ISSN 1927-0887 E-ISSN 1927-0895
Published by Canadian Center of Science and Education

Consumer Attitudes toward the Use of Gene Technology in Breakfast Products: *Comparison between College Students from the U.S. and China*

Nanying Wang[1], Jack E. Houston[1], Gregory Colson[1] & Zimin Liu[2]

[1] Department of Agricultural and Applied Economics, The University of Georgia, Georgia, USA

[2] College of Economics and Management, Southwest University, Chongqing, China

Correspondence: Nanying Wang, 11th floor, 600 Peachtree St NE, Atlanta, GA 30308 USA. E-mail: nanying.wang1986@gmail.com

Received: July 27, 2015 Accepted: August 23, 2015 Online Published: November 25, 2015

doi:10.5539/jfr.v4n6p143 URL: http://dx.doi.org/10.5539/jfr.v4n6p143

Abstract

Second-generation Genetically Modified (GM) crops are associated with consumer-oriented benefits such as improvement of nutritional quality. Given such an evolving market environment, this paper presents differences in consumer preferences and valuations for genetically modified breakfast grain products. The perception of consumers from a developing country, China, is discussed and compared to attitudes in a developed country, the U.S. The survey results reveal that there are notable differences in the attitude and perception of college students across these two countries. Purchase intent for GM foods was low, unless a benefit was promised, and some modifications are viewed more positively than others. Overall, it appears that GM foods may be acceptable in the U.S. and Chinese market. The findings in this study have potential implications for establishing various GM marketing strategies and information campaigns.

Keywords: college students, genetic modification, staple food products, willingness to pay

1. Introduction

Genetically Modified (GM) plant represents a revolutionary technological change in agriculture. Unlike traditional forms of plant and animal breeding, recombinant DNA techniques enable researchers to directly manipulate the genetic composition of target organisms. The first generation (Lust et al., 2005) of genetically modified crop varieties, currently most widespread in the maize and soybean sectors, sought to increase farmer profitability by improving agronomic traits. The second generation of GM crops is focusing on breeding for attributes desired by consumers (e.g., better nutritional content, improved storability). This achievement opens the way for the development of nutritionally complete cereals to benefit nutrition-deficient populations. These attributes can be used in processed foods, such as soda, juices, bread, processed meats and cereal. Over time, as the adoption of such lower-cost technologies spreads, this outward shift in the supply curve would be expected to lower the consumer price of nutrient value in food.

However, the debate over genetic modification remains intense. Supporters believe the breeding of new plants by recombinant DNA technology removes the economic burden and potential environmental problems (Brookes & Barfoot, 2005). Advocates see GM food as key to ensuring food security in developing countries, promising to solve the problem of world hunger.

Some countries, particularly in Europe, maintain tighter restrictions on genetically modified seeds than the U.S. China has approved some types of genetically modified crops, but its approval process often takes longer than in the U.S. These differences in planting of GM crops and regulatory systems are already causing international trade dispute. Starting in 1997, the U.S. largely stopped shipping bulk commodity corn to the EU because such shipments commingled corn including genetically modified varieties not approved by the EU. In 2002, Zambia refused emergency food aid from developed countries, fearing that the included GM food was unsafe. In 2010, flax exports from Canada to Europe were rejected when traces of an experimental genetically modified flax were found in shipments. China quarantine authorities refused to accept 545 000 tonnes of the U.S. corn in November and December 2013 because shipments contained a GM variety that has been awaiting China's approval for more than two years.

A factor that is important in determining the extent of continued expansion of transgenic crop plantings and the development and adoption of new GM varieties is consumer attitudes. Understanding consumers' attitudes toward GM foods is important not only to the decision makers, GM food producers and exporters can also use this information to design effective marketing strategies.

GM staple products

Within different types of GM food, GM staple foods have had wide exposure in the global news media. Due to the important role of staple foods, they have not been approved to be commercialized in all counties. In developing countries, the main sources of vitamins and minerals for low-income rural and urban populations are staple foods. However, the major staple food crops, in particular cereal grains, are poor sources of key mineral nutrients, such as folic acid, iron, lysine, selenium, vitamin A, and zinc which are essential for normal growth and metabolism (Welch & Graham, 2004). Even in the West, lifestyle choices and lack of education can lead to an improper diet and, hence, deficiencies in some vitamins and iron (Franz, Bantle, & Wheeler, 2002). Transgenic plants offer effective ways to increase the vitamin and mineral content of staple crops. As products with enhanced attributes appear, consumers may face choices between GM products that bring tangible benefits (but carrying unknown risks) and traditional nutritional supplements.

GM development in China

China has been careful in allowing GM field experiments without permitting commercialization. However, China has been importing GM raw materials, including soybeans, corn, cotton, canola seed and sugar beets. Many people in China are starting to be concerned about GM ingredients in food. Evidence of Chinese consumers' attitudes toward GM foods from the existing literature is mixed and sometimes confusing. The uncertainty about Chinese consumers' attitudes toward GM foods contributes to uncertainty for policy makers on how China should proceed with its future biotechnology policies in general and GM foods in particular. China's final decision on whether it should commercialize GM crops will greatly influence what the rest of Asia does about GM food.

GM development in the U.S.

The U.S. is by far the largest user of GM crops. By 2013, roughly 91% of the planted area of soybeans, 88% of cotton and 85% of corn were genetically modified varieties. Labeling regulations for GM in the U.S. is a controversial topic as well. There have been numerous efforts to pass labeling laws in the U.S., especially at the state level. As of September 2013, legislation for GMO labeling was pending in at least 20 U.S. states.

Given the importance of GM staple crops to the Chinese and U.S. economies, consumers from these two countries are in a unique situation regarding their perception of GM foods. Different cultural and experiential backgrounds in the U.S. and China may address the risks and benefits of this new technologies in disparate ways in the international exchange of GM foods. College students are chosen here as the target group since, although their shopping habits are still developing, they represent a critical portion of the 'next generation' of consumers as well as future business leaders, thus they will play an important role in the future acceptance and use of GM products. Country-of-origin labeling is an increasingly politicized credence attribute in the globalizing food system. Mixed with different regulation of GM products, it is not clear if this emphasis on origin in country would result in different consumer preferences for breakfast cereal products.

The major objective of this study is to assess consumers' willingness to pay for various attributes of multi-nutrition enhanced GM staple products within college students' consumer groups in the U.S. and China. This study also tested the effect of geographical origin of ingredients and brand on willingness to pay and then compare the attitudes difference between college students within these two countries.

In order to understand the factors affecting consumers' acceptance of GM foods and to estimate their willingness to pay (WTP) for GM products, a survey project was conducted. Survey participants were sent an email with a webpage link to complete a self-administered questionnaire concerning their health habits and perceptions of GMOs. A choice experiment survey instrument (Lusk, Roosen, & Fox, 2003) was designed to measure behavioral intentions with a focus on consumers' willingness to pay a premium for breakfast grain products made of non-GM ingredients and willingness to accept a discount for products made of GM ingredients although they are nutritional enhanced. Specifically, the WTP for GM breakfast products - cereal and/or toast (U.S.), bun and/or porridge (China) - the four major breakfast products in these two countries are considered. Altogether, 400 consumers were interviewed, but only 252 of the responses are complete, from which 130 were from the U.S. and 122 from China. All surveys were completed during November 2013 to December 2013. Attempts were made to include students with different majors in various colleges. The questionnaire, initially written in English, was translated into Chinese (Mandarin). A mixed-logit model was then estimated (Hensher & Green, 2003, Revelt & Train, 1998) in which the decision on buying a GM food is a function of the attributes including non-GM, less pesticide, safety certification, country of origin, etc.

Results reveal differences in the attitudes and perceptions of GM foods between college students in these two countries. Both of them are willing to pay a premium for the attributes, such as non-genetically modified, additional nutrition, food quality certification from U.S. and less pesticide or herbicide use. However, American students are also willing to pay a premium for a U.S. brand and products in which raw material is from the U.S. Chinese college students are more willing to pay a premium for a product with Chinese food quality certification. Taking the non-GM attribute as an example, American college students are willing to pay on average a $0.98 premium and Chinese students would likely to pay on average a ￥1.30 premium for the breakfast product.

2. Literature Review

A large number of studies have shown that consumers' concerns about GM foods are rising and acceptance of GM foods varies among countries (Hoban, 1998; Lusk, Jamal, Kurlander, & Taulman, 2005; Costa-Font, Gil, Traill, 2008; Ding, Veeman, & Adamowicz, 2012, Jose L. Domingo et al., 2007). Consumers in general are likely to be willing to pay a premium for non-GM foods, but this does not guarantee everyone is resistant to GM foods, nor that GM foods are always inferior to their non-GM counterparts. Particularly, in the United States, the introduction of GM foods has not elicited strong public concern or widespread opposition. Hossain et al. (2003) reported that less than 60% of Americans supported the use of genetic technology when it did not bring any tangible benefit to consumers.

There are also studies on the Chinese consumers' attitude. However, the evidence from the existing literature is mixed and sometimes confusing. On one extreme, a study in Guangzhou, Shanghai, and Beijing by Greenpeace (2004) claimed that GM foods were generally not accepted by Chinese consumers. On the other extreme, Huang (2005) found that about two thirds of consumers not only accepted GM foods but also believed that they would personally benefit from consuming GM foods.

3. Survey and Choice Experiment Design

In fall 2013, a survey was conducted in the U.S. and China to elicit college students' opinions and valuation for nutritionally enhanced GM breakfast products. College students from the University of Georgia (U.S.) and Southwest University (China) were invited to participate in the project and answer questions from an online survey. These two universities are public universities in the southern part within each country. Respondents were randomly selected campus wide. To achieve this, emails were sent out with instruction and link of the survey to the email lists in different classes randomly selected in these two universities. Each questionnaire lasting approximately 15 minutes.

The survey collected responses concerning consumers' purchasing behavior. Respondents were first asked about their opinion of GM food. Then a brief introduction of knowledge of GM nutrition-enhanced products was given to the respondents. Next the main part of the survey was presented: a discrete-choice experiment (12 questions for each student). Finally, respondents were asked about their socioeconomic characteristics, including age, education and income, etc.

3.1 Sample Characteristics

A total of 252 individuals completed the full survey process and provided complete responses. Table 1 and Table 2 present summary statistics of socio-demographic information and attitudes toward GM food for (a) the Entire Sample, (b) the respondents from Southwest University (China), and (c) the respondents from the University of Georgia (U.S.).

In terms of the socio-demographics of the sample, more female respondents (60%) answered than males (40%). Respondents' average age is 23 years (varying from 18 to 36 years old); persons younger than 18 were not selected for the interviews. The students are from most different majors. For the U.S. college students, about half of them are Christian, and for the Chinese students, about 85% of them do not have a stated religion. As for their health habits, on average more than half of them do exercise once or twice a week, and approximately half of them have the habits of taking vitamin supplement. The average annual income of the U.S. respondents' parents was approximately 50 000 to 75 000 U.S. dollars, while for the Chinese students, it was between 40 000 to 50 000 RMB (approximately 6 000 to 8 000 U.S. Dollars).

As for their attitude, 94.8% of them have heard of GM food. About 15% of the respondents agreed with the statements that GM food have substantial benefits, only 23% are concerned with their negative effects. Almost half of respondents are not sure if they are beneficial or harmful. To ascertain the respondents' idea about the effects of GM food on the environment, the questionnaire simply asked whether they believe GM foods could bring good or bad effects to environment. Almost 60% of the respondents agree that GM foods can have both effects. Also, almost half of the students believe that GM technology benefits producers more than consumers.

For their attitudes towards whether GM food should be labeled, results showed that the attitudes of students from these two countries are quite different. Only 33% of the U.S. students are proponents, while 60% are not sure. However, 95% of the Chinese students think that GM food should be labeled. This result is consistent with the current regulation of each country.

The students' opinions of the effects of GM technology on the environment are quite similar. Around 60% of them believe that they can both have good effect and bad effect. To analyze how risky it is consuming GM foods, responses were given scores between 0 and 10 (0 for no risk and 10 for significant risk), so average scores could be calculated to estimate in general how risky it is in college students' minds. U.S. students gave an average score of 4.64, which is lower than the 5.52 of the Chinese students. However, the scores largely show that the students do not perceive GM food as "dangerous", but at the same time they still are concerned they may not be totally safe.

Table 1. GMO consumer sample characteristics, demographic, 2013

		U.S.(n=130)		China (n=122)		Total(n=252)	
Variable	**Variable Definition**	**Count**	**% of sample**	**Count**	**% of sample**	**Count**	**% of sample**
Age	Years of Age	25.28	5.85	21.74	1.89	23.57	4.74
Gender	1 if Male	58	44.62	41	33.61	99	39.29
	2 if Female	72	55.38	81	66.39	153	60.71
Major	1 if Visual and Performing Arts-related	2	1.54	16	13.11	18	7.14
	2 if Science and Math	36	27.69	12	9.84	48	19.05
	3 if Business	34	26.15	78	63.93	112	44.44
	4 if Engineering & Technology	8	6.15	11	9.02	19	7.54
	5 if Language, Literature & Social Science	50	38.46	5	4.10	55	21.83
Grad	1 if Undergraduate students	51	39.23	79	64.75	130	51.59
	2 if Graduate students	79	60.77	43	35.25	122	48.41
Religion	1 if Christianity	60	46.15	2	1.64	62	24.60
	2 if Buddhism	2	1.54	11	9.02	13	5.16
	3 if Hinduism	2	1.54	0	0.00	2	0.79
	4 if Islam	0	0.00	3	2.46	3	1.19
	5 if Judaism	3	2.31	0	0.00	3	1.19
	6 if no religion	57	43.85	103	84.43	160	63.49
	7 if other	6	4.62	3	2.46	9	3.57
Income	1 if parents' income is $0-$25,000	19	14.62	34	27.87	53	21.03
	2 if $25,001-$50,000	26	20.00	32	26.23	58	23.02
	3 if $50,001-$75,000	17	13.08	14	11.48	31	12.30
	4 if $75,001-$100,000	21	16.15	10	8.20	31	12.30
	5 if $100,001-$125,000	17	13.08	16	13.11	33	13.10
	6 if $125,001-$150,000	9	6.92	4	3.28	13	5.16
	7 if $150,001-$175,000	4	3.08	2	1.64	6	2.38
	8 if $175,001-$200,000	5	3.85	3	2.46	8	3.17
	9 if $200,000+	12	9.23	7	5.74	19	7.54
Exercise	1 if never	9	6.92	13	10.66	22	8.73
	2 if 1-2 times a week	51	39.23	87	71.31	138	54.76
	3 if 3-5 times a week	51	39.23	16	13.11	67	26.59
	4 if almost every day	19	14.62	6	4.92	25	9.92
Vitamin	1 if never	60	46.15	76	62.30	136	53.97
	2 if 0-2 times a week	23	17.69	37	30.33	60	23.81
	3 if 3-5 times a week	17	13.08	4	3.28	21	8.33
	4 if almost every day	30	23.08	5	4.10	35	13.89

Table 2. GMO survey sample characteristics, attitude, 2013

		U.S.(n=130)		China (n=122)		Total(n=252)	
Variable	**Variable Definition**	**Count**	**% of sample**	**Count**	**% of sample**	**Count**	**% of sample**
Heard	**1 if yes**	122	93.85%	117	95.90%	239	94.84%
	2 if not sure	6	4.62%	3	2.46%	9	3.57%
	3 if no	2	1.54%	2	1.64%	4	1.59%
Attitude	**1 if GM foods are beneficial**	23	17.69%	15	12.30%	38	15.08%
	2 if GM foods are harmful	39	30.00%	19	15.57%	58	23.02%
	3 if GM foods are neither	27	20.77%	10	8.20%	37	14.68%
	4 if do not know	41	31.54%	78	63.93%	119	47.22%
Benefit	**1 if producers benefit more**	74	56.92%	75	61.48%	149	59.13%
	2 if consumers benefit more	6	4.62%	3	2.46%	9	3.57%
	3 if both benefit	42	32.31%	42	34.43%	84	33.33%
	4 if neither benefit	8	6.15%	2	1.64%	10	3.97%
Label	**1 if not necessary mandatory**	11	8.46%	2	1.64%	13	5.16%
	2 if should mandatory	43	33.08%	116	95.08%	159	63.10%
	3 if not sure	76	58.46%	4	3.28%	80	31.75%
Environment	**1 if bad effects**	45	34.62%	14	11.48%	59	23.41%
	2 if good effects	11	8.46%	20	16.39%	31	12.30%
	3 if neither	9	6.92%	5	4.10%	14	5.56%
	4 if both	65	50%	83	68.03%	148	58.73%
Necessary	**0 if unnecessary** **10 if very necessary**	4.72		4.24		4.97	
Risk	**0 if no risk** **10 if huge risk**	4.64		5.52	—	5.06	
Wheat	**1 if support commercialization**	72	55.38%				
	2 if not support	58	44.62%				
Import effect	**1 if no effect**			4	3.28%		
	2 if some effect			104	85.25%		
	3 if huge effect			14	11.48%		

Similarly, the questionnaire asked how necessary it is to produce GM food, where 0 means unnecessary and 10 mean necessary. The U.S. students gave a slightly higher score of 4.72, and Chinese students gave an average score of 4.24. Since GM wheat products have not been commercialized in U.S., the survey also asked the U.S. students a question about their opinion about it. It is surprising to find that half of the respondents support production. There seems to exist a positive outlook for the commercialization of wheat in the U.S. Due to the large amount of GM products imported in China, the survey also collected the opinion of Chinese students on importing GM products. About 85% of respondents from China think the importing behavior have some effect on them, but only 11% of them believe the effect is huge.

3.2 Consumer Preferences for Attributes toward GM Breakfast Products

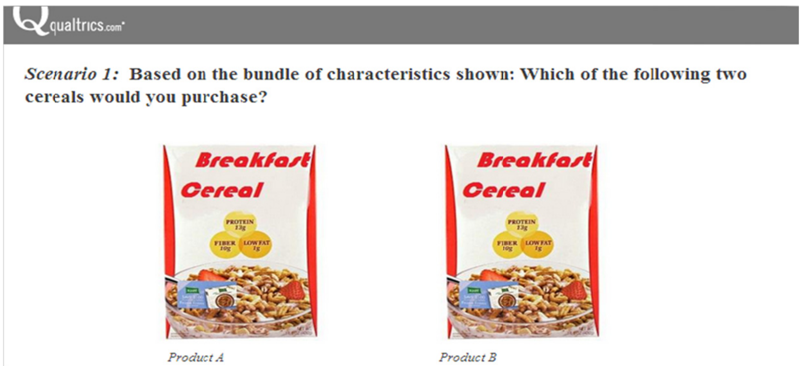
In the latter part of the survey, a choice experiment was implemented in order to assess college students' attitudes toward the different attributes of GM breakfast food products. The survey used cereal and toast as target products for the U.S students, and porridge and buns for Chinese students, which are most common breakfasts for college students in these two countries.

The core section of the survey consisted of a discrete-choice experiment, following standard procedures (Louviere, Hensher, & Swait, 2000; Street & Burgess, 2007). One of the advantages of a choice experiment is that it yields quantitative measures of the tradeoff between attributes of interest.

Specifically, in each of the 12 scenarios, each student was asked to select between two different breakfast products and the 'Prefer to Choose' option. In each scenario, they were asked to make a choice between two different breakfast products. Each product included seven different key attributes. These included different prices, whether they are GM, and if they are more nutritious, etc. Each of these seven attributes was varied according to their respective different levels summarized in Table 3. An example choice scenario is presented in Figure 1.

Table 3. GM grain breakfast attributes and levels in the choice experiment

GM grain breakfast good attributes	Attribute levels
Price	$4 (￥1.5)
	$2.8(￥1.0)
Genetic Modification	Non-GM
	GM
Additional Nutritional Benefits	Yes
	No
Brand	A U.S. brand name company
	A Chinese brand name company
Raw material Origin	US
	China
Food Quality Certification	US
	China
	None
Pesticide/Herbicide Use	30% less than current level
	current level



Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	GM	Non-GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No
Brand	A Chinese Brand Name Company	A U.S. Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country Agency	U.S.	None
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

- Product A
- Product B
- Neither of the two options above

Figure 1. Example of choice set (English version)

3.3 Mixed Logit Model

One recognized framework to analyze the consumers' choice is a mixed logit model (MXL) with random and correlated coefficients. This approach has become increasingly standard in choice experiment research for estimating consumers' willingness to pay for certain attributes. It was proposed by Revelt and Train (1998). This method relaxes the assumption that all respondents have the same preferences for some breakfast product attributes by allowing for random taste variation among individuals. It supports consideration of a correlated distribution of taste parameters.

In this study, the model can be expressed and estimated as follows. Survey respondents $i(i=1,\cdots,N;N=252)$ are faced with 12 choice scenarios $(t=1,\cdots,T;T=12)$ among different breakfast products. Each choice set consists of three elements: two breakfast products and the 'Prefer to Choose' option. In total, there are 25 alternatives, indexed by $j(j=1,\cdots,J;J=25)$, including 24 breakfast products and the one 'Prefer to Choose' option. Assuming the utility is linear in parameters, the individual i' utility function is defined by a deterministic component $x_{ijt}\beta$ and a stochastic component ε_{ijt}:

$$U_{ijt} = x_{ijt}\beta + \varepsilon_{ijt} \tag{1}$$

Where x_{ijt} is a vector representing the attributes of alternative j in choice scenario t and β is a vector of unknown parameters. The elements of vector x_{ijt} are described in Table 4. The error term is assumed to be independent and identically distributed over individuals, alternatives, and choice scenarios.

Table 4. Variables used in the analysis

Variable	Variable definition
GM	1 if Non-GM
Nutri	1 if contain more nutrition
Brand	1 if it is a U.S. brand
Raw	1 if raw material from U.S.
CertUS	1 if certified in U.S.
CertChina	1 if certified in China
Herbi	1 if 30% less Persitcide/Herbicide use
Prefer	1 if Prefer to 'Choose'

Using Equation (1), six models were estimated, which include estimation using total data of U.S. and China, as well as their subsamples which group by students who chose different products as their experimental product.

The probability of individual i choosing alternative j in choice scenario t is expressed as:

$$P_{ijt} = \mathrm{Prob}(U_{ijt} > U_{ikt} \forall j \neq k) \tag{2}$$

The probability is attained from utility maximization of the formula of the conditional logit model:

$$P_{ijt} = \frac{\exp(x_{ijt}\beta)}{\sum_{k=1}^{J}\exp(x_{ikt}\beta)} \tag{3}$$

Letting $y_i = y_{i1},\cdots,y_{iT}$ denote individual consumer $i's$ sequence of choices, conditional on $\beta = \{\beta_{0,i},\cdots,\beta_{N,i}\}$. Given the independent error structure, the probability of $i's$ sequence of choices is equal to

$$L(y_i|\beta) = \prod_{t=1}^{T}\frac{\exp(x_{ijt}\beta)}{\sum_{k=1}^{J}\exp(x_{ikt}\beta)} \tag{4}$$

which corresponds to a product of logits. The unconditional probability of individual i's sequence of choices is the integral of the expression $L(y_i|\beta)$ over β.

Specifically, coefficients in vector β are defined as random variables following density function f:

$$\beta \sim h(\theta + \upsilon, \Omega) \tag{5}$$

Where h is a probability distribution function, θ is the mean vector value of the distribution, V is an *i.i.d* error term vector, and Ω is a parameter covariance matrix. Given this specification, the choice probability can be written as:

$$P_{ijt} = \int \frac{\exp(x_{ijt}\beta)}{\sum_{k=1}^{J}\exp(x_{ikt}\beta)} h(\beta)d\beta \tag{6}$$

The unconditional probability of individual i's sequence of choices is the integral of the expression $L(y_i|\beta)$ over β, which is expressed as:

$$L(y_i|\beta) = \int L(y_i|\beta) f(\beta)d\beta \tag{7}$$

Where $f(\beta)$ is the multivariate distribution of the parameters. Summing the logarithm of the unconditional probabilities gives the log-likelihood function,

$$\sum_i \ln L(y_i|\beta) \tag{8}$$

With a fixed price coefficient, the willingness to pay is equal to the ratio of the attribute's coefficient to the price coefficient. For example, $-\beta_{Non-GM}/\beta_{Price}$ is the additional WTP for one breakfast product with non-GM ingredients compared with an otherwise equivalent product with GM ingredients. In addition, with a fixed price coefficient, the distribution of WTP corresponds to the scaled distribution of the attribute's coefficient. The mean and variance of WTP estimated under MXL models were calculated using the simulation approach with 200 iterations. The WTP measures follow similar interpretation of the part worth utilities but they offer dollar values or RMB values for various attributes.

4. Results

Because consumers in these two countries may differ in culture, experiences and other unmeasured features, it is possible that these consumer groups differ in their food product preferences. Table 5 displays the results of the MXL models for each of the two sample categories: the U.S. respondents and the Chinese respondents.

Table 5. Breakfast product attribute preferences: mixed logit estimates

Variable	U.S (n=130)		China (n=122)	
	Mean Coef.	St.dev. Coef.	Mean Coef.	St.dev. Coef.
Price	-1.188***		-0.652***	
	(0.129)		(0.243)	
Non-GM	0.965***	1.549***	1.025***	1.529***
	(0.204)	(0.163)	(0.174)	(0.147)
Nutrition	0.452**	0.589***	0.190	0.819***
	(0.154)	(0.181)	(0.141)	(0.131)
U.S. Brand	0.577***	0.512***	-0.179	0.008
	(0.158)	(0.165)	(0.139)	(0.149)
U.S. Raw material	0.738***	0.661***	-0.026	0.119
	(0.150)	(0.149)	(0.124)	(0.122)
China Certification	-0.171	0.501**	0.825***	0.689**
	(0.265)	(0.226)	(0.279)	(0.346)
U.S. Certification	1.208***	1.702***	0.827***	0.740***
	(0.247)	(0.236)	(0.193)	(0.148)
30% Less Pesticide	0.755***	0.685***	0.580***	0.847***
	(0.152)	(0.125)	(0.134)	(0.102)
Prefer to Choose	-4.950***	3.050***	-2.868***	2.909***
	(0.838)	(0.249)	(0.738)	(0.264)
Log-Likelihood	-960.276		-1035.736	
Log-Likelihood Ratio	799.21		594.53	
Observations	4680		4392	

Note: Standard Deviations in parenthesis. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

In each of the two models reported in Table 5, the signs of the coefficient estimates fall in line with expectations and the majority of the attributes are statistically significant at the 1% level. The price coefficient is negative and statistically different from zero, which is consistent with expectations that college students prefer, holding all other factors constant, breakfast products with lower price. With regard to the non-GM attribute, in each of the two models the coefficient is found to be positive and statistically different from zero. This implies that students in both countries prefer non-GM products and are willing to pay a premium for this attribute. This corresponds with the perception that people worry there might be some uncertainty surrounding GM food products. Additionally, the variance coefficient for non-GM is found to be significant and sizeable, indicating that consumers are heterogeneous in their preferences for non-GM products.

For the enhanced nutrition benefit, only the coefficient of the U.S. students group is significant and positive. The Chinese student respondents apparently perceive paying more for additional nutrition as necessary. Similarly, U.S. brand and raw ingredients from U.S. are only significant for the U.S. group. The origin of brand and raw ingredients from U.S. were not preferred by the Chinese students.

For the products with food quality certification approved by a Chinese agency, respondents from the U.S. do not particularly value it. Only Chinese respondents prefer this attribute. However, foods with quality certification approved by a U.S. agency are valued by students from both countries. This shows that, in general, consumers have trust in the institutions, and thus they may perceive more clear benefits in GM foods with certain certification. Moreover, the coefficient for 30% less pesticide or herbicide use is positive and significant. This shows that students from both countries prefer less pesticide usage.

While the signs of the coefficient estimates correspond with expectations, to quantify the value of the different attributes for each sample sub-group, their willingness to pay is computed. WTP is computed for students groups choosing different products as their target product within each country first. The results are displayed in Table 6 (U.S.) and Table 7 (China). The two models within each country exhibit high consistency in terms of significance and signs of coefficients. Also, the results of the t test of WTP for each attribute indicate that no significant differences of the WTP value were observed for each attribute when selecting cereal and bread ($p > 0.1$). The results suggested that there was no difference in response between consumers choosing different breakfast product within each country, and thus the two groups were pooled and a single model is estimated within each country.

Table 6. GM product preferences: mixed logit estimates of the U.S. students

Variable	US Cereal (n=94)			U.S Bread (n=36)			WTP Diff p-value
	Mean Coef.	St.dev. Coef.	WTP	Mean Coef.	St.dev. Coef.	WTP	
Price	-1.035***			-1.671***			
	(0.143)			(0.285)			
Non-Genetic	0.835***	1.527***	$1.957***	1.095***	1.559***	$1.354**	0.215
Modification	(0.227)	(0.180)	(0.260)	(0.072)	(0.293)	(0.631)	
Additional	0.351**	0.826***	$0.491**	0.776**	0.186***	$0.424**	0.515
Nutritional Benefits	(0.187)	(0.178)	(0.195)	(0.341)	(0.017)	(0.171)	
U.S. Brand	0.522***	0.484***	$0.544***	0.854**	0.514**	$0.581***	0.308
	(0.183)	(0.144)	(0.182)	(0.351)	(0.283)	(0.191)	
Raw material	0.920***	0.177***	$0.749***	0.691**	0.722**	$0.814***	0.175
Origin from U.S.	(0.168)	(0.073)	(0.275)	(0.327)	(0.314)	(0.125)	
Food Quality Certification	1.262***	1.197***	$1.209***	1.196***	3.975***	$1.715***	0.494
from U.S.	(0.296)	(0.577)	(0.232)	(0.625)	(0.757)	(0.116)	
Food Quality Certification	0.069	1.678**	$0.266	1.730	2.414***	$0.335**	0.283
from China	(0.362)	(0.267)	(0.371)	(0.612)	(0.440)	(0.156)	
30% less Pesticide /Herbicide	0.574***	0.743***	$0.875**	1.403***	0.538**	$0.589***	0.590
	(0.171)	(0.12)	(0.132)	(0.341)	(0.275)	(0.133)	
Prefer to Choose	-4.252***	4.268***	$-4.107***	-5.842***	3.257***	$-5.303***	0.3623
	(0.945)	(0.523)	(1.267)	(0.572)	(0.784)	(0.331)	
Log-Likelihood	-715.73			-232.139			
Log-Likelihood Ratio	597.73			206.19			
Observations	3384			1296			

Note: Bootstrapped Standard Errors in parenthesis. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. WTP Diff. presents the p-value for a t-test comparing the WTP between the students who chose Cereal and Bread, respectively.

Table 7. GM product preferences: mixed logit estimates of Chinese students

Variable	China Cereal (n=91)			China Bread (n=31)			WTP Diff p-value
	Mean Coef.	St.dev. Coef.	WTP	Mean Coef.	St.dev. Coef.	WTP	
Price	-0.616***			-0.692***			
	(0.283)			(0.105)			
Non-Genetic	0.849***	1.632***	￥1.179*	1.735***	1.470***	￥1.131*	0.715
Modification	(0.192)	(0.196)	(0.427)	(0.253)	(0.261)	(0.637)	
Additional	0.212	0.766***	￥0.344	0.297	0.855**	￥0.392	0.747
Nutritional Benefits	(0.166)	(0.142)	(0.727)	(0.275)	(0.231)	(0.667)	
U.S. Brand	-0.194	0.288	￥-0.014	-0.151	0.065	￥-0.054	0.712
	(0.165)	(0.146)	(0.597)	(0.270)	(0.181)	(0.088)	
Raw material	-0.007	0.239	￥0.211	0.098	0.270	￥0.266	0.646
Origin from U.S.	(0.145)	(0.174)	(0.556)	(0.241)	(0.200)	(0.626)	
Food Quality Certi-	0.946***	0.709***	￥1.037*	0.535***	0.827***	￥1.204*	0.190
fication from U.S.	(0.228)	(0.165)	(0.386)	(0.062)	(0.190)	(0.675)	
Food Quality Certi-	0.882***	0.720***	￥1.433*	0.833	0.667	￥1.497*	0.676
fication from China	(0.140)	(0.297)	(0.525)	(0.552)	(0.621)	(0.763)	
30% less Pesticide	0.681***	0.862***	￥1.069**	0.512***	0.824***	￥1.005**	0.581
/Herbicide Use	(0.162)	(0.137)	(0.264)	(0.155)	(0.191)	(0.232)	
None	-3.050***	3.375***	￥-7.530	-2.581***	2.288***	￥-7.070	0.875
	(0.910)	(0.527)	(12.098)	(0.331)	(0.646)	(18.596)	
Log-Likelihood	-754.688			-274.182			
Log-Likelihood Ratio	475.80			125.64			
Observations	3276			1116			

Note: Bootstrapped Standard Errors in parenthesis. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. WTP Diff. presents the p-value for a t-test comparing the WTP between the students who chose Cereal and Bread, respectively.

Table 8 provides estimates of the consumers' willingness to pay (WTP) of the students from both countries for breakfast product with different attributes calculated using the coefficient estimates from the mixed logit models.

Table 8. Willingness to pay for GM enhanced breakfast product

Variable	U.S. Total (n=130)	China Total (n=122)
Non-GM	$0.982***	￥1.147*
	(0.385)	(0.644)
Nutrition	$0.414	￥0.356
	(0.261)	(0.297)
U.S. Brand	$0.573***	￥-0.023
	(0.285)	(0.147)
U.S. Raw material	$0.728**	￥0.224
	(0.310)	(0.185)
U.S. Certification	$1.133**	￥1.048*
	(0.518)	(0.564)
China Certification	$0.301	￥1.467*
	(0.463)	(0.789)
30% Less Pesticide	$0.584**	￥1.045**
	(0.295)	(0.513)
Prefer to Choose	$-4.419***	￥-7.150
	(0.987)	(15.245)

Note: Bootstrapped Standard Errors in parenthesis. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Note that the U.S. Dollar and Chinese Yuan are used as monetary units in U.S. and China, respectively. To interpret the importance of WTP for breakfast products with different benefits, the premium should be compared with the "currently" available market prices for these products in U.S. and China. The current market prices at the time of the study were $2.8 for U.S. plain cereal and toast and 1.0 RMB ($1 equals about 6 RMB) for

Chinese plain porridge and bun.

A key focus of this experiment was to evaluate the WTP for the non-GM attribute. With all else equal, U.S. college consumers are willing to pay 98.2 U.S. Cents more for one box of cereal or one loaf of toast with non-GM content. For the Chinese students, the experimental results suggest that consumers are willing to pay modestly higher prices for breakfast identified as non-GM. The estimated WTP for this attribute was about 1.1 RMB (about 2 U.S. cents) per bun or porridge. Similarly, U.S. college students are willing to pay a premium for U.S. certification and for 30 percent less pesticide or herbicide use of 1.13 USD and 60 cents, respectively. The other attributes for which Chinese college consumers would pay a premium are U.S. and China certification, with premiums of 1 RMB and 1.5 RMB, respectively. It is, perhaps, surprising that they would pay higher for the China agency certification. This may be attributed to the fact that it is difficult for them to validate the U.S. certification agency.

Because these attributes were independently displayed in the experiment, and there were no significant interaction effects for these attributes, these WTP values are additive. Thus, what consumers are willing to pay for certain mixed additive attributes can be obtained. For example, with attributes GM and more nutrition, U.S. students would pay a discount of 57 Cents USD. In this study, the benefit perceptions of applying gene technology to produce food products are seen as not outweighing risk perceptions of that application.

5. Conclusions

Public perceptions and attitudes to the introduction of emerging technologies have long been recognized as important factors in determining the likelihood of consumer support and prospective success in product development. There is concern about the extent to which consumers will accept genetically modified (GM) staple foods if they are commercialized in the U.S. and China. In this article, choice-modeling experiments are employed to determine willingness to pay of college student consumers from the U.S. and China regarding breakfast foods with GM and other attributes related with consumer benefits when the consumers are placed in an online purchasing situation. The analysis of data predicts that food products made of genetically modified ingredients could have a place in supermarkets in these two counties.

The results suggest that consumers from different countries have different concerns and interests towards GM food products. The U.S. students group value almost every attribute with a premium, except for the food with quality certification in China. They are prepared to pay a premium of about one dollar for the non-GM attributes compared with GM products. The Chinese students are more concerned with GM food and pesticide or herbicide use. Their willingness to pay for non-GM is quite high, which is about one Dollar in U.S. and one RMB in China. The results also support the notion that Chinese consumers are willing to support the staple GM food if they have the quality certification from the regulatory institutions.

Based on the findings of this study and given that the sample is college students, it can be conclude that the commercialization of GM foods is not likely to receive insurmountable from consumers in China and U.S., although people are willing to pay a significant premium for the non-GM attribute. In fact, foods emphasizing their selling point by labeling as non-GM foods are indeed more expensive than GM foods in these two countries. These survey results suggest governments and GM food marketers have an opportunity to make extra efforts for the public to understand the benefits or usefulness from applying gene technology to produce food products, thus increasing the public's acceptance of GM foods.

6. Policy Discussion

The results obtained contribute to the knowledge of the food market, particularly of genetically modified foods, identifying consumers' preferences. Based on these findings, food producers and marketers can develop specific marketing mixes according to the needs of the consumers to increase profit. For example, the GM technology primarily focused on insect and disease resistance potentially should be continued because it could assist U.S. and China improve its food safety and will meet consumers' demand for less pesticide residuals in food.

Providing such a framework is also important for policy development, decision making, and risk communication about GM. Because trust in the regulatory institutions of certification of the quality of food exerts a strong effect on the benefit perceptions, governments should take the responsibility of monitoring the proper functioning of the safety mechanism in producing GM foods so as to gain trust from the consuming public. Moreover, governments should increase transparency in formulating fair laws and communicate more frequently and effectively with consumers. Adequate regulations, constant monitoring, and intensive research are essential to avoiding possible harmful effects from GM food technology.

References

Brookes, G., & Barfoot, P. (2005). GM crops: the global economic and environmental impact-the first nine years 1996-2004. *The Journal of Agrobiotechnology Management and Economics, 8*(2), 187-196.

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy, 33*(2), 99-111. http://dx.doi.org/10.1016/j.foodpol.2007.07.002

Ding, Y., Veeman, M. M., & Adamowicz, W. L. (2012). The impact of generalized trust and trust in the food system on choices of a functional GM food. *Agribusiness, 28*(1), 54-66. http://dx.doi.org/10.1002/agr.20287

Franz, M. J., Bantle, J. P., & Wheeler, M. (2002). Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications. *Diabetes care, 25*(1), 148-198. http://dx.doi.org/10.2337/diacare.25.1.148

Hoban, T. J. (1998). Trends in consumer attitudes about agricultural biotechnology. *The Journal of Agrobiotechnology Management and Economics, 1*(1), 3-7.

Hensher, D. A., & Greene, W. H. (2003). The mixed logit model: the state of practice. *Transportation, 30*(2), 133-176. http://dx.doi.org/10.1023/A:1022558715350

Hossain, F., Onyango, B., Schilling, B., Hallman, W., & Adelaja, A. (2003). Product attributes, consumer benefits and public approval of genetically modified foods. *International Journal of Consumer Studies, 27*(5), 353-365. http://dx.doi.org/10.1046/j.1470-6431.2003.00303.x

Jose, L. D. (2007). Toxicity Studies of Genetically Modified Plants: A Review of the Published Literature. *Critical Reviews in Food Science and Nutrition, 47*, 721-733. http://dx.doi.org/10.1080/10408390601177670

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods: analysis and applications* (pp. 34-282). Cambridge University Press. http://dx.doi.org/10.1017/cbo9780511753831

Lusk, J. L., Roosen, J., & Fox, J. A. (2003). Demand for beef from cattle administered growth hormones or fed genetically modified corn: a comparison of consumers in France, Germany, the United Kingdom, and the United States. *American Journal of Agricultural Economics, 85*(1), 16-29. http://dx.doi.org/10.1111/1467-8276.00100

Lusk, J. L., Jamal, M., Kurlander, L., & Taulman, L. (2005). A meta-analysis of genetically modified food valuation studies. *Journal of Agricultural and Resource Economics, 30*(1), 28-44.

Revelt, D., & Train, K. (1998). Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. *The Review of Economics and Statistics, 80*(4), 647-657. http://dx.doi.org/10.1162/003465398557735

Street, D. J., & Burgess, L. (2007). The construction of optimal stated choice experiments: Theory and methods (pp. 249-268). *John Wiley & Sons*. http://dx.doi.org/10.1002/9780470148563

Train, K. E. (2009). *Discrete choice methods with simulation*. Cambridge university press. http://dx.doi.org/10.1017/cbo9780511805271

Welch, R. M., & Graham, R. D. (2004). Breeding for micronutrients in staple food crops from a human nutrition perspective. *Journal of Experimental Botany,* 55(396), 353-364. http://dx.doi.org/10.1093/jxb/erh064

Copyrights