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The market for genetically modified foods: consumer characteristics and policy implications☆

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Abstract

Conjoint analysis was used to explore consumer preferences for food products that are the product of genetically modified organisms (GMOs). The results of a cluster analysis indicated that consumers fell into three homogeneous groups based on their preference for a branded, low-priced, or GMO-free product. There were some differences between the segments based on the sociodemographic characteristics of age, education, and income. However, consumers in the segment that wished to avoid GMOs were most easily distinguished from consumers in the other two segments based on their high level of risk averseness and belief that GMOs do not positively affect the quality or safety of food products. Implications for food marketers and policymakers are discussed. © 2002 Elsevier Science Inc. All rights reserved.

1. Introduction

U.S. consumers have consistently exhibited a high level of concern for the safety of the foods they eat. They demand food that is free from harmful substances including pesticides, chemical additives, hormones, and antibiotics. Until recently, the controversy over genetically modified foods was largely confined to Europe. However, recent incidents involving genetically modified organisms (GMOs) in the food supply have served to raise U.S. consumer awareness regarding foods that are the product of genetic engineering.

The most prominent of these incidents involves the inadvertent introduction of the genetically modified StarLink corn into taco shells and other food products. StarLink corn

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contains a gene that enables the corn plant to produce a pesticide to protect it from certain pests. The EPA has only approved the StarLink corn for use in animal feed or industrial purposes, since it is has not been shown that it will not cause an allergic reaction or other adverse effects in humans.

Increased consumer concern for GMOs has manifested itself in calls for increased government regulation in the form of a ban on GMOs in the food supply or mandatory labeling. Government policymakers are faced with the challenge of balancing human safety concerns and other risks with the potential benefits offered by GMO foods. They are increasingly under pressure from consumer groups to require labeling of the products of GMOs. Food manufacturers have also been pressured by consumer groups, and some companies have sought to promise consumers that their products are free of GMOs.

The purpose of this research is to develop an understanding of the factors influencing consumers' preferences for GMO food products that will serve to guide policymakers in the development of policy and food manufacturers in developing and marketing products. To date, little research has been published on this topic. Kaiser, Scherer, and Barbano (1992) studied the relationship between milk consumption and the use of the genetically engineered product bST in milk production. Several studies have analyzed the more general relationship between sociodemographic factors and consumer concern for other aspects of food safety. These include studies examining the relationship between sociodemographic factors and the perceived risk associated with the pesticide residues in food (Ott, 1990; Misra, Juang, & Ott, 1991; Baker & Crosbie, 1994; Nayga, 1996; Baker, 1998).

While previous food safety research will be useful in understanding consumer preferences for GMO food products, some key differences between the concern for GMO food products and other food safety concerns lend support to conducting a study specifically focused on GMO foods. The major difference is that consumer concern for GMO food products is apparently the result of a new and unfamiliar technology, that in many cases, poses no known scientifically accepted threat to human health, whereas, many other food safety concerns, such as those due to pesticide residues, are the result of well understood threats to human health.

The objectives of this study are to:

1. determine the extent to which the GMO content of food products will influence consumer preferences for food products; and
2. explore the relationship between consumer characteristics and their preferences for GMO food products.

This information will be useful in developing and characterizing market segments for food products based on information on consumers' concerns for the GMO content of food.

2. Research method

In order to determine the effect of GMO content on consumer purchasing decisions, the conjoint analysis technique was used. Conjoint analysis has been widely used in marketing to evaluate consumer preferences for hypothetical products and services (Hair, Anderson,

Tatham, & Black, 1992; Acito & Jain, 1980). It is ideally suited for understanding how consumers value various product attributes based on their valuation of the complete product.

Conjoint analysis requires that a hypothetical product be described to participants in the study along with the attributes and attribute levels that define the product. Respondents are then asked to either rate or rank several hypothetical products, as defined by different combinations of attribute levels (Hair et al., 1992). In this simulated market experiment, consumers are faced with choices similar to those that they would face in making any purchase decision.

In this experiment, the product was defined as corn flakes cereal. Two attributes were deemed to be most important to consumers in making purchase decisions, based on the results of a questionnaire filled out by members of a focus group and subsequent discussions with this group. These attributes were price and brand. A third attribute, the GMO content of the corn, was included because understanding the impact of a GMO product on consumer preferences was the primary focus of this study. While other attributes could have been included, it is necessary to balance the number of attributes required to realistically represent the product with the need to simplify the representation so as not to unnecessarily complicate the respondent's task.

The attribute levels are determined based on the levels that consumers might realistically face. Two levels of the brand attribute were described. The first level, ''Kellogg's Brand'' corn flakes was chosen because Kellogg's is the leading national brand. The second level was ''Store Brand'' corn flakes and was described as cereal produced for a supermarket like Kroger, Albertson's, or Safeway (the three largest U.S. supermarket chains) and sold under the respective store's label.

The three price levels for an 18 oz. box, $2.75, $3.50, and $4.25, were determined based on the range of prices actually observed for name brand and Store Brand cereals. The lowest price was slightly below, and the highest price was slightly above, the non-sale prices actually observed in U.S. supermarkets at the time the study was conducted.

The third attribute described the source of corn used to make the cereal. The first attribute level was described as ''GMO Corn'' and indicated that the corn was grown from seed developed using modern biotechnology or genetic engineering techniques. The second attribute level was described as ''Non-GMO Corn'' and indicated that the corn was grown from seed developed through traditional breeding techniques.

The hypothetical products were defined by choosing one attribute level for each of the three attributes. A full factorial design was used resulting in 12 hypothetical products. For example, the first hypothetical product was an 18 oz. box of Kellogg's Brand corn flakes cereal, made with GMO Corn, at a price of $2.75.

A random, national sample of 2,000 people was purchased from a company that maintains a list of the names and addresses of people in over 110 million households. The company compiles the list using multiple sources including telephone directories, credit card records, census data, court house records, and other public sources in order to ensure the representation of all types of households.

Each of the 2,000 people was mailed a survey packet in June and July of 2000. The packet included a letter briefly explaining the purpose of the survey and encouraging their participation, an instruction sheet, a product information sheet, a product rating form, a data sheet, and a postage-paid return envelope. To encourage participation, a $1 incentive

Table 1
Characteristics of survey respondents[a]

Characteristic	Sample statistic
Gender (% female)	59
Mean age (years)	51.5
Median household income category ($)	25000 to 39999
Competed high school (%)	96.6
Ethnicity (%)	
White non-Hispanic	82.2
Black	6.3
Hispanic	5.2
Other	6.3

[a] Survey sample size = 383.

payment was included in the mailing. Additionally, respondents were told that they would be entered in a drawing, and that two winners would each receive a Palm Pilot. Follow-up postcards were mailed 1 and 2 months after the original mailing.

The instruction sheet explained the task and the steps the respondent should follow. The product information page described the hypothetical product and product attributes. The product rating form presented each of the 12 hypothetical products and asked the respondent to rate each product on a scale of 1 to 10 with 1 being least preferred and 10 being most preferred. Respondents were also told that a number could be used more than once. The data sheet asked respondents to provide sociodemographic data on themselves and their household as well as their knowledge of biotechnology, their risk preferences and their opinions about GMOs.

Of the 2,000 surveys that were mailed, 175 were returned as undeliverable. A total of 448 surveys were returned. After eliminating those surveys with incomplete responses and those that were otherwise unusable, 383 usable responses were obtained for a net response rate of 21%.

In order to determine whether there was non-response bias, the mean age of the respondents was compared to the mean age of the sample. The mean ages were 51.5 and 50.5, respectively. A *t*-test indicated that the means of the sample and population were not significantly different at the 10% level of probability. Thus, there was no evidence of non-response bias. Sample statistics for the 383 respondents are presented in Table 1.

3. Results and analysis

The survey responses were analyzed by regressing the 12 product ratings on the continuous variable price and the two dummy variables representing the brand and corn source. The regression results were converted into part-worth scores that indicate the impact of each variable on the product rating score. For the continuous variable price, this is accomplished by multiplying the price coefficient by the difference in the minimum and maximum price. For the two dummy variables, the part-worth scores are the respective coefficients for the variables. The part-worths may be interpreted as the impact of each

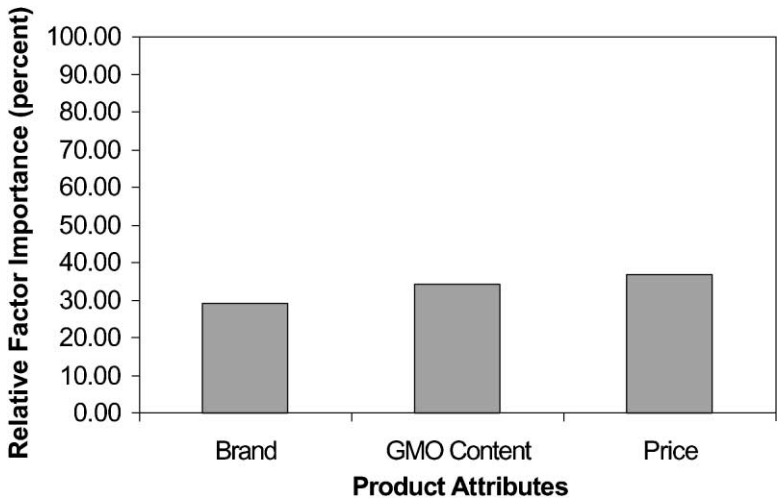

Fig. 1. Consumer preferences for cereal product attributes, all respondents, $n = 383$.

variable on an individual's preference for the product over the range of the variable. For example, for the price variable the part-worth score indicates the estimated change in the product rating score for each individual based on the difference between the maximum and minimum price.

The part-worth scores may be further analyzed to determine the relative importance of each attribute in a respondent's preference function. The relative factor importance score for each attribute is calculated by dividing the absolute value of an attribute's part-worth by the sum of the absolute values of the part-worths for all attributes. The aggregate relative importance scores for all respondents, calculated by first averaging the preference functions for all 383 respondents are reported in Fig. 1.

The results presented in Fig. 1 indicate that, in the aggregate, the importance scores of the three product attributes were roughly equal. Price had the highest importance score, 37%, followed by GMO content and brand, with 34% and 29%, respectively. This information indicates that no one factor dominates consumer preferences. However, it is of limited value in understanding consumer behavior since consumers do not make purchase decisions in the aggregate. Product preferences are a collection of many individual purchase decisions based on individual consumers' preference functions.

4. Market segment analysis

In order to better understand how consumer preferences might be revealed in the marketplace, market segments were developed. Cluster analysis, a statistical technique used to classify sets of observations into relatively homogeneous groups, was used to develop the market segments based on the each respondent's importance scores. The procedure was performed using Ward's minimum variance model. Three market segments were defined as illustrated in Figs. 2–4.

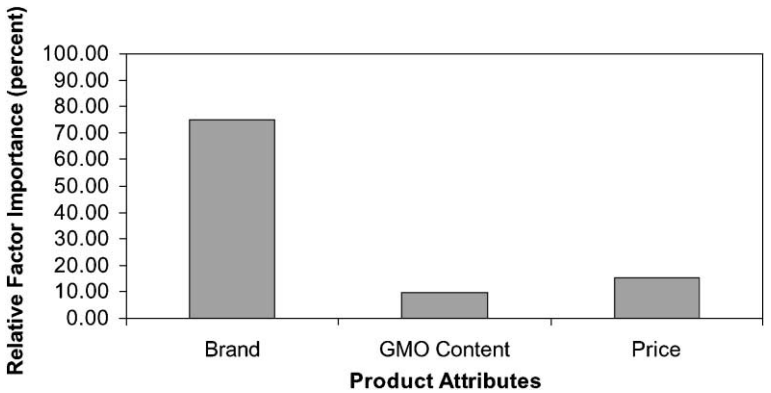

Fig. 2. Consumer preferences for cereal product attributes, segment 1, $n = 155$.

The market segment analysis indicates that the respondents fell into one of three groups. Segment 1 consumers consisted of 155 respondents. Their preferences were based largely on the brand of the cereal, with consumers in this group expressing a strong preference for the Kellogg's Brand cereal over the Store Brand.

Segment 2 includes 116 respondents. Consumers in this segment expressed a strong preference to avoid cereal with GMO content. Their expressed product preference was based largely on the absence of genetically modified material in the cereal. Price and brand had relatively little impact on their expressed product preferences.

The product choices of consumers in segment 3 were determined primarily based on the price attribute. The 112 consumers in this segment strongly preferred a low-priced cereal over a high priced cereal. The remaining two attributes, price and brand, were relatively unimportant in determining product preferences.

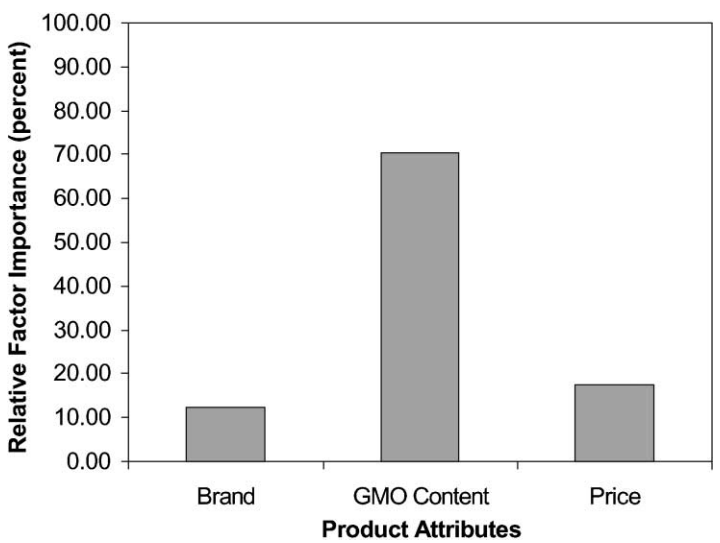

Fig. 3. Consumer preferences for cereal product attributes, segment 2, $n = 116$.

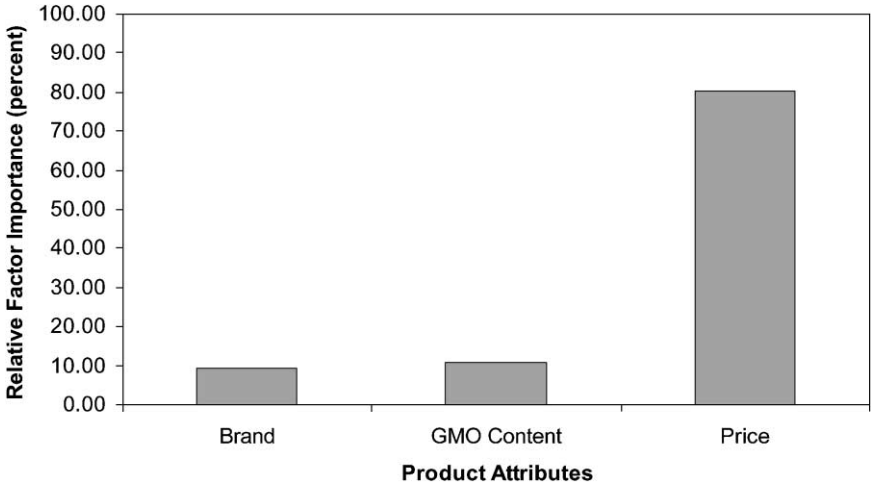

Fig. 4. Consumer preferences for cereal product attributes, segment 3, $n = 112$.

In order to examine the differences between consumers in the three market segments, the data describing the characteristics of the respondents was analyzed. Initially, F-statistics were calculated to determine whether the group means for each variable were different from each other. When the F-statistic was significant at the 10% level for a variable, the mean of each segment was compared to the mean of the other two segments for that variable and t-statistics were calculated. The results of this analysis are presented in Table 2.

The results indicate that there were relatively few differences in the sociodemographic characteristics of consumers in different market segments. The F-statistics were not significant for the gender, marital status, children at home, ethnicity, and location of residence variables. However, there were differences among the segments for three sociodemographic characteristics: age, income, and education. Members of segment 3, the price sensitive group, tended to be younger, more affluent, and better educated than members of the other two segments. Segment 3 consumers also had more knowledge of biotechnology than members of the other two segments. This is consistent with the higher level of income and education associated with this group.

To measure a respondent's aversion to risk, each survey recipient was asked to indicate his or her level of agreement with three statements: (1) I don't like to take chances if I don't have to; (2) I like to experiment with new ways of doing things; and (3) I am cautious in trying new/different things. Thus, a high level of risk aversion is indicated by a high score on questions 1 and 3 and a low score on question 2. Respondents were also asked their opinion regarding the following two statements: (1) What effect do you think the use of GMOs will have on food quality, i.e., taste, freshness?; and (2) What effect do you think the use of GMOs will have on food safety, i.e., food allergies, unknown effects? They were asked to indicate their response on a scale of 1 to 5 with 1 signifying a "negative effect" and a 5 indicating a "positive effect."

The variables measuring respondents' risk preferences and opinions regarding the benefits of GMOs were all good discriminators of those consumers who want to avoid food with

Table 2
Characteristics of the market segments

Characteristic	Segment		
	Segment 1 (n = 155)	Segment 2 (n = 116)	Segment 3 (n = 112)
Gender (% male)	61.3	57.8	57.1
Age (years)*	53.4 (3)	52.2 (3)	48.3 (1, 2)
Income ($)*	51838 (3)	51163 (3)	60089 (1, 2)
Education (years)*	13.6 (3)	14.0 (3)	15.1 (1, 2)
Married (%)	63.9	69.0	60.7
Children at home (%)	39.4	42.2	41.1
Ethnicity (% white)	80.6	80.2	86.6
Residence (% urban)	67.1	60.3	68.8
Biotechnology knowledge[a]*	2.5 (3)	2.3 (3)	2.7 (1, 2)
Risk measure 1 (do not like to take chances)[b]*	3.4 (2)	4.1 (1, 3)	3.4 (2)
Risk measure 2 (like to experiment with new things)[b]*	3.5 (2)	3.0 (1, 3)	3.5 (2)
Risk measure 3 (cautious in trying new products)[b]*	3.1 (2)	3.5 (1, 3)	3.1 (2)
GMOs positively affect food quality[c]*	3.2 (2)	2.6 (1, 3)	3.4 (2)
GMOs positively affect food safety[c]*	2.9 (2)	2.3 (1, 3)	3.1 (2)

Note: F-statistics were calculated to determine whether the variable means of the market segments were different from each other. When the F-statistic was significant at the 10% probability level (indicated by a superscript asterisk (*) after the variable name), individual t-statistics were calculated for each pair of means for each variable. Statistically significant differences at the 10% probability level are indicated by the number in brackets. For example, the (1, 2) following the mean age of 48.3 for segment 3 indicates that the mean for this variable is significantly different than the mean for segments 1 and 2.

[a] Biotechnology knowledge indicates the respondents knowledge of biotechnology on a scale of 1 to 4, with 1 representing ''no'' knowledge and 4 representing ''a lot'' of knowledge.

[b] Respondents were asked to express their level of agreement with the risk statement on a scale of 1 to 5, with 1 representing ''strongly disagree'' and 5 representing ''strongly agree.''

[c] Respondents were asked to express their opinion on the effect of GMOs on a scale of 1 to 5, with 1 representing ''negative effect'' and 5 representing '''positive effect.''

GMO content. The F-statistic for the group means was significant at the 10% probability level for all of the risk and GMO opinion variables. Individual t-tests indicated that consumers in segment 2, the GMO sensitive segment, were different than consumers in segments 1 and 3 along the three risk and two GMO opinion dimensions. Segment 2 consumers were more risk averse and believed that GMOs were less likely to positively affect food quality and safety, than consumers in the other two segments.

5. Discussion and conclusions

5.1. Marketing implications

The results of this research will be useful in the marketing of food products containing GMOs. The analysis indicates that consumers who wish to avoid GMOs are best identified based not on *who they are*, but rather based on *what they believe*. Sociodemographic factors

were somewhat useful in discriminating between consumers in the price sensitive segment and consumers in the brand and GMO sensitive segments. However, sociodemographic factors were not useful in discriminating between consumers in the GMO and brand sensitive segments. Therefore, designing a marketing program to reach consumers who wish to avoid GMOs will be difficult, if only sociodemographic characteristics are used.

On the other hand, understanding that consumers are driven by deeply held values provides insight into their actions and their underlying motivations. This understanding should aid in defining the message used to reach those consumers.

Based on the results of this study, it appears that those consumers most resistant to purchasing the products of genetic engineering are probably motivated by the same reasons that make them reluctant to purchase other new products, that is, they are risk averse and slow to change. A strategy of targeting early product adopters, who are most likely to believe that the benefits of the new product outweigh the potential risks, has been successfully used for many consumer products. Such a strategy for GMOs is supported by this analysis, which indicates that consumers in the market segments least likely to avoid GMOs, the price and brand sensitive consumers, were more likely to believe that GMOs would have a beneficial effect on food quality and food safety than members of the GMO sensitive segment.

This strategy is similar to that used with microwave ovens. When this product was introduced in the 1950s, there were concerns that the new ovens would cause cancer or sterility. However, as more consumers bought the products, and the oven's safety was demonstrated over years of use, the product eventually became a common fixture in American kitchens.

Another strategy that may help increase consumer acceptance of GMO food products is to focus on products that have direct benefits for consumers. While GMO products that have increased insect or disease resistance may benefit consumers through lower food costs, the benefits may not be easily perceived by consumers. On the other hand, focusing on benefits that are transparent to consumers, such as increased shelf life, improved taste, or greater nutritional may improve consumer acceptance. Such direct benefits are easily perceived by consumers, making it easy for them to understand the benefits they will receive and balance them against any perceived risks.

5.2. Policy implications

The relatively large number of consumers who desire to avoid GMOs raises the question of what type of government regulation might be enacted to address these concerns. The results of this research indicate that the size of the group that wishes to avoid GMOs is substantial—30% of the respondents in this study. One alternative that might address this concern is mandatory labeling. Labeling products based on their GMO content could provide consumers valuable information to consider in making their product choices in much the same way that nutritional labels indicate nutritional content. However, drawing attention to the technology used in producing the food may raise concern among consumers and lead to increased resistance to the technology. Labeling of the GMO content of foods would surely be controversial and would almost certainly be opposed by the biotechnology advocates in the food industry.

In the absence of mandatory labeling, policymakers may want to consider labeling guidelines similar to those governing health claims. Such guidelines would provide uniformity in the content of labels. They could be used as a means of differentiation by food manufacturers who wanted to emphasize that their foods do not contain GMOs in much the same way that organic food producers emphasize the organic nature of their products. Labeling guidelines would also serve to help ensure that claims regarding GMOs are accurate and supported by scientific evidence.

5.3. Limitations and future research

The sample was randomly selected from households in the U.S. Although there was no evidence of non-response bias, it is possible that respondents or their opinions were not representative of the U.S. population as a whole. Furthermore, while every effort was made to present the information to respondents in a balanced way, simply raising the issue of GMOs may have influenced who responded and how they responded.

This research suggests that a substantial portion of the population would like to avoid GMO food products. The results invite a number of questions that future research may answer. An area that could be explored more deeply is the underlying factors that lead to GMO acceptance or resistance. Future research may also explore strategies that may be used to overcome resistance to GMO acceptance such as government or private certification programs and voluntary or mandatory labeling programs that would provide consumers with information and choice in making their purchase decisions.

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