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Consumer Willingness to Pay for Genetically Modified Food Labels in a Market with Diverse Information: Evidence from Experimental Auctions

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With the continuing controversy over genetically modified (GM) foods, some groups advocate mandatory labeling of these products, while other groups oppose labeling. An important issue is how GM labels affect consumers' willingness to pay for these food products in the market. Using a statistically based economics experiment with adult consumers as subjects, we examine how willingness to pay changes for three food products—vegetable oil, tortilla chips, and potatoes—when GM labels are introduced. Participants in the experiments discounted GM-labeled foods by approximately 14% relative to their standard-labeled counterparts. The evidence also showed that sequencing of food labels affects willingness to pay, and that randomizing treatments is an important methodological feature in experiments of willingness to pay.

Key words: consumer demand, corn chips, experimental economics, food labels, genetic modification, GM foods, laboratory auctions, potatoes, vegetable oil, willingness to pay

Introduction

The growing controversy over genetically modified (GM) food products and consumers' attempts to make better food purchasing decisions have stimulated interest in new objective information, including food labeling. Labeling has become an important public policy issue worldwide. In the United States, truthful labeling has been used to provide consumers with information on calories, nutrients, and food ingredients. But the federal government requires explicit labeling only if a GM food has distinctive characteristics relative to the non-GM version. In contrast, the European Commission adopted genetically modified food labels in 1997. The Commission requires each member country to enact a law requiring labeling of all new products containing GM organisms. Japan, Australia, and many other countries have also passed laws requiring GM labels for

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major foods. Labeling involves real costs—fixed costs of testing, segregation or identity preservation, and risk premium for being out of contract—and variable costs of monitoring for truthfulness. A key question is: Does consumer behavior change with the presence of different labels?

Mendenhall and Evenson report on a telemarketing survey conducted in February 1999 of 55 adults in New Haven, Connecticut. Eight-two percent of these respondents strongly believe foods made with GM ingredients should be labeled. This finding is consistent with most surveys on GM foods, but it is strikingly different from the results of the referendum vote in Oregon on November 2002, in which approximately 70% of voters rejected a ballot referendum that would have mandated labels for GM foods.

This study uses the tools of survey design, statistical experimental design, experimental economics theory, and the random *n*th-price auction to elicit consumers' willingness to pay (WTP) for both GM-labeled and standard-labeled foods using a random sample of adult consumers drawn from two Midwestern cities.[1] By gathering information on three goods—vegetable oil, tortilla chips, and potatoes—dislike for genetic modification can be distinguished from dislike for a particular food item. In an experimental auction with divergent information about risks and benefits, we examine whether consumers value information provided in GM labels.

In this study, tests of the following hypotheses are reported: (H1) GM food labels have no effect on WTP for food items; (H2) attributes of participants, including prior beliefs, do not affect WTP for food items; and (H3) no difference in willingness to pay occurs because of the sequencing of labels in laboratory trials (i.e., whether the consumer first bids on foods with or without GM food labels).

Background on GM Food and GM Labels

Few experimental auctions have been conducted to elicit information about genetic modification. Noussair, Robin, and Ruffieux (2001) used experimental auctions with a sample of 97 Europeans, and found that bids for biscuits decreased by 37% when participants were told a product was GM. In a subsequent experimental auction paper, Noussair, Robin, and Ruffieux (2002) found that French consumers ignored the information on GM labels when labels were placed on the back of a package. These consumers initially price-discounted GM chocolate bars by less than 2% relative to non-GM chocolate bars. When the monitors emphasized the presence of the GM food label on the back of a chocolate bar, the consumers discounted the GM chocolate by more than 25%. This latter study, however, focused solely on French consumers.

To our knowledge, only one other study has used experimental auctions to elicit U.S. consumer preferences for GM or non-GM foods. Lusk et al. conducted experimental auctions with 50 undergraduate agricultural business students at Kansas State University. All subjects were endowed with a bag of GM corn chips. Using first- and second-price auctions, Lusk et al. observed that a majority of the student participants would not pay to upgrade to a bag of non-GM corn chips. One potential problem in their experimental design was the inability to distinguish dislike for corn chips from dislike for GM chips. Because we use multiple products, employ a larger participant base, and work with

[1] Currently, many unlabeled GM food products are available in U.S. grocery stores, and labeling is voluntary. If GM labels were present, testing consumers' willingness to pay for foods with GM food labels and foods with standard food labels would be an appropriate measure.

adult, U.S. consumers, the present study can produce inferences extending beyond these earlier studies.

Caswell (1998, 2000) and Caswell and Padberg have shown that many policies are possible, including mandatory labeling of GM foods, voluntary labeling of GM foods, or bans on all labeling identifying whether a food is GM. The policies each country chooses are likely to be determined by the information demanded by domestic consumers. An informed decision on whether to implement a labeling policy on GM foods should only be made after a benefit-cost analysis is conducted. Then politicians can weight the net economic benefit against other purely political factors when deciding whether to require GM labeling.

Two prominent environmental groups, Greenpeace and Friends of the Earth, believe GM labeling would benefit consumers, and these groups advocate labels on GM foods to give consumers the right to choose whether to consume GM products. Many environmental and consumer advocacy groups have demanded mandatory labeling, which they argue will benefit consumers. While there may be benefits, implementing a labeling policy would be costly. The USDA's Economic Research Service considered the range of costs associated with implementing a labeling policy (Golan et al.). If a mandatory labeling policy on GM foods is enacted, significant costs would be incurred. Potential fixed costs include testing, identity preservation, accidental contamination of non-GM crops by their GM counterparts, and reformulation costs. All items imply real supply-side costs when a labeling policy is implemented.

Relatively few estimates of the cost of labeling GM foods exist in the literature. A study by Wilson and Dahl, however, estimates wheat identity preservation would cost $1.45 ($3.36) per bushel for a 5% (1%) tolerance level (although labeling costs could be lower than identity preservation costs). Moreover, in estimates published in the *AgBiotech Reporter* (August 2001), the Philippine Chamber of Food Manufacturers warned that mandatory GM food labels would increase production costs by 15%, and these increased costs would be passed on to consumers. These added labeling, handling, and storage costs would lead to higher prices for consumers and possibly lower prices to producers. One conclusion seems apparent: Implementing a labeling policy on GM foods is costly and involves uncertain effects on firms, consumers, and the industry.

Experimental Design

The research project was designed to incorporate the private information-revealing feature of experimental auction markets, the rigorous randomized treatments of statistical experimental design (see, for example, Hoffman et al.; Fox et al.; and Shogren, List, and Hayes), and random sampling methods from survey design.[2] The primary purpose of the project was to identify the effects of GM food labels and different perspectives on genetic modification on consumers' WTP for food items that might be GM. In this analysis, we concentrate on the set of experimental auctions in which food items differed only by the presence or absence of GM food labels.[3]

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[2] Professors Phil Dixon and Wayne Fuller, Department of Statistics, Iowa State University, provided assistance with the statistical design of the project.

[3] The conclusions from the statistical analysis of this paper are not changed significantly by including information treatment effects which were randomly assigned. In a major companion paper, we examine the analytics and measure the value of third-party or verifiable information (see Rousu et al.).

There are two factors in this experiment: first, the sequence in which consumers bid on the food products with GM labels, and second, the type of information consumers could receive. For the first factor, consumers could bid on food products with GM labels before they bid on plain-labeled food products, or they could bid on food products with GM labels after they bid on plain-labeled food products. For the second factor, associated with the perspective on genetic modification, consumers could receive a combination of the biotech industry perspective, the environmental group perspective, and the third-party perspective, or verifiable biotech information (see Huffman and Tegene).

There are two levels for the labeling-order factor and six levels for the information factor (biotech industry perspective, environmental group perspective, biotech industry and environmental group perspectives, biotech industry and third-party perspectives, environmental group and third-party perspectives, and all three perspectives). The experimental design has two levels by six levels, yielding a total of 12 treatments. Each of the 12 treatments is randomly assigned to one of 12 experimental units, comprised of 13 to 16 consumers. This design was anticipated to achieve a desired sample size of 165 to 190 participants, a size considered necessary for finding statistically significant results without being prohibitively costly.

Using statistical sampling methods, a random digital dialing procedure was employed to select consumers who were adults living in two major Midwestern metropolitan areas, Des Moines, Iowa, and St. Paul, Minnesota. These cities were chosen because they represent two large metropolitan areas of the Midwest (in contrast to small university cities like Ames), and yet were easily accessible by researchers centered in Ames, Iowa. Conducting experiments in two urban areas rather than one is also seen as enhancing credibility by demonstrating that the experiments can be replicated across urban areas. Nevertheless, caution must be exercised in generalizing to the broader population of the Midwest or to the entire U.S. population (also see relevant comments in Lusk et al.).

We now describe the four elements in this study's GM labeling experiments—the GM food, the auction mechanism, the experimental units, and the specific steps in the experiment (which includes the detailed information labels).

The GM Food

We anticipated that consumers might react differently to GM content for foods of different types. Because one food item was unlikely to reveal enough information, three items were used: vegetable oil made from soybeans, tortilla chips made from yellow corn, and russet potatoes. In the distilling and refining process for vegetable oils, essentially all of the proteins (which are the components of DNA and the source of genetic modification) are removed, leaving pure lipids. Minimal human health concerns should arise from consumption of the oil, but people might still fear that GM soybeans could harm the natural environment. Tortilla chips are highly processed foods which may be made from GM or non-GM corn, and consumers might have human health or environmental concerns or both. Russet potatoes are purchased as a fresh product and generally fried or baked before eating. Consumers might reasonably see the potential concentration of genetic modification as being different in potatoes than in processed corn chips. Consequently, consumers might have concerns about both human health and environmental risks from eating russet potatoes.

The Random nth-Price Auction

Over the past decade, scientists conducting valuation experiments have used auction mechanisms to induce individuals to reveal their preferences for new goods and services (e.g., see Shogren et al. 1994; Fox et al.; Shogren, List, and Hayes). Vickrey's sealed bid, second-price auction has been a popular mechanism. The popularity of the second-price auction mechanism is largely because it is demand revealing in theory, is relatively simple to explain, and has an endogenous market-clearing price. Also, evidence from induced-value experiments suggests the auction mechanism can produce efficient outcomes in the aggregate (Kagel).

Although a second-price auction is better than a first-price auction, a problem arises in second-price auctions in that they tend not to engage bidders who anticipate being off the margin (i.e., bidders whose value for a good is far below or above the market-clearing price). These bidders have a low opportunity cost from an insincere bid, making it difficult to measure accurately the entire demand curve for a new good like GM food (see Miller and Plott; Franciosi et al.). Insincere bidding can be sustained if the behavior is undetected and unpunished by the institutional structure of the auction mechanism (see Cherry, Crocker, and Shogren).

We chose the random nth-price auction for our GM food experiments over the second-price auction because it engages both the on- and off-the-margin bidders and helps ensure that consumers reveal their demand truthfully (see Shogren et al. 2001). The auction combines elements of two classic demand-revealing mechanisms: the Vickrey auction and the Becker-DeGroot-Marschak random-pricing mechanism. The key characteristic of the random nth-price auction is a *random but endogenously determined* market-clearing price. Randomness is used to give all participants a positive probability of being a purchaser of the auctioned good; the endogenous price guarantees the market-clearing price is related to the bidders' private values.

The random nth-price auction works as follows. Each of k bidders submits a bid for one unit of a good; then each of the bids is rank ordered from highest to lowest. The auction monitor then selects a random number (the n in the nth-price auction) which is drawn from a uniform distribution between 2 and k, and the auction monitor sells one unit of the good to each of the $n-1$ highest bidders at the nth price. For instance, if the monitor randomly selects $n = 4$, the three highest bidders each purchase one unit of the good priced at the fourth-highest bid. Ex ante, bidders who have low or moderate valuations now have a nontrivial chance to buy the good because the price is determined randomly. This auction increases the probability that insincere bidding will be costly (Shogren et al. 2001).

The Experimental Units

Auctions were planned and conducted at two Midwestern U.S. cities—Des Moines, Iowa, and St. Paul, Minnesota. An independent institution (the Iowa State University Statistics Laboratory) called telephone numbers chosen by a random digital dialing method, and each adult was asked if he or she was willing to participate in a group session in Des Moines (St. Paul) relating "to how people select food and household products."[4] They were informed the session would last about 90 minutes, and were also

[4] Because common grocery store products were auctioned, participants were not required to be the main grocery shopper in the household.

told that at the end of the session each participant would receive $40 in cash for his or her time.

Three different times were available each auction day—9 am, 11:30 am, and 2 pm. Willing participants were asked to choose a time most convenient to their schedule. The 12 experimental units were split equally between Des Moines and St. Paul and were held on April 7 and April 21, 2001. After adjusting for unusable phone numbers, the ISU Statistics Laboratory contacted approximately 950 people; 200 individuals accepted the invitation to participate, although 20 people failed to show, leaving 180 people who came to the lab to participate. The response rate, after adjusting for unusable telephone numbers, was 19%. In addition, eight individuals had to be turned away because the quota for their time slot was full by the time they arrived (a maximum of 16 people per group was set), leaving 172 total participants.[5]

Steps in the Experiment

The 10 specific steps in each experimental unit are detailed below.[6]

- In Step 1, when participants arrived at the experiment, they signed a consent form agreeing to participate in the auction. After signing this form, each individual was given $40 for participating and an ID number to preserve the participant's anonymity. The participants then read brief instructions and filled out a pre-auction questionnaire. The questionnaire was designed to collect demographic information and to determine consumers' perceptions of the safety of vaccinations for diseases, eating meat from animals fed growth hormones, and of irradiated and GM foods.[7]

- In Step 2, participants were given detailed instructions about how the random nth-price auction works, including an example written on the blackboard. After the participants learned about the auction, they were given a short quiz to ensure everyone understood how the auction worked.

- Step 3 was the first practice round of bidding, in which participants bid on a brand-name candy bar. The participants were all asked to examine the product and then place a bid on the candy bar. The bids were collected and the first round of practice bidding was over. Throughout the auctions, when the participants were bidding on items in a round, they had no indication of what other items they might be bidding on in future rounds.

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[5] We went to considerable expense to obtain participants who were selected by a random digital dialing process. Potential participants were told they were being invited to participate in an Iowa State University project dealing with household and food products, but they were not told the purpose of the project was to test consumers' willingness to pay for genetically modified foods. This information was purposely withheld to ensure the participation decision was unrelated to an individual's attitudes toward agricultural biotechnology. Of course, some individuals chose not to participate. It is unknown whether these unwilling subjects are statistically different from the participants. Based on the summary data reported in table 1, however, the demographic characteristics of our sample match closely those reported by the 2000 U.S. Census for the two areas where participants were chosen. Caution is warranted in making generalizations beyond the Midwest.

[6] The complete set of instructions given to participants is available from the authors upon request.

[7] It seems unlikely that the pre-auction questions about perceived GM risks significantly affected the results. The question dealing with GM food products was at the very beginning of each auction session and placed near questions about the frequency at which the population was made ill during the past year from eating irradiated meat or poultry and consuming meat from animals fed growth hormones. Also, after the participants went through several steps in the auction, they were given at least one full page of information from an interested party (either the biotech industry or the environmental group perspective) before bidding on food products. Any potential effect from the GM information question was likely to have been overwhelmed by other information presented to consumers in step 6.

■ Step 4 was the second practice round of bidding, and in this round the participants placed separate bids on three different items. The products were the same brand-name candy bar, a deck of playing cards, and a box of pens. Participants knew that only one of the two rounds would be chosen at random to be binding, which prevented anyone from taking home more than one unit of any product. Following Melton et al., this random binding round eliminates the threat of a person reducing his or her bids because the individual potentially buys more than one unit.[8] The consumers first examined the three products and then submitted their bids.

■ After the two practice auction rounds were completed, the binding round and the binding *n*th prices were revealed in Step 5. All bid prices were written on the blackboard, and the *n*th price was circled for each of the three products. Participants could see immediately what items they won, and the price they would pay. The participants were told that the exchange of money for goods was in another room nearby and would take place after the entire experiment was completed.

■ In Step 6, participants received information about biotechnology. Three info-packets were produced as follows: (*a*) the *environmental group perspective*—a collection of statements and information on genetic modification from Greenpeace, a leading environmental group; (*b*) the *industry perspective*—a collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta; and (*c*) the *independent, third-party perspective*—a statement on genetic modification approved by a third-party group, consisting of a variety of people knowledgeable about GM goods, including scientists, professionals, religious leaders, and academics, who do not have a financial stake in GM foods. These information sheets are provided in the appendix.

These three info-packets were used to create six information treatments: (*a*) only the biotech industry perspective, (*b*) only the environmental group perspective, (*c*) biotech industry and environmental perspectives, (*d*) biotech industry and third-party perspectives, (*e*) environmental group and third-party perspectives, and (*f*) all three perspectives. In the context of this study, focus is exclusively on the important issue of consumers' preferences for GM- versus plain-labeled food items. The impact of information on consumer behavior is not addressed.[9]

Once the appropriate info-packet was distributed to the participants in a given unit, two auction rounds were then conducted. The rounds were differentiated by the food label—either the food had a standard food label or a GM label (see figure 1). In one round, which could be round 1 or round 2 depending on the experimental unit, participants bid on the three food products each with the standard food label. These labels were made as plain as possible to avoid any influence on the bids from the label design. In the other round, participants bid on the same three food products, but with a GM label, which differed from the standard label by the inclusion of only one extra sentence: "This product is made using genetic modification (GM)." For each experimental unit,

[8] If one assumes there is little or no income effect from the deck of cards and box of pens, the two bids on the candy bar should be the same—i.e., because the deck of cards and box of pens are neither complements nor substitutes to the candy bar, they should not affect the bids on the candy bar. A Wilcoxon signed-rank test confirmed the bids for the candy bars are not significantly different in the two rounds, with a test statistic of 0.03. This result does not contradict the notion that the subjects' bidding behavior was reasonable.

[9] To more intricately examine the issue of consumer acceptance of GM labeling, this analysis is devoted entirely to the consumer reaction to labeling, without examining impact of information treatments. The interested reader is referred to a companion paper that presents a detailed evaluation of the information effects (Rousu et al.).

Russet Potatoes *Net weight 5 lbs.* **This product is made using genetic modification (GM).**	**Russet Potatoes** *Net weight 5 lbs.*
Tortilla Chips *Net weight 16 oz.* *Fresh made Thursday April 5th* **This product is made using genetic modification (GM).**	**Tortilla Chips** *Net weight 16 oz.* *Fresh made Thursday April 5th*
Vegetable Oil *Net weight 32 fl. oz.* **This product is made using genetic modification (GM).**	**Vegetable Oil** *Net weight 32 fl. oz.*

Figure 1. GM and standard labels used for the three food items

participants knew that only one round would be chosen as the binding round which determined auction winners.[10] The sequencing of the standard food and GM labels was randomized across experimental units. One unit had the standard label in round 1, and the GM label in round 2; the second unit had the GM label in round 1, and the standard label in round 2.

- In Step 7, participants bid on three different food products: a bag of potatoes, a bottle of vegetable oil, and a bag of tortilla chips, either with the standard or GM label. The participants were instructed to examine the three products and then to write down their sealed bid for each of the three goods. Participants bid on each good separately. The monitor then collected the bids from the participants and told them they were next going to look at another group of food items.[11]

- Step 8 had participants examine the same three food products, each with a different label, from round 1. Again the participants examined the products and bid on the three products separately. The bids were then collected from all of the individuals.

- Step 9 selected the binding round, and the binding random nth prices for the three goods. Winners were notified. Each individual was asked to complete a brief post-auction questionnaire to see if the participant's risk attitudes changed, and to inquire about who he or she would trust for information on genetic modification (see Huffman et al.).

[10] By bidding on foods with GM labels in one round and standard labels in the other round, participants are bidding on labels with statements which are similar to those found on labels in major markets with GM labels, like those in the European Union and Australia (see CNN; Australia-New Zealand Food Authority 2000, 2001).

[11] Unlike some food safety experiments (e.g., Shogren et al. 1994), we do not require immediate consumption of the products for people who win the auction. At least two of our three products are ones that are *not* usually consumed at the point of sale—vegetable oil and raw potatoes. Furthermore, adults regularly make family food-purchase decisions in grocery stores and supermarkets (e.g., see Carlson, Kinsey, and Nadav), which suggests that having an adult place bids in our experiment seemed entirely appropriate for most households.

■ In Step 10, the monitors dismissed the participants who did not win. The monitors and the winners exchanged money for goods, and the winners were then dismissed.

Although standard experimental-auction valuation procedures were followed (e.g., Shogren et al. 1994), several refinements were made to our experimental design to better reflect consumer purchases. First, our subjects submitted only one bid per product. The protocol of using multiple repeated trials and posting market-clearing prices was not followed, to avoid any question of creating affiliated values that can affect the demand-revealing nature of a laboratory auction (see, for example, List and Shogren). Second, subjects were not endowed with any food item and then asked to "upgrade" to another food item; rather, participants were paid $40, and then they bid on different foods in only two trials. This approach avoids the risk of an in-kind endowment effect distorting the participant's bidding behavior (e.g., see Lusk and Schroeder, or Corrigan and Rousu) and the risk of any credit constraint. Third, each consumer bid on three unrelated food items. Thus, if he or she did not have positive demand for one or two products, we could still obtain information on the participant's taste for genetic modification based on the second and (or) third products. Fourth, treatments to the experimental units were randomly assigned; now estimation of treatment effect is simply the difference in means across treatments (see Wooldridge, pp. 603–607).

Fifth, we used adult consumers over 18 years of age from two different Midwestern metropolitan areas, who were chosen using a random digital dialing method.[12] Because we use common food items available to shoppers in grocery stores and supermarkets, we wanted adult rather than student subjects, to better reflect a typical household of consumers. Although several studies have used college undergraduates in laboratory auctions of food items (e.g., Hayes et al.; Lusk et al.), students are not the best choice for participants when the items being auctioned are ones sold in grocery stores or supermarkets. Using a national random sample of grocery store shoppers, Katsaras et al. found that the share of college-age (18 to 24 years) shoppers falls far below their share in the population—8.5% of shoppers versus 12.8% in the U.S. Census of Population. College students obtain a large share of their food from school cafeterias and only a small share from grocery stores and supermarkets compared to older shoppers (Carlson, Kinsey, and Nadav). Although our participants are slightly skewed toward women, Katsaras et al. note that women make up a disproportional share of grocery shoppers—83% of shoppers versus 52% in the U.S. Census of Population. A sample primarily of grocery store shoppers also weakens the sometimes-stated need for having students participate in several rounds of bidding to stabilize bids for food items. The Iowa State University Statistics Laboratory selected potential participants from a randomly generated list of telephone numbers in the Des Moines and St. Paul areas by using a random digital dialing method. A summary of the demographic characteristics of the participants is displayed in table 1.

Finally, this experimental design and implementation allow for results going beyond those of the two earlier experimental auction studies of GM foods (Lusk et al.; and Noussair, Robin, and Ruffieux 2002). The Noussair, Robin, and Ruffieux study was conducted in France; our experiments were conducted in two cities in the Midwestern

[12] Information on other characteristics, like the age of children in the household and membership in environmental groups, was collected but is not reported to simplify the exposition. All non-reported information is available from the authors upon request.

Table 1. Characteristics of the Auction Participants and Characteristics of the Populations of Polk and Ramsey Counties (which contain Des Moines, IA, and St. Paul, MN)

		Sample		County Population Mean[a]	
Variable	Definition	Mean	Standard Deviation	Polk	Ramsey
Gender	1 if female	0.62	0.49	0.52	0.52
Age	Participant's age (years)	49.5	17.5	45.7	45.7
Married[b]	1 if the individual is married	0.67	0.47	0.59	0.51
Education[c]	Years of schooling	14.54	2.25	13.52	13.76
Household	Number of people in participant's household	2.78	1.65		
Income	Household's income level ($000s)	57.0	32.6	46.1	45.7
White	1 if participant is white	0.90	0.30	0.90	0.80
Read_L	1 if never reads labels before a new food purchase	0.01	0.11		
	1 if rarely reads labels before a new food purchase	0.11	0.31		
	1 if sometimes reads labels before a new food purchase	0.31	0.46		
	1 if often reads labels before a new food purchase	0.37	0.48		
	1 if always reads labels before a new food purchase	0.20	0.40		
Informed	1 if individual is self-reported as at least somewhat informed regarding genetically modified (GM) foods	0.42	0.49		
Labels1	1 if the treatment bid on foods with GM labels occurs in round 1	0.52	0.50		

Note: For the Polk and Ramsey county figures, all variables are for individuals of all ages, except for *Married*, which is for individuals 18 or older; *Education*, which is for individuals 25 or older; and *Age*, which is for individuals 20 or older.

[a] Source: U.S. Bureau of the Census.

[b] For the Polk and Ramsey county estimates, the number of married people who are 18 or older was obtained by taking the number of people married over 15 and assuming that the number of people who were married at ages 15, 16, and 17 was zero. This gives the percentage of married people who are 18 or older.

[c] For Polk and Ramsey counties, the years of schooling were estimated by placing a value of 8 for those who have not completed 9th grade, 10.5 for those who have not completed high school, 12 for those who have completed high school but have had no college, 13.5 for those with some college but no degree, 14 for those with an associate's degree, 16 for those with a bachelor's degree, and 18 for those with a graduate or professional degree.

United States. Compared to the one published experimental economics study measuring tastes for genetic modification using U.S. consumers (Lusk et al.), our experimental design extends the earlier work in three areas. First, our 172 participants are adult consumers, unknown to us, and randomly chosen from a list of telephone numbers in two Midwestern cities. Our sample is more than three times larger than the 50 students used in Lusk et al., and consists of adults responsible for household food shopping rather than university students. Second, the incentive-compatible random nth-price auction is used, rather than splitting the sample into a second-price auction and a nondemand-revealing first-price auction, and, to avoid learning effects, consumers are randomly assigned to treatments that did not have a multiple sequence of trials. Third, in the Lusk et al. study, it is impossible to correctly interpret a zero bid—i.e., whether it meant a student disliked the food for sale or disliked genetic modification. In contrast, we asked consumers to bid on three different food items rather than on one product. This approach permits identification of a consumer's preferences for food versus his or her preferences for genetic modification. If a participant did not like one kind of food, reliable information on the other two food products can be obtained.

Table 2. Number and Percentage of Individuals Who Bid Less for the GM-Labeled Food than for the Standard-Labeled Food (N = 172)

	Individuals Bidding Less for GM-Labeled Version of the Product	
Description of Product	Number	Percent (%)
Tortilla Chips, 16 oz. bag	70	41
Vegetable Oil, 32 fl. oz. bottle	63	37
Russet Potatoes, 5 lb. bag	60	35
All three items	44	26
At least one of the three items	100	58

Experimental Results and Statistical Analysis

Table 2 reports the number of participants who bid less for the GM-labeled food than for the standard-labeled food. For each good, 35% to 41% of the participants bid less for the GM-labeled variety. Most participants showed a general dislike for genetic modification—about 60% of the participants bid less for the GM-labeled version for at least one of the three products. About 26% of the subjects bid less for all three GM-labeled products than for standard-labeled products, which indicates a strong preference against GM foods.

Table 3 gives the mean bids for each of the three products: a 32-ounce bottle of vegetable oil, a 1-pound bag of tortilla chips, and a 5-pound bag of potatoes. Panel A of table 3 shows the mean bids for all participants. For each of the three food products, participants were willing to pay less when the product had the GM label than when it displayed the standard food label. Both one-tailed *t*-tests and Wilcoxon signed-rank tests show that the difference is statistically significant at the 5% significance level.[13]

Both table 2 and panel A of table 3 provide univariate tests of the first hypothesis: (H1) GM labels have no effect on consumers' WTP for food items. This hypothesis is rejected; GM labels are found to affect consumer WTP for food products.[14] The percentage discount for each product was approximately 14%, indicating consumers displayed a general dislike for genetic modification, but they did not seem to dislike one type of genetically modified product more or less than another. Consumers, for instance, did not appear to view genetic modification of the soybeans used to make vegetable oil better than genetic modification in potatoes. This result suggests respondents' concerns about GM technology are largely environmental and not human health.

In most economics experiments of food products (e.g., Melton et al.; Hayes et al.; Lusk et al. 2001; Shogren et al. 2000), all participants have been subjected to the same sequence of treatments. It is impossible to disentangle treatment effects from sequencing

[13] These tests are univariate tests. Like all univariate tests, they suggest a simple relationship, indicating here that consumers paid less for food products with GM labels. However, they provide no information about why consumers paid less for food products with GM labels.

[14] The mean bid prices are slightly lower than a person might see in a grocery store. This is logical because a rational bidder should not bid more for a product than the price he or she can find in a store (although some participants could add travel costs to a bid price). This upper bound suggests that mean bids in most auctions should be less than the average price for a product one finds in a store, although this remains to be established in the lab.

Table 3. Mean Bids for Each of the Three Products

PANEL A. Mean Bids, All Participants

Product Description	No. of Observations	Mean Bid	Standard Deviation	Maximum	No. of Zero Bids
Vegetable oil (GM)	172	0.91	0.84	3.99	39
Vegetable oil (standard)	172	1.05	0.85	3.79	28
Tortilla chips (GM)	172	0.93	0.86	3.99	37
Tortilla chips (standard)	172	1.08	0.85	4.99	17
Russet potatoes (GM)	172	0.78	0.67	3.00	33
Russet potatoes (standard)	172	0.91	0.67	3.89	14

PANEL B. Mean Bids When Participants Bid on Food with GM Food Labels in Round 1

Product Description	No. of Observations	Mean Bid	Standard Deviation	Maximum	No. of Zero Bids
Vegetable oil (GM)	88	0.98	0.91	3.99	23
Vegetable oil (standard)	88	1.04	0.89	3.79	19
Tortilla chips (GM)	88	0.95	0.87	3.25	22
Tortilla chips (standard)	88	1.05	0.81	4.99	12
Russet potatoes (GM)	88	0.90	0.69	2.50	15
Russet potatoes (standard)	88	0.94	0.63	2.51	7

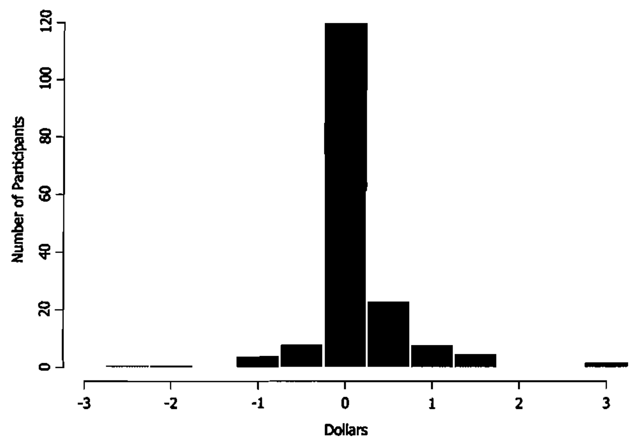
PANEL C. Mean Bids When Participants Bid on Food with GM Food Labels in Round 2

Product Description	No. of Observations	Mean Bid	Standard Deviation	Maximum	No. of Zero Bids
Vegetable oil (GM)	84	0.83	0.77	3.25	16
Vegetable oil (standard)	84	1.06	0.80	3.00	9
Tortilla chips (GM)	84	0.90	0.86	3.99	15
Tortilla chips (standard)	84	1.11	0.89	4.99	5
Russet potatoes (GM)	84	0.65	0.63	3.00	18
Russet potatoes (standard)	84	0.88	0.72	3.89	7

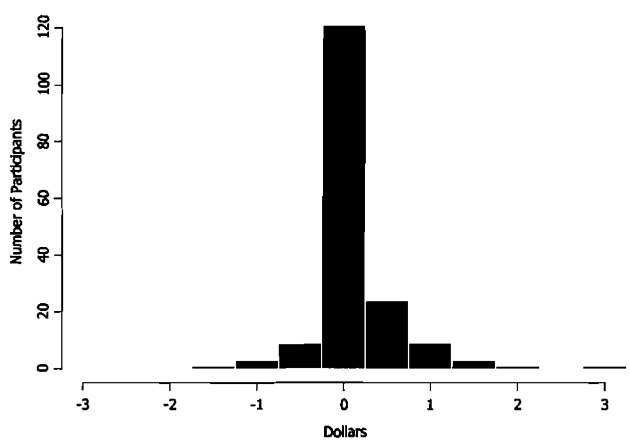
effects. In table 3, panel B, bids are shown for the subset of auction participants who bid on food products having GM food labels in round 1, and panel C shows the bids for participants who bid on food products having the GM labels in round 2. The bids for the GM-labeled and standard-labeled food are much closer when participants bid first on GM food (round 1) compared to those who bid on GM-labeled food second (round 2). For two of the three products (potatoes and vegetable oil), the difference due to the order is statistically significant at the 5% level (both t-tests and Wilcoxon rank-sum tests show the same results). We therefore reject hypothesis 3: (H3) no difference exists in consumers' WTP for food items due to the GM food label treatment sequence. In our experiment, the order in which consumers bid on food products influences their bid. This is an important finding because many experimental economics studies use repeated, non-randomized trials to gain information on consumer preferences. The results of this analysis indicate randomization is important to ensure results are not an artifact of the sequence used in the experiment.

To graphically explore the distribution of the difference in bid prices between the GM-labeled and plain-labeled products, histograms are presented in figure 2. For all

A. Vegetable Oil (bid for plain-labeled minus bid for GM-labeled)



B. Tortilla Chips (bid for plain-labeled minus bid for GM-labeled)



C. Potatoes (bid for plain-labeled minus bid for GM-labeled)

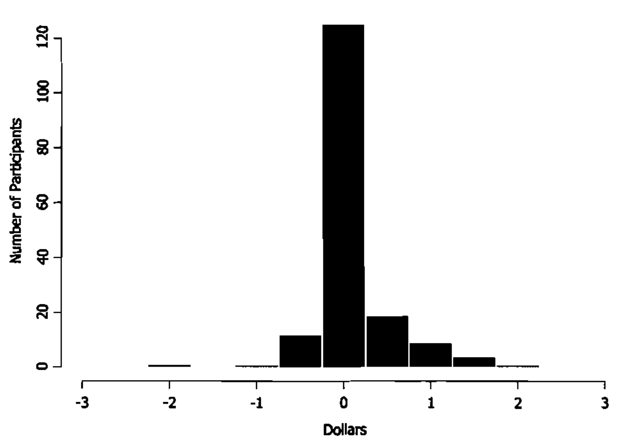


Figure 2. Histogram of the difference in bid prices ($s) for plain-labeled and GM-labeled versions of each of the three commodities (N = 172)

three products, the majority of participants have no difference in bid prices between GM-labeled and plain-labeled food products. However, for all three products, there are some participants who bid more for the plain-labeled products, with several participants placing premiums of $1 or more. For all three products, very few people bid less for the plain-labeled product than for the GM-labeled product.

To further explore the bids for GM-labeled and plain-labeled food products of participants, consider the following equation:

$$(1) \qquad P_j^k = \beta_j + \beta_2^k \mathbf{X}_{j2} + \mu_j^k, \quad k = \text{plain-labeled, GM-labeled},$$

where the price of the kth labeled commodity by the jth participant, P_j^k, is a function of a linear unmeasured effect (β_j) that is constant across commodity labels for a given individual, regressors $\mathbf{X}_{j2}$ that vary across individuals but not across labels for a given individual (i.e., a participant's age, education, household income, gender), and a zero mean random disturbance term across labels and individuals (μ_j^k). Now taking differences across label types gives:

$$(2) \qquad P_j^{plain\text{-}labeled} - P_j^{labeled} = \left(\beta_2^{plain\text{-}labeled} - \beta_2^{labeled}\right)\mathbf{X}_j + \mu_j^{plain\text{-}labeled} - \mu_j^{labeled}.$$

Note that the intercept term, the unmeasured effect across labels for a given individual, vanishes and the vector of coefficient differences is a measure of the difference in impact of a factor on a plain-labeled versus a GM-labeled food item, and the differenced disturbance term across individuals and labels. The coefficients and error terms in (2) can be condensed and rewritten as:

$$(3) \qquad P_j^{plain\text{-}labeled} - P_j^{labeled} = \beta_1^* + \beta_2^* \mathbf{X}_j + \mu_j^*.$$

The coefficient of β_1^* is expected to be small and not significantly different from zero; the vector of parameters β_2^* is expected to be significantly different from zero *only* if a regressor has a different *marginal* impact on the price of plain-labeled than on GM-labeled food items. Otherwise these coefficients should be approximately zero. The disturbance term μ_j^* is expected to have a zero mean after the censoring in equation (1).

All participants placed a bid on GM-labeled and plain-labeled potatoes, tortilla chips, and vegetable oil. Equation (3) is then estimated using a fixed-effects model in which each product is a fixed effect. All bids are pooled over the three products, yielding $172 \times 3 = 516$ observations. Although the minimum bid for any product is zero, some participants may have viewed a product as a "bad" and preferred a negative valuation.

In equation (1), for {k = plain-labeled, GM-labeled}, the price could be censored at zero, so we take account of this censoring in fitting equation (3). The censored regression model examines the two components of the dependent variable, the bid for the plain-labeled product and the bid for the GM-labeled product. The dependent variable is considered censored if *either* (*a*) the bid for the GM-labeled product is zero, (*b*) the bid for the plain-labeled product is zero, or (*c*) the bids for the plain-labeled product and the GM-labeled product are both zero. Note that in our model, the dependent variable itself can be zero and still not be censored (e.g., if a participant bids $2 for both the GM-labeled and plain-labeled version of a product). Our findings show this result arises quite frequently. This model is estimated using a maximum-likelihood procedure in the LIFEREG PROCEDURE in SAS, version 8 (the data and code used are available from the authors upon request).

The censoring has four cases:[15]

- Case 1. Consumer *j* bids a positive amount for both the GM-labeled and the plain-labeled product. The measured difference in bid prices is the difference between the two bid prices (non-censored case).
- Case 2. Consumer *j* bids zero for the GM-labeled product and a positive amount for the plain-labeled product. The "true" difference in bid prices with the censored regression will be greater than the difference between the two observed bid prices. This outcome arises because the bids on the GM-labeled product are censored at zero.
- Case 3. Consumer *j* bids a positive amount for the GM-labeled product and zero for the plain-labeled product. This is similar to case 2 in which the true difference in bid prices for the censored regression is absolutely larger than the measured difference between the two bid prices.
- Case 4. Consumer *j* bids zero for both products. This case does not give any information about the consumer's true demand for GM products.[16]

Because our model treats zero bids for both the GM-labeled and plain-labeled food products as censored bids, all four cases are correctly accounted for.

Censored regression results from fitting equation (3) with commodity fixed effects to explain the difference in bid price (plain-labeled minus GM-labeled) for the sample are reported in table 4. In regressions (1) and (2), the estimate of the intercept is small, as expected, and it is not significantly different from zero at the 5% level in regression (2). The coefficients of the sociodemographic variables in regression (2) are not significantly different from zero, i.e., a participant's gender, education, age, or prior beliefs about GM technology individually do not have a significant effect on bid price differences.

Also, we performed a joint test that all four of the coefficients for the sociodemographic variables are zero. Using the information in regressions (1) and (2), the sample value of the chi-squared statistic for this test is 3.04, and the critical value is 9.5 with four degrees of freedom at the 5% significance level. Hypothesis H2 cannot be rejected: Sociodemographic attributes of participants, including prior beliefs about genetic modification, individually and jointly do not have a significant effect on bid price differences.[17] However, hypothesis H3 is rejected: The estimated coefficient for the dummy variable denoting a respondent was presented with GM labels in round 1 of bidding is significantly different from zero. Randomizing the labeling treatment is an important

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[15] The dependent variable in equation (2) has two parts, each of which could be censored. This is not a typical Tobit model, but rather a more general censored regression model. For a good review of censored regression models, see Wooldridge (2002, pp. 517–550).

[16] A participant might bid zero for each version of a product for several reasons. For example, the participant may dislike a particular food product. Or the participant may be placing a "protest bid" because he or she does not like the procedures. (See Shogren, List, and Hayes for a more detailed explanation on why consumers bid as they do in experimental auctions.)

[17] The method used is a linear labeling-variant fixed effect, censored regression model to carry out the tests of H2. The fixed effect being removed is any common unmeasured linear, labeling-invariant fixed effect that is product specific (see Wooldridge, pp. 247–249), and it is not a Tobit model. The differencing method safeguards against potential coefficient bias which would be caused by an unmeasured individual effect being correlated with demographic attributes.

Table 4. Censored Regression, Fixed-Effects Model Explaining Difference in Bid Price for Plain-Labeled and GM-Labeled Foods (N = 516)

(Dependent Variable: *Bid Price Plain-Labeled Food minus Bid Price GM-Labeled Food*)

	Regression (1)		Regression (2)	
Regressors	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	0.27***	0.05	0.14	0.22
GM Labels in Round 1	−0.17***	0.05	−0.15***	0.06
Female			−0.05	0.06
Education			0.01	0.01
Age			−0.00	0.00
Informed			0.06	0.06
Vegetable Oil (fixed effect)	0.00	0.07	0.00	0.07
Tortilla Chips (fixed effect)	0.02	0.07	0.02	0.07
Log Likelihood	−414.02		−412.45	

***Denotes statistical significance at the 1% level.

methodological feature of our study. The coefficients of the two dummy variables for commodity fixed effects, however, are not significantly different from zero.[18] No commodity-specific fixed effects are observed in the results in table 4.[19]

Discussion

The results presented here go beyond earlier studies in three key areas. First, it was observed that 58% of the adult participants bid less for at least one of the three GM-labeled products, while 26% of the participants disliked GM foods intensely enough that they bid less for every GM-labeled product. Second, the method allows us to estimate the price discount U.S. consumers might register in grocery stores if GM foods were labeled. In our lab experiments, consumers discounted the GM-labeled food by an average of 14% relative to the standard-labeled food.

The GM food industry seems likely to continue to oppose GM food labels, but the non-GM food industry may see new opportunities to supply non-GM foods at a premium. Although the results of this analysis differ from the experimental auction results reported by Lusk et al., they acknowledged the limitations placed on their results by using only undergraduate students: "If experiments were conducted with a larger, potentially more representative sample, we would expect a larger percentage of participants to bid [for non-GM food], and bid at higher levels" (Lusk et al., p. 55). Our results confirm the expectation expressed by Lusk et al. Specifically, the average adult in two major Midwestern cities discounted GM-labeled foods by about 14% relative to standard-labeled

[18] Our treatments include two labels and three information packets for a total of six labeling and information treatments. The econometric model for equation (3) was also refitted including dummy variables for information treatments, and results were not materially different from those reported in table 4. (See Rousu et al. for an analysis of the impacts of diffuse information on participants' willingness to pay.) Some of the information effects are statistically significant.

[19] Other censored regression models were fitted for equation (3), including regressors for a participant's pre-auction risk perceptions associated with irradiated foods, meat from animals fed growth hormones, and vaccines to prevent diseases. We also fitted models including a participant's household income, marital status, race, and other variables. None of these variables had a coefficient that was statistically different from zero for explaining bid differences for the GM-labeled and plain-labeled food products.

foods, and almost 60% of our sample showed a dislike for genetic modification, as revealed by a lower bid for a GM-labeled food relative to the standard-labeled counterpart. Third, participants in our lab experiments placed about the same percentage discount for each of the three GM-labeled food products, suggesting consumers are less concerned about *how* genetic modification enters the food product than the fact it *has* entered the food product, and that their concerns are primarily environmental.

Two interpretations are possible from our results. One interpretation is that without the GM labels, a respondent is bidding more for GM food than he/she otherwise would. Under this interpretation, GM food labels would therefore benefit consumers by informing them of GM content, which would lower their bids. The alternative interpretation is that consumers do not understand genetic modification. Given that GM food products are deemed to be "substantially equivalent" to their non-GM counterparts, this interpretation implies consumers would be better off by not being exposed to GM labels. If this is the case, more information on the risks or benefits of GM foods could help consumers make better informed decisions. Whatever the interpretation, our results provide evidence that consumers' willingness to pay for GM-labeled foods is significantly lower than their willingness to pay for the plain-labeled counterpart.

Conclusion

This study has demonstrated that consumers' willingness to pay for a food product decreases when the food label indicates the food product is genetically modified. The evidence shows consumers were willing to pay a 14% premium for food items they perceived as not genetically modified. Sociodemographic attributes of the participants—gender, education, household income, and prior beliefs about GM—do not alter significantly a consumer's WTP for GM foods. Our results, however, provide evidence that the order in which consumers bid on foods (i.e., whether they bid on the food with GM labels in round 1 or round 2) affects WTP for GM foods. Participants who bid on food with GM labels in round 1 had a higher WTP for GM food than the participants who bid on food with GM food labels in round 2. Because sequencing matters, we emphasize that future economics experiments randomize all treatments.

The implications of this study are notable given the ongoing global controversy over the issue of labels on GM foods. This debate has forced many countries around the world to consider or to implement new food-labeling policies. Given that the average adult consumer in a major Midwestern city revealed a significant premium for foods perceived as being non-GM, a mandatory GM labeling policy seems *unlikely* to be in the best interest of the biotechnology industry—but may be in the interest of consumers. From the perspective of the biotech industry, the use of GM labels would likely reduce consumers' willingness to pay for products which otherwise would be plain labeled.

Future research might examine the robustness of these results by replicating experiments in other areas of the country. Another avenue for future research would be to examine consumers' reaction to GM foods having specific consumer benefits, e.g., enhanced protein, vitamins, micro-nutrient content, shelf life. Two such products are Flavor-Saver tomatoes which were genetically engineered to have a longer shelf life, and "golden rice" which was genetically modified to provide more vitamin A, an attribute having potential benefits for people in third-world countries.

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Appendix:
Biotechnology Information Released to Participants During the Experiment

A. International Environmental Group Information

The following is a collection of statements and information on genetic modification from Greenpeace, a leading environmental group.

General Information

Genetic modification is one of the most dangerous things being done to your food sources today. There are many reasons that genetically modified foods should be banned, mainly because unknown adverse effects could be catastrophic! Inadequate safety testing of GM plants, animals, and food products has occurred, so humans are the ones testing whether or not GM foods are safe. Consumers should not have to test new food products to ensure that they are safe.

Scientific Impact

The process of genetic modification takes genes from one organism and puts them into another. This process is very risky. The biggest potential hazard of genetically modified (GM) foods is the unknown. This is a relatively new technique, and no one can guarantee that consumers will not be harmed. Recently, many governments in Europe assured consumers that there would be no harm to consumers over mad-cow disease, but unfortunately, their claims were wrong. We do not want consumers to be harmed by GM food.

Human Impact

Genetically modified foods could pose major health problems. The potential exists for allergens to be transferred to a GM food product that no one would suspect. For example, if genes from a peanut were transferred into a tomato, and someone who is allergic to peanuts eats this new tomato, they could display a peanut allergy. Another problem with genetically modified foods is a moral issue. These foods are taking genes from one living organism and transplanting them into another. Many people think it is morally wrong to mess around with life forms on such a fundamental level.

Financial Impact

GM foods are being pushed onto consumers by big businesses, which care only about their own profits and ignore possible negative side effects. These groups are actually patenting different life forms that they genetically modify, with plans to sell them in the future. Studies have also shown that GM crops may get lower yields than conventional crops.

Environmental Impact

Genetically modified foods could pose major environmental hazards. Sparse testing of GM plants for environmental impacts has occurred. One potential hazard could be the impact of GM crops on wildlife. One study showed that one type of GM plant killed Monarch butterflies. Another potential environmental hazard could come from pests that begin to resist GM plants that were engineered to reduce chemical pesticide application. The harmful insects and other pests that get exposed to these crops could quickly develop tolerance and wipe out many of the potential advantages of GM pest resistance.

B. Biotech Industry Information

The following is a collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta.

General Information

Genetically modified plants and animals have the potential to be one of the greatest discoveries in the history of farming. Improvements in crops so far relate to improved insect and disease resistance and weed control. These improvements using bioengineering/GM technology lead to reduced cost of food production. Future GM food products may have health benefits.

Scientific Impact

Genetic modification is a technique that has been used to produce food products that are approved by the Food and Drug Administration (FDA). Genetic engineering has brought new opportunities to farmers for pest control and in the future will provide consumers with nutrient enhanced foods. GM plants and animals have the potential to be the single greatest discovery in the history of agriculture. We have seen just the tip of the iceberg of future potential.

Human Impact

The health benefits from genetic modification can be enormous. A special type of rice called "golden rice" has already been created which has higher levels of vitamin A. This could be very helpful because the disease Vitamin A Deficiency (VAD) is devastating in third-world countries. VAD causes irreversible blindness in over 500,000 children and is also responsible for over one million deaths annually. Since rice is the staple food in the diets of millions of people in the third world, golden rice has the potential of improving millions of lives a year by reducing the cases of VAD. The FDA has approved GM food for human consumption, and Americans have been consuming GM foods for years. While every food product may pose risks, there has never been a documented case of a person getting sick from GM food.

Financial Impact

Genetically modified plants have reduced the cost of food production, which means lower food prices, and that can help feed the world. In America, lower food prices help decrease the number of hungry people and also let consumers save a little more money on food. Worldwide the number of hungry people has been declining, but increased crop production using GM technology can also help further reduce world hunger.

Environmental Impact

GM technology has produced new methods of insect control that reduce chemical insecticide application by 50% or more. This means less environmental damage. GM weed control is providing new methods to control weeds, which are a special problem in no-till farming. Genetic modification of plants has the potential to be one of the most environmentally helpful discoveries ever.

C. Independent, Third-Party Information

The following is a statement on genetic modification approved by a third-party group consisting of a variety of individuals knowledgeable about genetically modified foods, including scientists, professionals, religious leaders, and academics. These parties have no financial stake in genetically modified foods.

General Information

Bioengineering is a type of genetic modification where genes are transferred across plants or animals, a process that would not otherwise occur. (In common usage, genetic modification means bioengineering.) With bioengineered pest resistance in plants, the process is somewhat similar to the process of how a flu shot works in the human body. Flu shots work by injecting a virus into the body to help make a human body more resistant to the flu. Bioengineered plant-pest resistance causes a plant to enhance its own pest resistance.

Scientific Impact

The Food and Drug Administration standards for GM food products (chips, cereals, potatoes, etc.) are based on the principle that they have essentially the same ingredients, although they have been modified slightly from the original plant materials. Oils made from bioengineered oil crops have been refined, and this process removes essentially all the GM proteins, making them like non-GM oils. So even if GM crops were deemed to be harmful for human consumption, it is doubtful that vegetable oils would cause harm.

Human Impact

While many genetically modified foods are in the process of being put on your grocer's shelf, there are currently no foods available in the U.S. where genetic modification has increased nutrient content. All foods present a small risk of an allergic reaction to some people. No FDA-approved GM food poses any known unique human health risks.

Financial Impact

Genetically modified seeds and other organisms are produced by businesses that seek profits. For farmers to switch to GM crops, they must see benefits from the switch. However, genetic modification technology may lead to changes in the organization of the agribusiness industry and farming. The introduction of GM foods has the potential to decrease the prices to consumers for groceries.

Environmental Impact

The effects of genetic modification on the environment are largely unknown. Bioengineered insect resistance has reduced farmers' applications of environmentally hazardous insecticides. More studies are occurring to help assess the impact of bioengineered plants and organisms on the environment. A couple of studies reported harm to Monarch butterflies from GM crops, but other scientists were not able to recreate the results. The possibility of insects growing resistant to GM crops is a legitimate concern.