics (e.g., economic and demographic variables).

Empirical Model

Consumer preferences over food attributes are analyzed within the random utility discrete choice model framework (McFadden, 1978; Revelt and Train, 1997). Since market data from GM food products are not available, stated preferences (SP) choice modeling framework (Louviere, 2000) is used. The Lancaster (1966a,b) model provides the natural framework within which consumers' food choice can be analyzed. In this model, consumers derive utility (U) from the attributes or characteristics (*z*), which are embodied in the products they purchase:

$$U = U(z_1, z_2, \cdots, z_m) \text{ where } z_i = a_{ij} q_j \quad (1)$$

In the above equation, z_i is the amount of i^{th} attribute obtained by consuming the j^{th} product, a_{ij} is the amount of i^{th} attribute per unit of the j^{th} product, and q_j is the quantity of jth good consumed. Although Lancaster thought of this relation between goods and attributes as being objective, this model can also be used in a setting where consumers' subjective perception of the technology and attributes affect their consumption decisions. In the context of this study, these attributes include the production technologies (whether the product is genetically modified; for GM products, whether genetic modification involves plants or animals, whether there is gene transfer across plants and animals, etc.).

Assuming that each available choice is one configuration of M product attributes, each of which has multiple levels. Different levels of the M product attributes yield a total of N choices from which the consumer makes his/her choice. The consumers' utility from the choice of alternative j is given by:

$$U_j = V_j + \varepsilon_j = \sum_m \beta_m z_{mj} + \varepsilon_j \tag{2}$$

where U_j is the latent utility associated with choice j , V_j is the explainable part of latent utility that depends on the chosen product attributes (z_{mj}), and ε_j is the random component of utility associated with choice j. The consumer chooses alternative j if $U_j > U_r$ ($j \neq r$). Therefore, the probability that the consumer chooses the option j (which is indicated by $y_i = j$) is given by:

$$P(y_i = j) = P(U_j \succ U_r) \quad \text{for all other } r \neq j. \tag{3}$$

The model is implemented by making assumption about the distribution ε_j. Assuming that ε_j are iid with type-I extreme value (Gumbel) distribution, the probability that the consumer chooses option j is given by (McFadden, 1973):

$$P(y_i = j) = \exp\left(\sum_m \beta_m z_{mj}\right) \Big/ \sum_j \exp\left(\sum_m \beta_m z_{mj}\right) \tag{4}$$

which leads to the standard conditional logit model. However, the above model suffers from the well-known and restrictive *Independence from Irrelevant Alternatives (IIA)* property and, therefore, is unable to incorporate preference heterogeneity across consumers. To address this problem, we will model consumer preference using the random coefficient logistic (random parameter) model or the mixed logit model. In this framework, it is assumed that β_{ij} (β_j associated with consumer i) is random across individual consumers whose distribution can be specified as follows:

$$\beta_{ij} = \bar{\beta}_j + \sum_k \theta_{kj} x_{ik} + \sigma_k u_{ik} \qquad (5)$$

where u_{ik} is normally distributed with correlation matrix **R**, σ_k is the standard deviation of the distribution, $\bar{\beta}_j + \sum \theta_{kj} x_{ik}$ is the mean of the distribution that depend on x_{ik} representing person-specific (observable) characteristics (age, gender, etc.), and u_{ik} are random errors that capture unobservable and excluded consumer attributes. In this formulation, $\bar{\beta}_j$ reflects the *average taste* (preference) of all consumers for choice j and $\sum \theta_{kj} x_{ik}$ denotes the variation (or deviation) of individual preference that depends on observable consumer characteristics. The constant term b can be portioned into alternative specific constants (ASC) that are unique to each alternative that are considered in the choice sets. ASC capture the influence on choice of unobserved attributes relative to the specific alternative.

Substituting equation (5) in equation (2), the random utility function can be written as:

$$U_{ij} = \sum_m \bar{\beta}_m z_{im} + \sum_m \sum_k \theta_{km} x_{ik} z_{im} + \sum_m z_{im} \sigma_k u_{ik} \qquad (6)$$

In this model, the mean utility is $\sum \bar{\beta}_m z_{im}$ which depends only on product attributes (z_{ij}) and, thus it is a product specific component that does not depend on consumer characteristics. On the other hand, heterogeneity in preferences depends on the interaction between product attributes and consumer characteristics. The parameters of the model will be estimated using the Maximum Likelihood (ML) estimator.

Application of Choice Modeling to the U.S GM Food Market

A private public polling firm conducted the national telephone survey between February 27, 2003, and April 1, 2003[1]. Targeting the non-institutionalized U.S. adult (18 years or older) civilian population, a random proportional probability sample was drawn from more than 97 million telephone households in the contiguous forty-eight United States. U.S. Census Bureau population estimates determined the distribution necessary for proportionate geographic coverage. The target sample size of 1200 allowed a sampling error rate of ±3 percent[2].

Two versions of the survey were used and some questions were only posed to half the sample. Using a computer-assisted telephone interview (CATI), a total of 1201 telephone surveys were completed, with the average cooperation rate for both versions of the survey was 65 percent.[3]

During the telephone survey interviews, respondents who reported consuming corn flakes, bananas or ground beef at least occasionally (1199 respondents) were asked if they would be interested in further participating in a mail survey. Of the 1199

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[1] Interviewing was not conducted on March 21 and 22 due to the start of "Operation Iraqi Freedom" and the coverage it was receiving on television.

[2] The sampling error associated with a nationwide sample of 1,200 people is approximately ±3 percent with a 95 percent confidence interval. This means that if 50 percent of the respondents gave a particular response, the likely percentage of the entire adult population should be between 47 percent and 53 percent, 95 out of 100 times.

[3] The cooperation rate is the percentage of completed interviews (1201) over completed interviews (1201) + refusals (636). A more rigid calculation of response rate, defined as the percentage of completed interviews (1201) over total numbers in-frame telephone number (3120) yields a response rate of 38.5%.

potential respondents, we ended with 661 (55.1%) agreeing to respond to the mail questionnaire in exchange for nominal compensation of $5. Of the 661 who agreed, 409 (61.9%) returned a completed survey distributed as follows: banana: 137, cornflakes: 128; and ground beef 144.

The mail survey consisted of three parts; with part one eliciting consumers' stated preference for the GM foods, part 2 focused on willingness to consume genetically modified food products, while part 3 covered trust questions on institutions associated with biotechnology. Instructions at the front page were; a presentation of a choice set example with directions of how a respondent will make a selection, a brief description of the GM technologies; and the accompanying cover letter explaining survey purpose.

Some questions from the telephone interviews were repeated in the mail survey to act as breakers to stop potential response patterns and fatigue. On the other hand, these questions were used to test whether the responses changed in any way due to learning process that would occur by taking the mail survey itself. The Choice modeling questions were pretested with suggestions to put "Price", "Product Benefit", and "Technology" as row headings and "Survey Instructions" at the top of the page.

The execution and planning of the mail survey was a stepwise procedure with the experimental design for the choice modeling first being subjected to several lengthy discussions by various groups, comprising of life and social scientists. The objective was to arrive at appropriate products that may appeal to the larger public, had potential and likely attributes and plausible genetic modification technologies through which the products will be delivered. The following principles guided the selection and consideration of the range and scope of products, technologies and benefits to be covered:

(1). **Products**; need to cover plant and animal food products, these products could be either whole (fresh) or processed; (2) **Benefits**; to broadly incorporate a number of benefits that either impact consumer's health, or some other type of consumer benefit, or could provide a "societal" benefit. (3) **Technologies**; to incorporate a wide range of existing and potential technologies such as plant or animal based genes or microorganisms (bacterium); (4) within and cross product analysis; and (5) keep the matrix of product, technology, price, and benefit combinations plausible.

The outcome of the group discussions and consultations was a proposal to offer specific product/benefits and generalized technology (i.e., genes from a different plant, genes from a different animal, genes from the same plant/animal that have been modified to emphasize a given attribute. Although there was an expressed need to carry out cross product and/or within product analysis, it finally emerged that it was only feasible and more enriching to carry out a within product analysis. The cross product analysis was viewed to be unnecessarily complex yielding no meaningful analysis. It was also argued that some of the combinations in the design matrix might lead to illogical permutations. Moreover, even if the categories of benefits were held constant (input trait, health benefit, non-health consumer benefit, etc.), the analysis was to be confounded by interaction effects between the specific benefit and the specific product, making across-product analysis difficult.

Admittedly, the within product analysis will yield differences in the marginal effects on consumer preference due to various (specific) benefits and technology combinations within a specific product. Additionally, it was argued that knowledge gained through this project should be applied towards meeting the commitment that from the project will emerge an industry advisory service. Thus, the specificity of the analysis would be attractive (even if the products/benefits we analyze may not be of interest to any specific company. The work will demonstrate our capability to examine "***their***" products in very specific detail. Second is the potential gain of value, as respondents are able to relate to specific product characteristics to give more thoughtful responses. For example, corn flakes with longer shelf life versus corn flakes that stays crispy in milk longer or a banana that does not often/bruise as quickly.

A fraction factorial experiment design was used to executed create a balanced and efficient design matrix for a number of choice sets for the Choice modeling part of the survey using the SAS Macros. The three products characterized by three (factors): technology, benefit and price with each of the factors having four different levels. The three Choice modeling experiments on banana, ground beef and cornflakes were run concurrently in a same survey leading to 48 choice sets. After elimination of the dominated choices, 40 choice sets remained. Three of the alternatives in each choice set were all variants of a GM product, with the fourth alternative being the status quo (a conventional product), which was constant and common to all choice sets across the three products. The 40 choice sets were split into 4 subsets, with each respondent randomly allocated one set of 10 questions to complete (a process refereed to as blocking).

A description of the products and possible permutations of levels of each of the attributes is detailed below:

Product: Commonly consumed food product from each of the three groups: (1) products that are consumed as fresh: ***Banana***; (2) a processed food product: ***Cornflakes***; and (3) a meat (beef) product: ***Ground beef***.

Technologies: For plant based products, the technology alternatives are (1) non-GM; (2) a plant genetically modified by simply removing or altering one of its own DNA; (3) a plant genetically modified by using DNA from another plant; (4) a plant genetically modified by using DNA from an animal; and (5) a plant genetically modified by using DNA from a microorganism (e.g., bacterium, virus, etc). For the animal product (ground beef), the technology alternatives are: (1) conventional livestock technology (non-GM animal; (2) cattle raised with feed that contains GM ingredients; (3) cattle genetically modified by simply manipulating one of its own DNA; (4) cattle genetically modified using DNA from another animal; and (5) cattle genetically modified by using DNA from a plant.

Benefits: For the plant-based products, we considered the following set of benefits: (1) no added nutritional or environmental benefit (the case of non-GM product); (2) reduced pesticide use in production (an environmental benefit that lowers risk of pesticide residue in fresh produce); (3) enhanced shelf-life for products consumed fresh or enhanced chemical properties that help processing; (4) enhanced level of a nutrient (e.g., lycopine or omega fatty acid, antioxidants, added compounds or nutrients that are believed to prevent disease); and (5) enhanced level of a nutrient that has medicinal value (e.g., a chemical that works as a remedy for arthritis type inflammation). Besides, the following benefits were considered for beef: (1) no added nutritional benefit (the case of conventional cattle); (2) reduced pesticide use in the production of inputs used in livestock industry (the case of Bt corn or Roundup Ready™ soybean used as feed); (3) beef with less cholesterol; (4) enhanced level of a nutrient that is believed to prevent disease; and (5) added nutrient that has medicinal value.

Price: We used the following price offers: (1) current price; (2) a 10% discount (relative to current price); (3) a 10% premium; (4) a 5% premium; (5) a 5% discount.

Results

Although the returned surveys yielded 4090 choice sets across the three products, only 2090 of these choice sets were used for analysis (i.e., banana: 1010; cornflakes: 980; and ground beef: 920). Of these respondents, 29 % were lexicographic; i.e., those respondents who would not chose A, B, & C regardless of the attributes contained in the other food alternatives. Therefore, inclusion of lexicographic respondents will not be amenable to choice modeling since by attempting to explain their choices on the basis of attribute levels (the basic premise of choice modeling) would produce biased estimates.

This analysis is based on 2910 choice sets spread across the three food products (i.e., 71 % of those respondents who chose A, B, C, & D). Several models were tried and in the process eliminated those yielding singular matrices. For example, in the case of cornflakes and banana, the inclusion of both own and plant technologies yielded singular matrices.

The random parameter (mixed) logit models results are presented in Tables 1-3 for each product while table 4 and 5 present correlations, elasticities and willingness to pay for non-marketable attributes. The results show that the signs of most of the price, benefit, and technology coefficients conform to our a priori expectations. The price has a negative effect on choice with the increase in price is associated with decreased demand (a negative impact on utility). Most of the product benefits have positive effect on choice. The exception is the increased antibiotics in cow production or added nutrients for stronger teeth and bones (insignificant), which reduces the probability of the ground beef GM alternatives being chosen. The negative coefficients on technology imply that moving from the conventional technology to the GM reduces utility. However, when ground beef product is from cows fed on GM corn and is modified using its own gene transfer, it leads to an increase of utility. Animal genes, Bacterium, and in some cases plant genes had a negative effect on choice (i.e., reducing the probability of the GM alternatives being selected).

Monetary values of a unit change in an attribute level can be estimated by evaluating the ratio of the attribute coefficient to the coefficient of the monetary variable to produce the partworths. A part worth should be normally represented by an absolute currency figure, in this study the payment vehicle was defined as a percentage change in the price. Accordingly the numbers generated by the part worth calculations are also in percentage terms (e.g., the % change in price that there will be a WTP to achieve a change). The coefficients of price for the three products have the negative expected sign and were significant at 10 percent or lower levels of significance. The standard deviations of all the attributes across the three products were highly significant implying heterogeneity in preferences across the consumers. The implicit prices were obtained for non-monetary attributes i.e., benefits and technologies. The positive values are associated with changes that are seen to be beneficial (i.e. a respondent is willing to pay a positive amount for an increase of this attribute), negative values with changes that reduce utility (i.e., the respondents requires compensation in form of discount for a unit increase in this attribute and thus that value can be interpreted as a measure of WTA (See table 5).

In case of bananas, positively associated attributes were that of using less pesticides and chemicals to grow bananas, a direct human benefit of added antioxidants to promote heart health and increased banana shelf life i.e. stays riper longer and reduces bruises with respondents willing to pay 3%, 1.4% and 2 % more in order to obtain such benefits. However, if the banana product is a result of genetic modification via plant, animal or bacterium genes, the respondents need to be compensated to accept it. The results show that more compensation is required to induce acceptance of processes involving animal and bacterium genes (19 % and 4 %, respectively). The results also show that respondents rank technology from least to more acceptable (i.e., moving from a small to a larger negative and vice-versa). They rank genetic modification via own genes, followed by plant with bacterium. Modification using animal genes is ranked last. Thus given the valuation of the attributes, the responded ranked benefits and technologies in the following order: Benefits (oxidants, less pesticide, ripens longer); Technologies (own-gene, plant gene, bacterium, animal gene).

Given the normality assumption, at the same price, about 35-39% of the respondents would have placed a negative coefficient on less pesticide and ripens longer benefit with all the respondents placing positive coefficient for antioxidants. Unlike the benefits, all the respondents largely placed a negative coefficient, ranging from 58-83 % for animal gene based technology.

In the case of cornflakes the attributes of growing corn using less pesticides and chemicals, and added antioxidants that promote heart health were valued to contribute towards increased utility. Results indicate that respondents are willing to pay 17 % or more to get the of a health heart or gain environmentally via less pesticides. The consumers could pay 5% more for a cornflake that stays crunchier longer in milk. Moreover, the results show that if cornflakes are made possible via own corn genes genetic modification, the respondents are willing to pay 0.1 % more. In contrast to the positive valuation of genetic modification involving corn's own genes, the genetic modification process involving animal, bacterium and plant genes, shows that consumers need to be compensated 37% more to accept the cornflakes modified with the use of animal genes. Similar to the banana product, respondents ranked and viewed bacterium and animal technology as least acceptable with corn own genes used for the purpose of modification being viewed positively. The consumers ranked benefits and technologies as; Benefits (added antioxidants, less pesticides, stays crunchier): Technologies: (own gene, plant gene, bacterium, animal gene)

Given the normality assumption, at the same price, about 24-40% of the respondents would have placed a negative coefficient on less pesticide and ripens longer benefit with all the respondents placing positive coefficient for antioxidants. Unlike benefits all the respondents largely placed a negative coefficient on ranging from 57-80 % for animal gene based technology.

For ground beef, with the exception of antioxidants to promote health heart where the consumers have to pay a premium of 4% to obtain the product, while requiring a compensation of 1 % and 3% for nutrients to strengthen teeth and bones and fewer antibiotics. Similarly, in the case of technology, the consumers were willing to accept a premium of 5 % and 8 % for ground beef from the process involving plant genes and cows fed on genetically modified corn. In contrast, consumers require a compensation of 0.5 % and 13 % for a process involving own cow genes and genes from a different animal. Similar to the banana and cornflakes products, respondents ranked and/or viewed bacterium and animal technology as least acceptable with own gene or cows fed on genetically modified corn more acceptable. The respondents ranked the benefits and technologies in the following order: Benefits: added antioxidants, added nutrients fro stronger teeth and bones, fewer antibiotics: Technology: fed on GM corn, plant genes, own gene, bacterium, and animal gene

With the normality assumption, at the same price, about 40-56% of the respondents would have placed a positive coefficient on less pesticides and ripens longer benefit with all the respondents placing positive coefficient for antioxidants. On the other hand, fairly few compared to cornflakes and banana placed a positive coefficient on technology ranging from 30-66%.

Elasticity estimates (table 4) show that own elasticities for the three products tend to have similar magnitudes, whereas the cross elasticities are of smaller magnitudes compared to own. The similarities in elasticities within the product reflect similarity of the product options (variation of GM technology) A, B, and C, compared to the non-GM option, varying only on how the benefits and technologies are combined. A closer look at the correlation matrix for the random parameters reveals the tradeoffs made. Any individual choosing a bundle in an option may chose to combine a positively with negatively valued attribute.

Concluding Remarks and Policy implications

By examining respondents' preferences, choices and attitudes towards GM foods, the survey adds to knowledge about market potential and likely consumer response to GM crop development and production. In particular the choice modeling component of the survey enriches our knowledge about consumer attitudes towards GM foods in the context of other attributes (including price), and the tradeoffs made between those attributes when making purchasing decisions.

The evaluation of determinants of consumers food choice in terms of product attributes and consumer characteristics is important from competitive and policy perspective. For scientists and industry developing GM food products, this study provides important information about the product attributes that consumer's value most. This analysis also provides information on consumer willingness to trade-off the perceived risks of GM foods with the nutritional and environmental benefits embodied in bioengineered products. Information generated by this study will enable developers of bioengineered products and food industry to incorporate appropriate benefit attributes to overcome the potential negative impacts facing GM foods. For policy makers, this study provides a better understanding of the impacts of public attitudes and perceptions on their food choice. Therefore, regulators will be able to better evaluate the impacts of regulations (e.g., nutritional), educational and outreach programs on consumers' food attribute choice and acceptance of GM food products.

A limitation of this study is that the three products could not be used for all other foods. Thus, different products are capable of providing different attributes and their acceptance could differ from those products covered here. We have not included ethical and a number of socio-economic variables in these experiments and yet we know that other that tangible attributes, some attitudinal variables could add to the explanatory power of these models. Hence, future work should explore possibilities of including such variables.

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Table 1: Parameter Estimates: The Mixed Logit Model: Banana (normally distributed random parameters)

Variable		Coefficient	Standard error	t-ratio
PRICE		-0.3025	0.0766	-3.95***
Grown using Less chemicals and pesticides	Mean Coefficient	0.8053	0.2548	3.16***
	Standard Deviation of the Coefficient	2.1450	0.2919	7.35***
Added antioxidants to promote heart health	Mean Coefficient	0.4293	0.2181	1.97**
	Standard Deviation of the Coefficient	0.0933	0.2369	0.39
Stays Riper longer and reduces bruises	Mean Coefficient	0.5753	0.3077	1.87*
	Standard Deviation of the Coefficient	2.2572	0.3182	7.09***
Genetic modification using genes from a Bacterium	Mean Coefficient	-2.9013	0.5516	-5.26***
	Standard Deviation of the Coefficient	4.4051	0.5479	8.04***
Genetic modification using genes from a different Plant	Mean Coefficient	-1.1476	0.4006	-2.86***
	Standard Deviation of the Coefficient	3.5575	0.3878	9.17***
Genetic modification using genes from an Animal	Mean Coefficient	-5.7112	1.0798	-5.29***
	Standard Deviation of the Coefficient	5.3429	0.6056	8.82***
Genetic modification using Banana's Own Genes	Mean Coefficient	0.4838	0.3548	1.36
	Standard Deviation of the Coefficient	3.0041	0.3249	9.25***
Model statistics				
Log Likelihood	-963.21			
Restricted Log Likelihood	-1386.29			
Chi Square	846.17			
DF	39			

*** α=. 01, **α=. 05** and α=. 10

Table 2: Parameter Estimates: The Mixed Logit Model: Cornflakes (normally distributed random parameters)

Variable		Coefficient	Standard error	t-ratio
PRICE		-0.098	0.0598	-1.64*
Grown using Less chemicals and pesticides	Mean Coefficient	1.624	0.2728	5.95***
	Standard Deviation of the Coefficient	2.331	0.3972	5.87***
Added antioxidants to promote heart health	Mean Coefficient	1.844	0.3711	4.97***
	Standard Deviation of the Coefficient	2.133	0.3289	6.49***
Added compounds to increase energy	Mean Coefficient	0.447	0.2684	1.66*
	Standard Deviation of the Coefficient	2.102	0.3058	6.87***
Genetic modification using genes from a Bacterium	Mean Coefficient	-2.766	0.4537	-6.10***
	Standard Deviation of the Coefficient	2.958	0.5456	5.42***
Genetic modification using Banana's Own Genes	Mean Coefficient	-0.014	0.4310	-0.03
	Standard Deviation of the Coefficient	3.260	0.4180	7.80***
Genetic modification using genes from an Animal	Mean Coefficient	-3.587	0.5885	-6.09***
	Standard Deviation of the Coefficient	3.617	0.5871	6.16***
Genetic modification using genes from a different Plant	Mean Coefficient	-0.993	0.4351	-2.28**
	Standard Deviation of the Coefficient	3.445	0.4443	7.75***
Model statistics				
Log Likelihood	-964.76			
Restricted Log Likelihood	-1358.57			
Chi Square	787.62			
DF	39			

*** α=.01, **α=.05** and α=.10

Table 3: Parameter Estimates: The Mixed Logit Model: Ground Beef (normally distributed random parameters)

Variable		Coefficient	Standard error	t-ratio
PRICE		-0.177	0.0832	-2.13**
Cows produced using Fewer Antibiotics	Mean Coefficient	-0.517	0.3043	-1.70*
	Standard Deviation of the Coefficient	2.274	0.3431	6.63***
Added Nutrients to promote stronger teeth and bones	Mean Coefficient	-0.145	0.2735	-0.53
	Standard Deviation of the Coefficient	1.871	0.3004	6.23***
Added antioxidants to promote heart health	Mean Coefficient	0.613	0.3199	1.92**
	Standard Deviation of the Coefficient	2.395	0.2899	8.26***
Genetic modification using genes from a Bacterium	Mean Coefficient	-2.089	0.7839	-2.66***
	Standard Deviation of the Coefficient	4.372	0.5214	8.39***
Genetic modification using genes from a different Plant	Mean Coefficient	0.877	0.9520	0.92
	Standard Deviation of the Coefficient	4.238	1.0980	3.86***
Genetic modification using genes from an Animal	Mean Coefficient	-2.258	0.6207	-3.64***
	Standard Deviation of the Coefficient	4.327	0.5262	8.22***
		-0.064	0.4700	-0.14
Genetic modification using Cow's Own Genes	Mean Coefficient	-0.064	0.4700	-0.14
	Standard Deviation of the Coefficient	3.472	0.3890	8.93***
Cow fed on genetically modified corn	Mean Coefficient	1.459	0.4983	2.93***
	Standard Deviation of the Coefficient	2.631	0.4125	6.38***
Model statistics				
Log Likelihood	-900.5144			
Restricted Log Likelihood	-1275.391			
Chi Square	749.7528			
DF	46			

*** α=. 01, **α=. 05** and α=. 10

Table 4: Correlation matrix for random variables and Price elasticity Estimates

Bananas	Less chemicals and pesticides	Added antioxidants	Stays Riper longer	Bacterium	Plant Genes	Animal genes	Own Genes
Less chemicals and pesticides	1	-0.03	-0.54	0.48	0.46	0.46	0.45
Added antioxidants		1	-0.08	0.26	-0.09	0.00	-0.12
Stays Riper longer			1	-0.17	-0.05	0.09	-0.04
Bacterium				1	-0.47	-0.34	-0.26
Plant Genes					1	0.95	0.73
Animal genes						1	0.63
Own Genes							1

Cornflakes	Less pesticides	Added Antioxidants	Added compounds for energy	Bacterium	Own genes	Animal genes	Plant genes
Less pesticides	**1**	0.33	0.57	-0.92	-0.87	-0.91	-0.86
Antioxidants		**1**	-0.26	-0.56	-0.37	-0.40	-0.41
Added compounds for energy			**1**	-0.34	-0.47	-0.57	-0.50
Bacterium				**1**	0.74	0.82	0.69
Own genes					**1**	0.75	0.95
Animal genes						**1**	0.82
Plant genes							**1**

	Few Antibiotics	Compounds for Stronger teeth and bones	Added Antioxidants	Bacterium	Plant genes	Animal genes	Own genes	Fed on GM corn
Few antibiotics	1	-0.56	-0.64	0.32	0.36	0.34	0.50	0.61
Compounds for stronger teeth and bones		1	-0.21	-0.64	-0.49	-0.72	-0.63	-0.47
Added antioxidants			1	0.03	-0.18	0.08	-0.21	-0.45
Bacterium				1	0.97	0.94	0.84	0.63
Plant genes					1	0.91	0.85	0.65
Animal genes						1	0.82	0.48
Own genes							1	0.75
Fed on genetically modified corn								1

Estimated marginal utility increase/decrease given 1 % change in Price

Banana	k=1	k=2	k=3	k=4
j=1	**-0.362**	0.128	0.132	0.085
j=2	0.115	**-0.378**	0.107	0.078
j=3	0.139	0.126	**-0.364**	0.089
j=4	0.196	0.192	0.196	**-0.527**

Table 4 (cont.)

Cornflakes	k=1	k=2	k=3	k=4
j=1	**-0.131**	0.043	0.04	0.035
j=2	0.041	**-0.139**	0.036	0.033
j=3	0.054	0.051	**-0.121**	0.04
j=4	0.071	0.072	0.072	**-0.226**
Ground Beef	k=1	k=2	k=3	k=4
j=1	**-0.212**	0.07	0.067	0.047
j=2	0.07	**-0.216**	0.063	0.049
j=3	0.083	0.076	**-0.200**	0.056
j=4	0.113	0.115	0.118	**-0.316**

Table 5. Range of Willingness to Pay for the Normally Distributed Random Attributes

	% Respondents valuing attribute negatively			Mean	Standard Dev.			% Respondents valuing attribute positively	
Banana									
Less chemicals and pesticides	0.35	-11.52	-4.43	2.66	7.09	9.75	16.84	0.60	***
Added antioxidants	0.48	0.80	1.11	1.42	0.31	1.73	2.04	0.48	**
Stays Riper longer	0.39	-13.02	-5.56	1.90	7.46	9.36	16.83	0.56	*
Bacterium	0.70	-38.72	-24.16	-9.59	14.56	4.97	19.53	0.25	***
Plant Genes	0.58	-27.32	-15.55	-3.79	11.76	7.97	19.73	0.37	***
Animal genes	0.824	-54.21	-36.55	-18.88	17.66	-1.22	16.45	0.13	***
Own Genes	0.42	-18.26	-8.33	1.60	9.93	11.53	21.46	0.53	Insignificant
	% Respondents valuing attribute negatively			Mean	Standard Dev.			% Respondents valuing attribute positively	
Cornflakes									
Less pesticides	**0.24**	-30.96	-7.20	16.56	23.76	40.31	64.07	**0.71**	***
Antioxidants	**0.19**	-24.69	-2.94	18.80	21.74	40.54	62.28	**0.77**	***
Added compounds for energy	**0.40**	-38.30	-16.87	4.55	21.43	25.98	47.40	**0.55**	*
Bacterium	**0.79**	-88.49	-58.34	-28.19	30.15	1.96	32.11	**0.16**	***
Own genes	0.48	-66.60	-33.37	-0.15	33.23	33.08	66.30	**0.47**	Insignificant
Animal genes	**0.81**	-110.29	-73.42	-36.56	36.87	0.31	37.18	**0.14**	***
Plant genes	**0.57**	-80.34	-45.23	-10.12	35.11	24.98	60.09	**0.38**	**
	% Respondents valuing attribute negatively			Mean	Standard Dev.			% Respondents valuing attribute positively	
Ground Beef									
Few antibiotics	**0.55**	-28.59	-15.75	-2.9	12.84	9.92	22.75	**0.40**	*
Compounds for stronger teeth and bones	**0.50**	-21.94	-11.38	-0.8	10.56	9.74	20.30	0.45	Insignificant
Added antioxidants	**0.39**	-23.57	-10.06	3.5	13.51	16.97	30.48	**0.56**	**
Bacterium	**0.64**	-61.14	-36.46	-11.8	24.67	12.89	37.56	**0.31**	***
Plant genes	**0.40**	-42.88	-18.97	4.9	23.92	28.87	52.78	0.55	Insignificant
Animal genes	**0.65**	-61.58	-37.16	-12.7	24.42	11.67	36.09	**0.30**	***
Own genes	**0.48**	-39.55	-19.96	-0.4	19.59	19.23	38.83	0.47	Insignificant)
Fed on genetically modified corn	**0.29**	-21.46	-6.62	8.2	14.85	23.08	37.93	**0.66**	**

*** α=. 01, **α=. 05** and α=. 10