Comparing Perceptions of Biotechnology in Fresh versus Processed Foods: A Cross-Cultural Study

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Abstract

This study focused on investigating how respondents' perceptions of biotechnology used in food production differs depending on the level of product transformation (i.e. fresh versus processed food). Using cluster analysis, respondents were clustered into two groups, genetically engineered (GE) tolerant and GE sensitive, based on changes in their perceptions about fresh apples and apple juice produced with and without biotechnology. Comparisons of respondents from six countries were performed to measure relative attitudes about biotech food. In addition, three types of positive information about biotechnology were tested in order to determine what types of information influences respondents' GE tolerance. Results indicate that respondents were less likely to change their initial health perception for apple juice than for fresh apples when produced from trees that were genetically modified. The residency effect was strong and heterogeneous: respondents of Japan were much more sensitive than respondents of Spain and the United States.

Key Words: Biotechnology, product transformation, apple, a cross-cultural study, cluster analysis

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Introduction

Biotech crops have been adopted quickly in commercial usage, reaching 160 million hectares in 2011 worldwide, up from 1.7 million hectares in 1996 (James, 2011). Although uncertainty about the effects of biotech products on human health and moral/religious objections remains for biotechnology, in some cases, it may be the only available solution to cure crop diseases in agricultural production. However, industries hesitate to introduce biotechnology as their solution because of concerns about losing consumer loyalty and market share.

Worldwide consumption of food products vary, including the degree to which foods already produced with biotechnology are included. One factor includes the amount of processed foods consumed. For example, in the United States, most processed food products would contain at least some portion of biotech ingredients. Soybeans, corn, and canola seeds (three crops frequently produced with biotechnology) are important sources of vegetable oil in the U.S., corn is a principal source of sweeteners, and corn and soybeans are significant sources of other ingredients for processed foods (Rousu et al, 2007). In a report comparing total food consumption (per pound capita) of packaged food and fresh food for several countries (New York Times, 2010), consumers in France, the United States and Spain were found to consume consumed over half of their food as packaged (i.e., most are processed).

Foods produced with biotechnology may be found more often in processed foods. One reason for this may be that consumers could favor processed food made with biotechnology compared to fresh foods, as it may be perceived as 'farther' from the modification or 'less' modified. Previous research on consumer willingness to accept biotech foods have investigated various types of foods. In a study by Rousu et al (2007), participants lowered their rating of

genetic modification (GM)-labeled food items by 14% relative to the same non-GM food items. The products evaluated included tortilla chips (highly processed foods), Russet potatoes (fresh), and vegetable oil (minimal human health concern). Although, they included fresh and processed products in the experiment, the study was limited to directly testing how consumer perception of biotech food was altered according to how the product was utilized.

This study aims to develop an understanding of the factors influencing consumers' preferences for food products produced with biotechnology, with a special focus on comparing perceptions between fresh and processed products. Additionally in light of the growing importance of international trade, the survey was conducted in five international markets (Belgium, France, Germany, Japan, and Spain) as well as the United States. In a manner similar to previous studies, information on the potential benefits of biotechnology was given to test response to different reasons for use of the technology.

This study adds to the literature comparing acceptance in different U.S. export markets, including Japan. Additionally, the focus on consumer attitudes based on the level of product transformation may provide further input to producer and scientist decisions to invest in biotechnology. Finally, in addition to using the typical reasons for biotechnology (environmental benefit and consumer benefits), a benefit focusing on using biotechnology to aid farmers fighting a significant disease will provide input to industries faced with this major decision.

Previous Research

Previous studies found European consumers have higher valuations for non-GM food than do U.S. consumers (Gaskell et al, 1999; Lusk et al, 2005; Lusk et al., 2006). Lusk et al (2005) conducted a meta-analysis showing that European consumers have 29% higher valuations for non-biotech food than U.S consumers. Lusk et al (2006) employed quantile regression to evaluate the difference between consumers' conceptions of biotechnology in the EU and the

United States. They found that U.S. consumers WTA biotech food was twice that of British and French consumers at the median level of compensation. The lower the level of perceived risk and the higher the perceived benefit, the lower the compensation demanded. Gaskell et al. (1999) tried to explain why people in the U.S. are less troubled by biotech food than Europeans by examining the different public perceptions of biotechnology. They found that the increasing amount of press coverage of technological controversies is associated with negative public perceptions in both countries.

In one of few studies on Japanese consumers, McCluskey et al (2003) conducted in-person interviews to measure consumers WTA biotech noodles versus non-biotech noodles using the contingent valuation method (CVM) in Japan. They found that 80% of Japanese consumers would not choose the biotech noodles over non-biotech noodles for discount ranges of 5% to 50% and the required discount to be WTA was high (more than 50%). In the regression, cognitive variables such as food safety, environment attitudes, subjective knowledge and perceived risk and socio-economics such as income and education were significant in increasing the WTA compensation for choosing GM foods.

In addition to differences between countries, information has been found to impact willingness to accept biotech foods. Lusk et al (2004) conducted an experimental auction to determine what types of information on the benefits of biotechnology affect consumer acceptance of biotech food in Europe and the United States. WTA was measured before and after providing consumers with three types of positive information: environment benefits, health benefits, and benefits to the developing world. Environmental benefits had a significant influence on WTA bids. In particular, people in the U.S. were influenced by the environmental information while people in the EU tended to be affected more by the health information. In

addition, individuals with more subjective knowledge were less influenced by new positive information as they placed greater weight on their prior information. Rousu and Lusk (2009) expanded the finding of Lusk et al (2004) to evaluate the information. The results showed that the value of information was largest for health benefits, then for benefits to the developing world. Environmental benefits were third. Consumers who received the higher valued information were less likely to switch their decision to purchase. That is, consumers who received the health information were least likely to switch to the GM cookie after receiving the information. As the impact of information may be affected by prior knowledge, House et al (2004) investigated the effect of individual subjective and objective knowledge on willingness to consume biotech food for European and U.S. consumers using the same data from Lusk et al (2004). The study found that subjective knowledge was a significant determinant to eating biotech food but objective knowledge was not, calling into question the potential impact of educational programs on acceptance. However, as there was slight correlation between objective and subjective knowledge, increased objective knowledge could still increase biotech food acceptance.

Rousu et al (2007) verified the different impact of negative (environmental group perspectives), positive (biotech industry perspectives), and verifiable information (independent, third-party perspectives) on changing of consumers' WTP for three biotech products: tortilla chips, Russet potatoes and vegetable oil. Even though consumers were generally influenced more by negative information than positive information, consumers who had both anti-biotech and verifiable information discounted biotech food less than those who had only anti-biotech information.

This study seeks to fill the gaps by investigating consumer perception of biotechnology at different stages of food processing, as well as investigating acceptance in multiple countries.

Given the time between previous studies comparing acceptance across countries, this research also allows us to see if changes have occurred as biotechnology has existed in the markets for a longer time.

Data and Survey Design

An online survey was conducted in five international markets, as well as the United States, in June, 2012. Four European countries were selected based on their level of acceptance of buying biotech food; Germany and France were categorized as high-rejection of biotech food while Spain and Belgium were categorized as low-rejection of biotech food (Gaskell et al, 2006). In addition, we included Japan due to its importance as a market for U.S. agricultural exports. A random sample of 1,610 consumers was recruited through a survey panel to complete an online survey: 399 individuals in Japan, 408 individuals in Germany and France, 406 individuals in Spain and Belgium, and 397 individuals in the U.S.

To compare consumers attitude changes toward foods produced with/without biotechnology and to determine if perceptions differ based on whether the product is fresh or processed, participants were asked a series of questions about a variety of products. The questionnaire was designed to understand consumers' perception of biotech food as well as measure the knowledge and attitudes of individuals toward biotechnology in food production. To obtain a base measurement of health perceptions, consumers were asked to rate how much they agreed or disagreed that fresh apples/apple juice are healthy with semantic differential (1 is strongly disagree and 7 is strongly agree). Another question using the same format asks about apples from a tree that was genetically modified and juice from apples from a tree that was genetically modified.

Consumers' knowledge of biotech food was measured using both subjective and objective methods. Subjective knowledge was measured by respondents' self-reported

knowledge about issues related to biotechnology in food production using a 9-point scale (1 is not at all knowledgeable and 9 is extremely knowledgeable). Consumers' objective knowledge was measured using ten true/false questions. The appendix includes specific questions and correctly answered percentages for each question.

To measure a respondent's perceived risk and moral concerns toward biotechnology, participants were asked to indicate their level of agreement with ten statements (see appendix). Four statements measured attitudes of biotech benefits, while the rest of the statements expressed to measure perceived risk about uncertain effects and moral concerns. To reduce the number of variables in a regression analysis, factor analysis was performed for the statements. Participants were also asked their opinion regarding the acceptability of varying reasons biotechnology is used in agricultural production using a scale 1 to 7 (1 is strongly disagree and 7 is strongly agree): to reduce pesticides, to prolong shelf-life of food, to improve farmers' profits, to alleviate world poverty, and to protect plants from a specific disease that threatens future production of that plant.

As indicators of respondents' lifestyle related to biotechnology, we asked respondents to indicate their purchase behaviors for organic food and their levels of religious involvement. We expected that individuals who always purchase organic food or who are involved religion may be sensitive to biotechnology. In addition, this study included respondents' socio-economic characteristics of age, gender, income, education and presence of children.

Information treatment

Survey participants were provided with explanations of different benefits of biotech production, including benefits for consumers by improving food quality, for the environment by reducing the usage of pesticide, and for producers to maintain production when faced with a disease that threatens production. Consumers were randomly assigned to one of four

experimental groups, including one group that was not given any information (control group). The specific information is as follow:

> Fresher foods*: In the case of biotechnology, the apple has a special protein, which increases the shelf life of the apple. Because of this method, the apple will stay fresher longer and it is less likely to have bruises (soft brown spots).*
> Protection of the environment*: In the case of biotechnology, the apple has a special protein, which makes it resistant to certain insects. This allows the farmer to use less pesticide when producing the apple. Reducing the use of pesticides is good for the environment.*
> Disease control*: There is currently an insect that transmits a disease in apples. This disease causes the apple tree to produce less, or in extreme cases, die. In the case of biotechnology, the apple has a special protein, which makes it resistant to this insect. This will allow apple farmers to stay in business, and keep apple prices from increasing over time.*

Respondents were asked to answer a question in order to confirm whether respondents carefully read the information or not after reading the information. Respondents who correctly answered the question were only included in this study. Approximately 90% of respondents provided correct answers.

Research Methodology

Factor analysis

Factor analysis was conducted to narrow down the number of variables regarding to consumers' perceived risk and moral concerns toward biotechnology. An exploratory factor analysis was applied to ten statements measured with a five-point Likert scale. The data proved suitable for factor analysis, with Kaiser's measure of sampling adequacy reaching 0.85. A principle component analysis (PCA) was used to extract the number of factors and then Varimax rotation was applied. Three factors were derived by the Eigenvalues larger than 1 criterion.

Consumer segmentation

Focused on participants who initially indicated health perceptions of fresh apples and apple juice, the study segmented markets by the genetically engineered (GE) tolerant group and GE sensitive group using cluster analysis. Even though recent consumer segmentation studies

divided more than two categorical GM consumers (Barker and Burnham, 2001; Gaskell et al., 2004; Zhang et al., 2010), this study used two segmentations based on the clustering method. Cluster analysis is a statistical technique used to classify sets of observation into relatively homogenous groups. Using cluster analysis, market segments were developed based on the respondents' changed perceptions on how healthy apples or apple juice where once they were told apples and juice were from trees that were genetically modified. In the first procedure, Ward's minimum variance model was conducted to determine the number of clusters. From a tree diagram, two clusters were found in both the fresh apple and apple juice models. Accordingly, K-means cluster procedures were applied by taking the cluster seeds generated from the Ward's method. This method attempts to minimize the sum of squares of any two clusters that can be formed at each step.

Socioeconomic (age, education, race, gender, income, and education) and psychographic variables (lifestyles, personality characteristics, and social class) are two of the most common bases for market segmentation. In order to better understand and profile the two clusters, ANOVA tests were used to relate the mean values of the two clusters. The ANOVA tests were also conducted for country comparisons and product comparisons. The Tukey test was used for multiple comparisons. In addition, the binomial probit model was used to better understand consumers' characteristics and attitudes influencing the different perception changes between the two clusters.

Results

Health Perceptions of fresh apples and apple juice

Consumer health perceptions across multiple countries for fresh apples and apple juice are shown in Table 1. Overall, average total scores for fresh apples and apple juice are 5.6 and 5.2 (7 is the highest point), respectively. This is significantly different at the 5% level, indicating

that consumers perceived fresh apples as healthier than apple juice. Looking at individual countries, the average scores in France and Spain between fresh apples and apple juice were not statistically different. An F-test was conducted to test equal average scores across countries. All average scores across all countries significantly differed at the 5% level for fresh apples and apple juice with/without the information that the tree was genetically modified. Consumers in Spain perceived fresh apples and apple juice as the healthiest, followed by consumers in the United States.

Overall, 82% and 71% of participants, respectively, perceived fresh apples and apple juice as being healthy. However, the rating for fresh apples and apple juice made using apples from a tree that was genetically modified considerably decreased, down to 32% for both products. A t-test was conducted to test if the decrease in perception was significantly different for apples and juice from GM trees. The result showed that respondents' perception for fresh apples was significantly decreased compared to apple juice at 1% level indicating that the fact the apples and juice were from GM trees differently influenced respondents' perception depending on the level of product transformation. As expected, there was a stronger impact on fresh apples.

Comparing across countries, pair-wise comparisons indicate that Spain and the U.S. have homogenous groups for rating fresh apples and apple juice from GM trees, from which, the proportion of respondents who maintained a healthy perception was relatively high at approximately 49% for fresh apples and 45% for apple juice. In France, Germany and Japan, respondents (52% for fresh apples and 43% for apple juice) switched their initial healthy perception to unhealthy or neutral when the tree was genetically modified. However, the difference of average ratings between fresh apples and apple juice from GM trees was not significant.

For the rest of the study, we focus on the consumers who initially had healthy perceptions of fresh apples and/or apple juice and investigate in-depth what characteristics are different and what information may prevent respondents from experiencing a change to their initial perception.

Table 1. Healthy perceptions of fresh apples and apple juice by country

		Fresh apple								Apple juice							
		NO GE				GE APPLE TREE				NO GE				GE APPLE TREE			
	N	Unhealthy 1-3	Neutral 4	Healthy 5-7	Ave. score	Unhealthy 1-3	Neutral 4	Healthy 5-7	Ave. score	Unhealthy 1-3	Neutral 4	Healthy 5-7	Ave. score	Unhealthy 1-3	Neutral 4	Healthy 5-7	Ave. score
		%				%				%				%			
BE	167	6.0	10.8	83.2	5.5 $^{a}{}_{H}$	38.9	29.3	31.7	3.9 ^{a}	11.4	20.4	68.3	5.1 $^{a}{}_{I}$	40.1	29.9	29.9	3.7 ^{a}
FR	194	9.8	11.9	78.4	5.4 $^{a}{}_{H}$	49.5	27.8	22.7	3.3 ^{a}	11.3	17.0	71.6	5.2 $^{a}{}_{H}$	49.0	26.3	24.7	3.3 ^{a}
DE	180	8.3	26.7	65.0	5.3 $^{a}{}_{H}$	47.8	31.1	21.1	3.3 ^{a}	11.7	31.7	56.7	4.9 $^{a}{}_{I}$	50.0	30.6	19.5	3.3 ^{a}
JP	332	6.3	16.6	77.1	5.3 $^{a}{}_{H}$	35.8	43.7	20.5	3.8 ^{a}	5.1	27.4	67.5	5.0 $^{a}{}_{I}$	36.7	41.0	22.3	3.8 ^{a}
ES	182	3.3	7.7	89.0	5.9 $^{b}{}_{H}$	22.5	26.9	50.6	4.5 ^{b}	5.5	8.2	86.3	5.8 $^{b}{}_{H}$	24.2	27.5	48.4	4.4 ^{b}
US	376	2.1	6.4	91.5	5.9 $^{b}{}_{H}$	25.0	27.7	47.3	4.3 ^{b}	9.6	16.0	74.5	5.2 $^{a}{}_{I}$	27.4	30.1	42.6	4.2 ^{b}
Total	1431	5.5	12.7	81.8	5.6 $^{**}{}_{H}$	35.0	31.9	33.1	3.9 **	8.7	20.3	71.0	5.2 $^{**}{}_{I}$	36.4	31.8	31.8	3.8 **

a and b different superscripts in the same column indicate significant differences among countries at $p<0.05$.
H and I different subscripts in the same raw indicate significant differences between fresh apples and apple juice at $p<0.05$.
** indicates that average score differences across countries are significant at the 0.05 level.

Cross country comparisons

Average perceptions and respondents' characteristics for respondents who initially indicated a healthy perception of fresh apples and/or apple juice are shown in Table 2. ANOVA tests were conducted to test equal means across countries and the Tukey test was used for multiple comparisons. As expected, average scores of perception are slightly higher than total sample averages due to the elimination of respondents who rated fresh apples and/or apple juice as neutral and unhealthy.

Socio-economic characteristics varied across countries except for gender distribution. Average ages of respondents were between 35 and 54 years old. Respondents from the U. S. and Belgium were slightly older. Respondents in France and Spain were more likely to indicate that they graduated from a university. Respondents in Japan showed the highest average household

income among countries, while respondents in France and Spain indicated the lowest average household income level. Although we measured household income based on the U.S. dollar (directly converting using the exchange rate), it is difficult to compare between countries as this does not account for differences in purchasing power. Respondents in the U.S. indicated relatively low rates of children present in their households compared to respondents from other countries.

Respondents self-reported knowledge levels regarding biotechnology issues varied over countries. Respondents in Germany, Japan and Spain indicated relatively high subjective knowledge levels compared to France, Belgium and the United States. With regards to objective knowledge, respondents in Japan obtained the highest average score followed by respondents in Germany. That is, Japanese consumers correctly answered over six out of ten questions regarding biotechnology issues, while respondents in the U.S. obtained the lowest average scores for the quiz (5.1 correct on average).

Purchases of organic foods and involvement in religion were included to capture attitudes that might correlate with opinions related to biotechnology. Respondents in Germany purchased organic food most frequently, with 25% indicating they always purchase organics. This was followed by France (9.5%), Japan (8.2%) and the U.S. (6.3%). Approximately 50% of U.S. respondents indicated that they were strongly or somewhat involved in religion, followed by Spain (25.3%), Germany (20.5%), France (18.4%), Belgium (15.3%) and Japan (5.4%).

Perceived risk and moral concerns were measured using ten statements (appendix). The statements measuring moral concerns indicated that respondents in Germany, Japan and France were inclined to have a greater degree of concern compared to respondents from the U.S., Spain and Belgium. This is somewhat interesting in that higher proportions of respondents in the U.S.

and Spain felt closely associated with religion, but this did not translate to moral concerns for biotechnology. The four statements measuring perceived risk indicated that respondents in Spain and the U.S. perceived relatively low risk, while respondents in Germany and France perceived relatively high risk in biotechnology. Generally, respondents in Spain and the U.S. showed optimistic attitudes of biotech benefits, while respondents in Germany and France were cynical.

Table 2. Comparison of descriptive statistics for respondents initially presented health perception

		Belgium	France	Germany	Japan	Spain	U.S	F-value
Average ratings	Apples	5.9^{b}	5.9^{b}	6.1^{b}	5.6^{a}	6.1^{b}	6.1^{b}	14.9^{**}
	Apples from GM tree	4.1^{cd}	3.6^{b}	3.4^{b}	3.8^{bd}	4.6^{a}	4.4^{ac}	16.6^{**}
	Apple juice	5.4^{bc}	5.7^{ab}	5.6^{bc}	5.3^{c}	6.0^{a}	5.4^{bc}	10.3^{**}
	Apple juice from GM tree	3.9^{bc}	3.6^{cd}	3.3^{d}	3.8^{c}	4.6^{a}	4.2^{ab}	13.7^{**}
Demographics	Age	4.4^{ab}	4.3^{ab}	4.1^{b}	4.3^{b}	4.1^{b}	4.6^{a}	5.2^{**}
	Male	0.5^{a}	0.5^{a}	0.5^{a}	0.5^{a}	0.5^{a}	0.5^{b}	0.3
	Education	3.8^{a}	4.0^{a}	3.5^{b}	3.7^{b}	4.1^{a}	3.6^{b}	10.7^{**}
	Income	8.5^{d}	7.6^{c}	9.5^{a}	11.3^{b}	7.8^{cd}	9.5^{a}	83.8^{**}
	Presence of children	0.5^{a}	0.5^{a}	0.5^{a}	0.5^{a}	0.6^{a}	0.4^{b}	5.7^{**}
Lifestyle	Organic purchasers	0.0^{a}	0.1^{a}	0.3^{b}	0.1^{a}	0.0^{a}	0.1^{b}	11.4^{**}
	Involved in religion	0.2^{ab}	0.2^{b}	0.2^{b}	0.1^{a}	0.3^{b}	0.5^{c}	41.7^{**}
Knowledge	Subjective knowledge	3.9^{d}	4.1^{cd}	5.5^{a}	4.7^{b}	4.7^{bc}	4.1^{cd}	12.4^{**}
	Objective knowledge	60^{ac}	58^{ac}	59^{ac}	65^{a}	56^{bc}	51^{b}	11.2^{**}
GE attitudes	Man has no right	3.7^{b}	3.8^{a}	4.0^{a}	3.9^{a}	3.3^{b}	3.2^{b}	20.7^{**}
	No increase food supply	2.9^{ab}	3.0^{a}	3.5^{c}	2.8^{ab}	2.6^{b}	2.7^{b}	13.6^{**}
	BEN to developing world	3.2^{b}	3.0^{b}	2.9^{b}	3.1^{b}	3.5^{a}	3.5^{a}	10.2^{**}
	Only benefit large firm	3.7^{cd}	4.0^{de}	4.2^{e}	3.3^{ab}	3.6^{bc}	3.1^{a}	29.8^{**}
	Help human health	2.9^{bd}	2.6^{cd}	2.5^{c}	3.0^{b}	3.3^{a}	3.0^{b}	13.2^{**}
	Reduce production cost	3.2^{b}	3.3^{b}	3.0^{b}	3.2^{b}	3.7^{a}	3.3^{b}	7.6^{**}
	Super-weeds	3.5^{bc}	3.8^{ab}	4.0^{a}	3.6^{b}	3.3^{c}	3.4^{c}	12.6^{**}
	Right to alter	2.3^{cd}	2.1^{c}	2.3^{cd}	2.5^{bd}	2.7^{ab}	2.8^{a}	11.8^{**}
	Concern long term effect	4.0^{ab}	4.2^{ab}	4.3^{a}	4.0^{b}	4.0^{ab}	4.1^{ab}	2.6^{**}
	Little danger	2.6^{ab}	2.3^{b}	2.4^{b}	2.5^{b}	2.9^{a}	2.7^{a}	8.0^{**}
Reasons to use GE	Reduce pesticide	5.5^{ab}	5.0^{d}	4.3^{c}	5.0^{d}	5.6^{a}	5.2^{bd}	13.6^{**}
	Increase food supply	5.0^{ad}	4.6^{cd}	4.2^{c}	5.2^{ab}	5.5^{a}	5.0^{bd}	11.4^{**}
	Improve farm profit	4.2^{b}	3.6^{c}	3.4^{c}	4.2^{b}	4.9^{a}	4.5^{b}	17.5^{**}
	Cure disease	5.3^{ab}	4.9^{b}	4.2^{c}	4.9^{b}	5.6^{a}	4.9^{b}	12.0^{**}
	Shelf-life of food	4.3^{bc}	4.0^{cd}	3.5^{ad}	3.9^{cd}	3.2^{a}	4.5^{b}	14.8^{**}

a, b, c, d and e different superscripts in the same row indicate significant differences among countries at $p<0.05$.
** indicates that average score differences across countries are significant at the 0.05 level.

Consumers' attitudes toward using biotechnology in agricultural production were measured based on five different statements. Respondents in six countries all gave the highest score for reducing the use of pesticides in food production followed by protecting plants from a

specific disease that threatens future production of that plant and to contribute to the alleviation of poverty and hunger by increasing the food supply world-wide. In particular, respondents in Spain and Belgium showed relatively higher emphasis on the value reducing pesticides. In other words, most international consumers seemed to prefer biotechnology if it contributes to environmental and food security compared to more consumer related reasons.

Factor analysis for biotechnology attitudes

A factor analysis was used for the ten statements asking about respondents' attitudes toward biotechnology to identify a relatively small number of factors that can be used in further analysis. Kaiser-Meyer-Olkin (KMO)'s measure of sampling adequacy was used to identify the appropriateness of the factor analysis for the ten statements. The overall KMO was 0.85 which is a strong result or a sampling adequacy measurement.

Principal component analysis was used to identify the number of factors by applying a Varimax rotation. Using the criteria above 1 eigenvalue, three factors were derived which explained 63% of the total variance. The rotated factor loadings of the ten statements are presented in Table 3. Since factor loadings express the correlation between the original statements and the derived three factors, a higher loading indicates a higher correlation to the factors. The first factor is named "Optimism" because statements with high loadings in the first factor addressed bright benefit of biotechnology to the developing world, human health, and farmers. Also, the optimistic factor covers low perceived risk and moral concerns. Since statements in the second factor express high perceived risk and moral concerns for using biotechnology, the second factor is named "Skeptic". The last factor is named "Cynic" as the statement relates consumer cynicism about the potential contribution of biotechnology in increasing food supply.

Table 3. Rotated factor loadings about biotechnology attitudes for three factors

	Factor1:	Factor2:	Factor3:
Biotechnology will lead to a reduction in farmers' production costs.	**0.69**	0.05	-0.16
People in the developing world will benefit from biotechnology.	**0.68**	-0.14	-0.30
Biotechnology will help promote human health.	**0.66**	-0.33	-0.13
There is little danger that biotechnology will result in new diseases.	**0.57**	-0.41	0.12
Man has every right to alter plants and animals genetically for economic reasons.	**0.57**	-0.41	-0.01
I am concerned about the lack of knowledge of long-term effects of biotechnology on human health.	-0.07	**0.71**	0.05
The release of genetically modified organisms into the environment will result in	-0.22	**0.63**	0.19
Man has no right to "play God" with nature.	-0.23	**0.50**	0.25
Only large multinational corporations will benefit from the biotechnology revolution.	-0.10	**0.40**	0.32
The world's food supply will not be increased through the use of biotechnology.	-0.14	0.19	**0.75**

Consumer segmentations

To identify consumer segments based on respondents changed health perceptions of fresh apples and apple juice, a two-step cluster approach (Ward's method and K-means cluster analysis) was conducted. Two clusters were identified and the number of cases in each cluster by country is shown in Table 4. The first cluster was named GE tolerant. These respondents maintained their health perceptions or slightly changed their health perceptions to neutral when informed that the apple trees were genetically modified. On average, 58% of total respondents were segmented into this cluster. The second cluster was named GE sensitive. In this cluster, respondents changed their health perception to unhealthy or neutral when informed that the apple trees were genetically modified. On average, 42% of total respondents were segmented into a GE sensitive cluster. A relatively high portion of respondents in Spain and the U.S. were assigned into a GE tolerant cluster.

Table 4. Percentage of cases in each cluster

Products	Cluster names	Belgium	France	Germany	Japan	Spain	U.S	Total
					Percentages (%)			
Fresh apples	GE tolerant	55	48	42	48	75	68	58
	GE sensitive	45	52	58	52	25	32	42
Apple juice	GE tolerant	61	50	39	43	74	66	57
	GE sensitive	39	50	61	57	26	34	43

Respondents' characteristics and attitudes toward biotechnology were compared by cluster as shown in Table 5. As expected, respondents in the GE sensitive cluster rated significantly lower for health perceptions of fresh apples and apple juice regardless of presenting the information about GE treatments to the apple trees, but the gap is larger with the information. Gender and education characteristics were significantly different between clusters. Male and higher educated respondents were more frequently part of the GE tolerant cluster. Respondents' purchasing behaviors with regard to organic food and religious involvement were not significantly different between clusters. Objective knowledge was significantly different between clusters for both fresh apples and apple juice: respondents in the GE tolerant cluster were more knowledgeable. Subjective knowledge was only significantly different between clusters in apple juice.

Respondents in the GE tolerant cluster have positive scores in the optimism factor and negative scores in factors skeptic and cynic. This indicated that respondents in the GE tolerant cluster were aware of the benefits of biotechnology in reducing farmers' production costs, their benefit to people in the developing world, and in promoting human health. On the other hand, respondents in the GE sensitive cluster have opposite signs of the factors. That is, respondents in the GE sensitive cluster were worried about the uncertain effects of biotechnology on human health and the environment, as well as pessimistic of the potential for biotechnology to increase food supply. Not surprisingly, respondents in the GE tolerant cluster showed higher average scores than the GE sensitive cluster for the statements asking about attitudes toward reasons to use biotechnology in agricultural productions.

Table 5. Variable descriptions by cluster

		Fresh apples			Apple juice		
		GE tolerant	GE sensitive	F-value	GE tolerant	GE sensitive	F-value
Average ratings	Apples	6.2	5.8	95.8**	6.2	5.8	49.8**
	Apples from GM tree	5.2	2.6	1744.2**	5.2	2.8	1218.6**
	Apple juice	5.8	5.2	71.4**	6.1	5.7	76.6**
	Apple juice from GM tree	5.0	2.6	1311.0**	5.3	2.7	1603.6**
Demographics	Age	4.3	4.3	0.1	4.3	4.4	0.3
	Male	0.5	0.4	13.6**	0.5	0.4	9.5**
	Education	3.8	3.7	4.8**	3.8	3.7	5.0**
	Income	9.3	9.3	0.2	9.2	9.3	0.7
	Presence of children	0.5	0.5	0.6	0.5	0.5	0.2
Lifestyle	Organic purchasers	0.1	0.1	1.6	0.1	0.1	0.4
	Involved in religion	0.3	0.2	1.0	0.3	0.2	0.9
Knowledge	Subjective knowledge	4.5	4.3	2.0	4.6	4.3	7.0**
	Objective knowledge	59.7	54.7	13.1**	60.3	56.1	8.2**
Attitudes	Optimism	0.3	-0.4	224.1**	0.3	-0.4	191.7**
	Skeptic	-0.2	0.3	116.3**	-0.2	0.3	104.1**
	Cynic	-0.1	0.1	20.5**	-0.1	0.1	17.5**
Reasons to use GE	Pesticide reduction	5.6	4.5	185.7**	5.6	4.5	173.0**
	Increase food supply	5.5	4.3	186.9**	5.6	4.4	162.0**
	Farm profit improvement	4.8	3.5	172.6**	4.8	3.5	158.9**
	Cure disease	5.5	4.4	171.6**	5.6	4.4	163.3**
	Prolong shelf-life of food	4.5	3.3	141.5**	4.6	3.3	141.5**

** indicates that average score differences across clusters are significant at the 0.05 level.

Results of binomial probit models

In order to examine the relationship between consumer perception changes for biotech food and consumer socioeconomics and attitudes discussed earlier, a binomial probit model was estimated based on the market segmentation. The estimated results were shown in Table 6. The dependent variables is a dummy variable representing cluster membership: 1 is the GE tolerant cluster and 0 is the GE sensitive cluster. The summary statistics indicate both models (apple and apple juice) provide a good fit from the likelihood ratio (LR) test prediction percent (over 75%).

The sign of estimated covariates is similar for both fresh apples and apple juice models, with few exceptions. However, estimated covariates with different signs between the two models were not significant, indicating some consistency of opinions between factors influencing response to biotechnology for apples and apple juice. The probability of GE tolerance significantly increases if respondents' have high objective knowledge, if their reasons for

supporting biotechnology are to improve the shelf-life of food and increase food supply, and if they are aware of biotechnology benefits and worry less about biotechnology. Similar to House et al (2004) and in contrast to Zhang et al (2010), consumers who were more aware of biotechnology were more likely to be tolerant of biotech food. Self-rated knowledge did not significantly influence the likelihood of GE tolerance. Also, consumers who tended to believe that usage of biotechnology prolongs the shelf-life of food and contributes to the alleviation of poverty and hunger by increasing the food supply world-wide were consequently more likely to be tolerant of biotech food. As expected, these optimistic attitudes increased the likelihood of GE tolerance, while skeptical attitudes decreased the likelihood of GE tolerance. However, the absolute value of the marginal effect indicates that the magnitude of the two attitude variables influence on the probability is different for both models. The probability of GE tolerance in the fresh apple model was greatly influenced by optimism, while the apple juice model was largely affected by skepticism. Interestingly, no socioeconomic or life-style variables significantly influenced the probability of GE tolerance, which is similar to the results of Barker and Burnham (2001).

The probability of GE tolerance increased in the fresh apple model when respondents agreed that biotechnology should be used to protect plants from a specific disease that threatens future production of that plant, while this variable did not significantly influence the probability of GE tolerance in the apple juice model. The probability of GE tolerance was not significantly different between respondents who did not have any of three information treatments (control group) and respondents who had one of the three information treatments in the fresh apple model. However, the probability of GE tolerance increased as respondents were given the information about disease control in the apple juice model.

Nationality influences the probability of GE tolerance. The differences are larger in the fresh apple model than in the apple juice model. In the fresh apple model, respondents in Japan, France, Germany and Belgium were significantly less likely to be GE tolerant compared to respondents in the U.S., while, in the apple juice model, only respondents in Japan and Germany were significantly less likely to be GE tolerant compared to respondents in the U.S. A Wald test was conducted to test cross country comparisons. Within the European countries, respondents in Spain were relatively likely to be GE tolerant and their attitudes toward biotechnology were closer to U.S. respondents. Respondents in Japan showed the highest GE sensitivity among the six countries followed by France and Germany which were the most GE sensitive among the EU countries. The results from European consumers reinforce the findings of Gaskell et al (2006).

The marginal effects indicated that respondents' residence was relatively important to the probability of respondent GE tolerance; the absolute value of marginal effect over countries ranged from 0.16 to 0.32 for both fresh apples and apple juice. This implied that overseas respondents would be less likely to be GE tolerant than respondents in the U.S. by 16% to 32%. Improvement of shelf-life of food influenced the likelihood of GE tolerance approximately four times more than the reason of using biotechnology to improve farm profit. Respondents with objective knowledge scores of 60 were 4% more likely to be tolerant of biotech food than respondents with scores 50. For the apple juice model, respondents who read positive information about biotechnology contributing to disease control were 11% more likely to be tolerant of apple juice made by apples produced from GE treated apple trees than respondents who were not given any information.

Table 6. Estimated results of binomial probit model

		Fresh apples			Apple Juice		
	Variables	Estimate	Std. Err	Marg. Fx.	Estimate	Std. Err	Marg. Fx
	Intercept	-1.680**	0.410	–	-1.916**	0.441	–
Demographics	Age	-0.031	0.038	-0.012	-0.062	0.041	-0.024
	Male	0.161	0.092	0.062	0.075	0.098	0.029
	Education	0.028	0.051	0.011	0.005	0.054	0.002
	Income	0.002	0.021	0.001	0.029	0.022	0.011
	Presence of children	0.132	0.091	0.051	-0.074	0.099	-0.029
Lifestyle	Organic purchasers	0.167	0.170	0.063	0.068	0.193	0.026
	Involved religion	-0.123	0.113	-0.048	-0.133	0.121	-0.052
Knowledge	Subjective	-0.039	0.024	-0.015	0.018	0.026	0.007
	Objective	0.010**	0.002	0.004**	0.008**	0.002	0.003**
Reasons for	Reduce pesticide	0.064	0.045	0.025	0.069	0.049	0.027
biotechnology	Shelf-life of food	0.083**	0.034	0.032**	0.095**	0.037	0.037**
	Improve farm profit	0.024	0.037	0.009	0.033	0.039	0.013
	Cure disease	0.083**	0.040	0.032**	0.076	0.044	0.030
	Increase food supply	0.107**	0.038	0.041**	0.091**	0.042	0.036**
Attitude toward	Optimism	0.388**	0.070	0.150**	0.354**	0.074	0.138**
biotechnology	Skeptic	-0.369**	0.062	-0.142**	-0.407**	0.065	-0.159**
	Cynic	-0.051	0.063	-0.020	-0.073	0.069	-0.028
Country	Japan	-0.785**	0.140	-0.305**	-0.820**	0.154	-0.318**
	France	-0.470**	0.162	-0.185**	-0.186	0.170	-0.074
	Spain	-0.038	0.167	-0.015	0.186	0.175	0.071
	Germany	-0.393**	0.180	-0.155**	-0.435**	0.201	-0.172**
	Belgium	-0.530**	0.160	-0.209**	-0.084	0.176	-0.033
Information	Fresher food	0.053	0.123	0.020	0.141	0.134	0.054
treatment	Disease control	0.179	0.123	0.068	0.281**	0.132	0.107**
	Environmental protection	0.071	0.120	0.027	0.029	0.128	0.011
N			1,115			969	
LR test			415.95**			374.90**	
Pseudo R^2			0.274			0.282	
% of correct			75.5			75.7	

** indicates that coefficients are statistically different at the 0.05 level.

Discussions and Conclusions

This study focused on investigating how respondents' perceptions of biotechnology treatment on food production differs depending on the level of product transformation (i.e. fresh versus processed food). Using cluster analysis, respondents were clustered into two groups, GE tolerant and GE sensitive, based on changes in their perceptions about fresh apples and apple juice with and without biotechnology treatments on the source apple tree. Cross-cultural comparisons over six countries were performed to measure relative attitudes about biotech food. In addition, three types of positive information about biotechnology were tested in order to determine what types of information influence respondents GE tolerance.

Prior to information on biotechnology, respondents showed significantly different perceptions of fresh apples and apple juice; fresh apples were perceived as healthier than apple juice. Approximately half of respondents' initial perceptions of fresh apples and apple juice did not change, but 54% (apples) and 48% (apple juice) decreased their opinion when the apple trees were treated with biotechnology, indicating that biotechnology still negatively impacts consumers' food perceptions in many cases (only in 2% did perception increase). In particular, the perception of how healthy apples were was more strongly impacted than apple juice.

Respondents who initially perceived fresh apples or apple juice as healthy were clustered into two groups, GE tolerant and GE sensitive, based on perception changes. From the results of the probit analysis, socioeconomic and life style variables were not significant in explaining the segment to which a respondent belonged. Residency was a strong indicator of which segment consumers belonged to. Residents of European countries were generally more sensitive than residents of the U.S., which was a result similar to Lusk (2004). However, residents of Spain were analogous in attitude to residents of the U.S., which may reflect that Spain is the biggest adopter of genetically modified Maize in the EU (Gómez-Barbero, Berbel, and Rodríguez-Cerezo, 2008). Residents of Japan indicated the strongest sensitivity to GE treatment with Germany trailing far behind. Respondents' objective knowledge was significant in explaining the segment to which a consumer belonged but subjective knowledge was not. This result was supported by the published finding that increased objective knowledge could increase biotech food acceptance (House et al, 2004). We also found that respondents' optimistic and skeptical attitudes toward biotechnology were significant indicators of segment in both the fresh apple and apple juice models. Considering the close relationship between inclination toward biotechnology

and residency, the findings broadly support that the segmentation is subject to the influence of respondents' surrounding environment rather than individuals' socio-demographic characteristics.

The cluster to which a respondent belonged was affected differently by respondents' reactions to new information about benefits to the disease control and agreement that plants should be protected from disease. Even though the statements were not exactly same, both statements supported the idea that biotechnology contributes to maintaining agricultural production by protecting plants from a disease. Individuals' self-agreement was not significant in predicting the segment for apple juice but it was significant for fresh apples. New information on disease control significantly increased the level of respondent segmentation for GE tolerance of apple juice made by apples from GE treated apple trees. However, no positive benefits of biotechnology explained the segmentation for fresh apples. That is, respondents' perceptions were relatively inflexible about fresh apples from GE treated apple trees, even when presented with new information, while their personal agreement was significant. Overall, these results suggest that consumer attitudes toward biotech food can be changed by positive information, but the effect of information may vary depending on the type of product.

The results confirm the industry's concerns that introducing biotechnology to solve a specific disease may lead to perception changes. However, the results suggest that advertising efforts by agribusiness to enlighten consumers about biotechnology's importance to production will alleviate strong resistance. Since the residency effect was strong and heterogeneous across countries, different marketing approaches may be required for success in each market. Our findings also suggest that introducing biotechnology for processed products will have relatively less impact than on fresh products.

One limitation of this study is that the dependent variable is based on a rating of how healthy a person believes a product to be. Future research that explores the impact of these changes in perception on willingness to pay for products, again examining the difference based on both level of product transformation and country of residence, would be of interest as well.

References

Barker, B. and Burnham, T.A. (2001) "Consumer response to genetically modified foods: market segment analysis and implications for producers and policy makers*" Journal of Agricultural and Resource Economics* 26(2):387-403.

Bureau of Labor Statistics (2008). U.S. Department of Commerce Industry Report: Food Manufacturing NAICS 311. Bureau of Labor Statistics, Washington, DC. Available at: http://trade.gov/td/ocg/report08_processedfoods.pdf. Accessed on: January 23, 2013

Gaskell, G., A. Allansdottir, et al. (2006). Europeans and Biotechnology in 2005: Patterns and Trends, Eurobarometer 64.3.

Gaskell, G., N. Allum, et al. (2004). "GM foods and the misperception of risk perception." *Risk Analysis* 24(1): 185-194.

Gaskell, G., M.W. Bauer, J. Durant, and N.C. Allum (1999). "Worlds apart? The reception of genetically modified foods in Europe and the U.S." *Science* 285: 384-387.

Gómez-Barbero, M., J. Berbel, and E. Rodríguez-Cerezo. (2008). "Bt corn in Spain- the performance of the EU's first GM crop", Correspondence, *Nature Biotechnology* 26: 384-386.

James, C. (2011). Global status of commercialized biotech/GM crops: 2011, International Service for the Acquisition of Agri-biotech Applications (ISAAA) Brief No. 43. ISAAA: Ithaca, NY. Available at: http://www.isaaa.org/resources/publications/briefs/43/. Accessed on: January 23, 2013.

House, L., Lusk, J., Jaeger, S., Traill, W.B., Moore, M., Valli, C., Morrow, B., and Yee, W.M.S. (2004). Objective and subjective knowledge: Impacts on consumer demand for genetically modified foods in the United States and the European Union. *AgBioForum*, 7(3): 113-123.

Kipe, S. (2006). The world fresh fruit market. Foreign Agricultural Service, USDA, Washington DC. Available at: http://www.fas.usda.gov/htp/hort_circular/2006/02-06/world%20fresh%20fruit%20market%202004.pdf. Accessed on: January 23, 2013. http://www.nytimes.com/imagepages/2010/04/04/business/04metrics_g.html?ref=business

Lusk, J. L., L.O. House, C. Valli, S.R. Jaeger, M. Moore, B. Morrow, and W.B. Traill (2004). "Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: Evidence from experimental auctions in United States, England, and France." *European Review of Agricultural Economics* 31: 179-204.

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

Lusk, J. L., W. B. Traill, et al. (2006). "Comparative advantage in demand: experimental evidence of preferences for genetically modified food in the United States and European Union." *Journal of Agricultural Economics* 57: 1-21.

McCluskey, J. J., K. M. Grimsrud, et al. (2003). "Consumer response to genetically modified food products in Japan." *Agricultural and Resource Economics Review* 32(2): 222-231.

Rousu, M. C., and Lusk, J.L (2009). "Valuing information on GM foods in a WTA market: What information is most valuable?" *AgBioForum* 12(2).

Rousu, M. C., Wallace E. Huffman, Jason F. Shogren, and Abebayehu Tegene (2007). "Effects and value of verifiable information in a controversial market: Evidence from lab auctions of genetically modified food." *Economic Inquiry* 45: 409-432.

Zhang, X., Huang, J., Qiu, H. and Huang, Z. (2010) “A consumer segmentation study with regards to genetically modified food in urban China” *Food Policy* 35:456-462

Appendix. Variable descriptions

Variables	Descriptions/Categories
Demographics	
Age	1 if 18 to 19; 2 if 20 to 24; 3 if 25 to 34; 4 if 35 to 44; 5 if 45 to 54; 6 if 55 to 64; 7 if 65 years and over
Male	1 if male; 0 if female
Education	1 if primary school; 2 if secondary/high school; 3 if technical or associate or equivalent; 4 if university graduate; 5 if Post university/Masters, Ph.D.
Income	1 if less than $10k; 2 if $10k - 14,999; 3 if $15k- 19,999; 4 if $20k - 24,999; 5 if $25k - 29,999; 6 if $30k - 34,999; 7 if $35k - 39,999; 8 if $40k- 49,999; 9 if $50k-59,999; 10 of $60k-74,999; 11 if $75k-99,999; 12 if $100k-149,999; 13 if $150k - 199,999; 14 if $200k or over
Presence of children	1 if a household has children under the age 18; 0 otherwise
Lifestyle	
Organic purchasers	1 if individual always purchase organic food; 0 otherwise
Involved in religion	1 if individual is very or somewhat involved with his/her religion; 0 otherwise
Subjective knowledge:	
How knowledgeable would you say you are about the facts and issues related to biotechnology in food production?	9 point scale (1 if not at all knowledgeable and 9 if extremely knowledgeable)
Objective knowledge	Scores correctly answered (0 to 100%)
• By eating a genetically modified fruit, a person's genes could also become modified. (61.4% correct)	
• It is impossible to transfer animal genes into plants. (29.6% correct)	
• Genetically modified plants or animals are always bigger than ordinary ones. (49.2% correct)	
• Foods containing genetically modified ingredients are more likely to cause allergic reactions than foods which do not include genetically modified ingredients. (26.3% correct)	
• Foods containing genetically modified ingredients are required by law to be labeled in our country. (61.2% correct)	
• Yeast used to make beer contains living organisms. (79.7% correct)	
• All bacteria found in food is harmful.(83.9% correct)	
• We eat DNA every day. (64.1% correct)	
• To be healthy, food should be sterile before it is eaten. (56.9% correct)	
• Ordinary fruit does not contain genes but genetically modified fruit does. (53.0% correct)	
Measuring biotechnology attitude	5 point scale (1 if SD and 5 if SA)
• Man has no right to "play God" with nature. (Moral concerns)	
• The world's food supply will not be increased through the use of biotechnology. (Benefit attitudes)	
• People in the developing world will benefit from biotechnology. (Benefit attitudes)	
• Only large multinational corporations will benefit from the biotechnology revolution. (Benefit attitudes)	
• Biotechnology will help promote human health. (Perceived risk)	
• Biotechnology will lead to a reduction in farmers' production costs. (Benefit attitudes)	
• The release of genetically modified organisms into the environment will result in dangerous mutations and "super-weeds" that cannot be killed by conventional herbicides. (Perceived risk and moral concerns)	
• Man has every right to alter plants and animals genetically for economic reasons. (Moral concerns)	
• I am concerned about the lack of knowledge of long-term effects of biotechnology on human health. (Perceived risk)	
• There is little danger that biotechnology will result in new diseases. (Perceived risk)	
Attitude for reasons of biotechnology	7 point scale (1 if SD and 7 if SA)
• To reduce the use of pesticides or herbicides in food production.	
• To contribute to the alleviation of poverty and hunger by increasing the food supply world-wide.	
• To help to improve the profitability of farmers.	
• If it was the only way to protect plants from a specific disease that threatens future production of that plant.	
• To prolong shelf-life of food.	
Measuring healthy perception	7 point scale (1 if SD and 7 if SA)
Apple/ Apple from GM tree/ Apple juice/ Apple juice from GM tree	

1) SD means strongly disagree and SA means strongly agree.