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Japanese Consumer Preference for 2nd Generation Genetically Modified (GM) Food Products

Renee B. Kim

School of Business, Hanyang University, Seoul 133-791, Korea

일본 소비자들의 제2세대 유전자 변형 식품에 대한 선호도에 관한 연구

김 보 영

한양대학교 경영학과

Abstract

최근 유전자 변형 기술에 의해 제조된 식품에 대한 소비자들의 관심과 주의가 높아지고 유전자 변형 식품 생산과 판매는 국내는 물론 국제통상과 식품산업에 막대한 영향을 끼치고 있다. 본 연구는 이런 산업내의 변화에 맞추어 유전자 변형 기술에 의해 제조된 빵에 대한 일본 소비자들의 지각과 행동적 특성을 제시하는데 있다. 차별화된 유전자 변형에의 창출된 이익에 대한 일본 소비자들의 반응과 선택을 **conjoint** 분석을 사용하여 실증적으로 분석하였다. 본 연구의 목적은 유전자 변형 기술에 의해 창출되는 다양한 종류의 이익으로 차별화된 **GM** 식품의 상품화의 실행 가능성을 평가하는데 있다. 연구 결과에 의하면 일본 소비자들은 유전자 변형에 의해 영양적 요소가 강화된 상품에 큰 관심을 보였고, 유전자 변형 식품이 주는 소비자 이익에 생산자 이익보다 높은 프리미엄을 지불할 의사가 있는 것으로 나타났다.

Key words : Japanese consumers' preference, GM food products, consumer choice behavior, conjoint analysis.

Introduction

This study employed stated preference method (SPM) to examine Japanese consumers' interest and willingness to pay premium for genetically modified (GM) wheat bread. Since the development of herbicide resistant (HR) spring wheat in early 2000s in Canada, there has been considerable interest in understanding the nature of consumer concerns about the safety of GM wheat and the implication of the consumer concern on market potential of GM food products.

HR wheat is genetically engineered in order to extend resistance to high doses of specific herbicides which are used in crop production to control weeds. The development of HR wheat could reduce crop loss from weeds, generate higher yields and reduce costs to agricultural producers from lower herbicide applications. Despite these evident benefits of GM wheat, substantial level of opposition has been voiced against commercialization of GM wheat due to the potential adverse reactions of customers and regulators in major importing markets such as Japan.

† **Corresponding author** : Renee B. Kim, Tel : +82-2-2220-2597, E-mail : Kimrby@gmail.com

Japan is a premium wheat import market, where the issues of food quality and safety are highly rated. Japan imports an annual average of 6.5 MMT of wheat in recent years, with only about 15 percent of the wheat consumption is supplied domestically. Consumer preferences in major import markets such as Japan are important as they play a considerable role in determining whether or not wheat exporting countries will produce GM wheat.

GM food is an innovative product which offers new untested opportunities, but may present potential unforeseen risks, causing consumers to have fear, uncertainty and doubt (Phillips and Corkindale, 2002). Therefore, some strategic marketing efforts need to be made by GM food marketers, if they are to successfully focus on this innovative product. This involves determining what the likely eventual total response to GM food is and what the important factors are, that may trigger early buyers and leaders in the consumer market to accept GM food. GM food is likely to be adopted more promptly by consumers who seek specific tangible benefits. Gaining trial and consumption of GM foods may need to be directly prompted by targeted marketing to those in search of a particular benefit (e.g. health, medical, nutrition benefits)

(Phillips and Corkindale, 2002).

Consumers have given different responses to GM products in abstract questions versus specific questions about products with defined attributes (Adelaja *et al* 1999). Currently available benefits of GM crops are designed for producers via enhanced input traits such as lower production cost due to higher yield, greater pest and herbicide resistance. These producer-benefiting GM organisms may not be sufficient to induce consumers to accept GM food, as consumers may perceive these benefits as intangible or producer-oriented. The "2nd generation" of GM food is claimed to bring possible enhanced output traits or tangible benefits valued by the consumers.

Consumer acceptance is likely to determine the future development of GM food, and determine the success or failure of products reaching the marketplace (Frewer *et al* 1995). There is extensive biotechnological research on varying forms of product quality that may lead to consumer benefits. These include enhanced protein quality, nutritional content, novel starch types (functionality), reduced allergens, and improved freshness, storability, and shelf life for baked products (Wilson *et al* 2003). Increased shelf life, improved taste, and greater nutritional value are potential consumer benefits that may improve acceptance (Mayer, 2002; Biane, 2001 and Wilson *et al* 2003). Application of biotechnology to develop "functional" foods that promote these health and wellness may present potential in the market place (Riley and Hoffman 1999, Adelaja and Schilling 1999, Pew Initiative 2001; Schilling *et al* 2004). However, consumer acceptance of these GM foods with consumer benefits is an empirical question to be explored.

In this study, we aim to elicit and compare Japanese consumers' interest and willingness to pay premium for GM wheat processed bread with specific consumer versus producer benefits (i.e. GM wheat processed food with medical or nutritional benefits versus GM wheat processed food with lower pesticide usage). Findings from this study address the question of what potential consumer attributes may be accepted by Japanese consumers.

We hypothesized in our SPM analysis that: (a) Japanese consumers'acceptance of GM wheat bread may be different for GM wheat bread with various benefits. In other words, Japanese consumers may be more receptive of GM foods that can directly benefit consumers. (b) Japanese consumers may be reluctant to accept GM foods that have intangible, producer oriented benefits. (c) Different type of GM consumer benefits may induce different degrees of acceptance by Japanese consumers.

To estimate Japanese consumers' willingness to pay premium for GM wheat processed bread that have alternative benefits, the stated preference method (SPM) was applied to collect the consumer data. The SPM is used to illustrate the relative trade-offs consumers are willing to make across wheat based food products. This methodology also allows us to examine the extent to which Japanese consumers are willing to pay premiums for alternative benefits from GMO technology.

One of the advantages of SPM is the ability to frame the issue at hand - in this case Japanese consumers' interest in various types of benefits provided by GMO technology. This method is likely to be more reliable than a conventional willingness to pay (WTP) type question, in which respondents are asked to state amount of premium or discount on GM foods within certain boundary (James and Burton 2001). The procedure used here is similar to the following studies which include: Unterschultz *et al* 1998, Quagrainie *et al* 1998, Louviere 1992, Adamowicz *et al* 1997, Kuperis *et al* 1999 and Heaner *et al* 2000. It has been applied extensively in empirical studies examining choices of travel, environmental amenities, and recreational facilities as well as in food marketing studies.

Methods

1. Survey Study and Data Collection

This study used a mail survey instrument that was administered in Japan during the fall of 2003. In total 202 individuals responded to the mail survey for a response rate of 27.5 percent. Japanese consumer perceptions, attitudes toward GM food, food consumption patterns and demographic data, were collected through a questionnaire based survey with 202 households in two major cities -Tokyo area (Fuchu city) and Osaka. The survey questionnaire was designed using input from qualitative interviews with Japan food industry representatives and food marketing academics prior to execution of the survey.

A convenience sample of primary food shoppers in these two areas was collected beginning in November 2003. Although the sample size was relatively small, the rules of thumb suggested by Long (1997) for justifying the use of maximum

likelihood estimation and the resulting significance tests are largely met (Verbeke *et al* 2000).

2. Stated Preference Method (SPM)

The stated preference method (SPM) was applied to collect the consumer data. The SPM often referred to as experimental or stated choice analysisis a variant of conjoint analysis and assesses buyer's stated responses to specified choice sets. The analytic framework is based on the premise that buyers' perceptions of selected products, as represented by relevant product characteristics, including price, strongly influence product choice decisions. The approach is built on the views of Lancaster (1966) that buyers' product preferences reflect the utility associated with particular product characteristics. The SPM applied in this study is based on respondents' hypothetical choice behavior for GM wheat processed bread purchases. Respondents are asked to simulate discrete choice behavior for GM wheat bread with specified attributes (i.e. GM benefits).

The SPM survey questions were designed to assess Japanese consumers' preference for five different types of GM benefits. These five alternative GM benefits include: diet benefit, nutrition benefit, extended shelf life, producer benefits (lower usage of pesticide/ increased yield of wheat production), and medical benefits. An experimental design procedure (fractional factorial design) was applied to design the scenario choices, based on these five GM benefit alternatives and three different levels of price. The survey consisted of 7 questions per each respondent. Respondents were asked to choose one alternative from alternative A, B, C, D and E for each of 7 sets of hypothetical GM wheat processed bread purchasing scenarios (Fig. 1).

3. Multinomial Logit Model (MNL)

Multinomial logit (MNL) model was used to estimate the collected SPM data. Discrete choices among product alternatives in the SPM methodare modeled in a random utility framework. Following Ben-Akiva and Lerman (1985) and Adamowitz *et al* (1997), this random utility function can be expressed as:

$$U_{in} = V(X_{in}) + e \quad (1)$$

where:

U_{in} is person n's utility of choosing alternative i

V is the systematic component of utility; e is a random element; and

X_{in}, is a vector of attribute values for alternative i as viewed by respondent n.

The probability of individual n choosing alternative i is equal to the probability that the utility of alternative i is greater than the utilities of all other alternatives in the choice set. This can be written as follows:

$$\pi_n(i) = \Pr(V_{in} + e_{in} \geq V_{jn} + e_{jn};\ \text{for all } j \in C_n) \quad (2)$$

where C_n is the choice set for respondent n.

The probability of choosing an alternative i is defined as

Question 10. Please check (√) one only, /a, /b

Please imagine that application of GMO (biotechnology) can produce the following benefits in a pack of sliced bread (6 slices). Choice A, B ,C, D & E in each question have different GMO benefits and price levels. If the following five choices are the only ones (sliced bread) available, which of the following sliced bread would you choose? Please check (√) one only.

Choice A	Choice B	Choice C	Choice D	Choice E
Diet benefits GMO with calorie reduced	Nutrition benefits GMO with Vitamin enhanced	GMO with extended shelf life	Producer benefits GMO with No pesticides usage	Medical Benefits GMO with Anticancer effects
178 yen	**118 yen**	**238 yen**	**178 yen**	**238 yen**
( )	( )	( )	( )	( )

/a Factors and factor levels are selected based on preliminary research that was conducted prior to the survey study. The preliminary research included focus group discussion with Japanese housewives, a series of interviews with the Japanese food industry representatives and experts. The survey questionnaire was pre-tested and revised by Japanese marketing professors.

/b Price factor was specified to have three different possible levels and GM benefit factor was specified to have five different levels in the survey to provide a balance between the complexity for the respondent and the amount of information collected.

Fig. 1. Example of SPM survey question.

the multinomial logit (MNL) model:

$$\pi_n(i) = \frac{\exp(\mu V_{in})}{\sum_j \exp(\mu V_{jn})} \quad (3)$$

Assuming that V_{in} is linear in parameters, the functional form can be expressed as:

$$V_{in} = \beta_1 + \beta_2 X_{in2} + \cdots + \beta_k X_{ink} \quad (4)$$

Where:

V_{in} is respondent n's conditional indirect utility function;

X_{ink} is the kth attribute value for alternative i as viewed by respondent n;

β_1 to β_k are coefficients to be estimated, representing the five types of GM benefits.

One of the main objectives of SPM/MNL analysis was to evaluate the relative importance of five types of GM benefits in Japanese consumers' buying decisions for GM wheat bread. The estimated coefficients of the MNL model were then used to measure values of five types of GM benefits by calculating the marginal effect of an explanatory variable on consumer purchasing probability.

4. Marginal Analysis of Selected Five Types of GM Benefits

The marginal effects of changes associated with the estimated coefficients of the MNL model were calculated and used to compare the predicted responses of Japanese consumers toward five types of GM benefits. By differentiating equation (3), the marginal effect of an explanatory variable (i.e. GM benefit) can be derived as:

$$\delta_i = \frac{\partial \pi_i}{\partial X_i} = \pi_i [\beta_i - \sum_j \pi_j \beta_j] \quad (5)$$

where $\pi(i)$ is the probability of a buyer's choice of alternative i.

The marginal effect δ_i in the equation (5) measures the shifts in the probability of an outcome with respect to a change in a given regressor (factor) (Huang and Fu, 1995). Valuation of each GM benefit can be also interpreted as Japanese consumers' willingness to pay for each particular GM benefit associated with GM wheat bread.

5. Data Analysis

Data obtained from the SPM mail survey questionnaire were used to estimate the MNLmodel of equation (4), with maximum likelihood procedure of the statistical program LIMDEP 8.0. Since the data on GM benefit and price factors were collected as categorical variables, dummy variables are used to effects-code the factor levels. The fifth level of each factor was omitted during estimation to avoid the singularity and calculated afterward using the effect-coding constraint that all five coefficients on the factor level must sum to zero (Johnson and Dinardo 1997).

Results and Discussion

Estimates of MNL model are reported in Table 1. The coefficient estimates denote the relative effects of product attribute level on a consumer's utility and on the probability of a product being purchased. A positive coefficient indicates that product attribute level increases the probability of a Japanese consumer choosing a product profile incorporating that attribute. The pseudo-R square (0.261) indicated the model coefficient estimates have explanatory power in modeling Japanese consumer's preferences for GM wheat bread.

The MNL results indicated that Japanese respondents preferred lower prices, as expected. Regarding GM benefits, GM wheat bread with nutritional benefits was the most preferred by the respondents, while GM wheat bread with medical benefits was the second most preferred alternative. The other three benefits, diet benefits, extended shelf life and low pesticide use (producer benefit) were found to have negative effects

Table 1. Estimates of the multinomial logit model : preference for GM wheat bread with five types of GM benefits

Factor	Factor level	Coefficient	Standard Error
Price	118 yen / 100g	1.008*	0.067
	178 yen / 100g	−0.056	0.066
	238 yen / 100g	−0.952*	0.064
GM benefits	Diet benefit	−0.044	0.597
	Nutrition benefit	1.173*	0.059
	Extended shelf life	−1.211*	0.111
	Producer benefit (Lower pesticide use)	−0.790*	0.094
	Medical benefit	0.873*	0.072
Pseudo R^2=0.261			
N (number of respondent)= 202			

* Statistically significant at the 0.01-level of significance.

on Japanese consumers' choice for GM wheat bread.

These findings suggest that Japanese respondents were more likely to be interested in GM food with nutritional benefits relative to other four GM benefit alternatives. This study supports our *a priori* hypothesis (c) that of different types of GM consumer benefits may induce different degrees of acceptance by Japanese consumers.

Table 2 presents the calculated marginal effects of changes in the levels of the specified factors on the probability of GM wheat bread purchasing behavior of Japanese consumers. Three scenario analyses were presented in this paper to address implicit values of selected GM benefits.

The first scenario (Table 2) compared two GM wheat bread products that had identical factor conditions for price and had two different types of GM benefits. Alternative A was a GM wheat bread with nutritional benefit and alternative B was a GM wheat bread with extended shelf life. Predicted probabilities for these bread products with different GM benefit options were calculated in order to evaluate price changes to compensate for this GM benefit difference. There was 83 % probability of consumers choosing alternative A versus 7.6 % probability that the consumers would choose alternative B. Marginal probability calculation indicated that a price change of −9.9 % for alternative B (extended shelf life) was required to equalize the probability that alternative B would be chosen. This implies that GM wheat bread with nutritional benefit commands 9.9% price premium compared to the bread product with extended shelf life.

Scenario 2 indicated that GM wheat bread with nutritional benefit commands 8.5% price premium compared to a bread product with low pesticide use (producer benefit), while scenario 3 showed that GM wheat bread with medical benefit commands 7.5% of price premium compared to a bread product with low pesticide use. These results implies that Japanese respondents were more willing to pay a premium for GM food with consumer benefits than for GM food with producer benefits, supporting our *a priori* hypotheses (a) and (b). This result also supports the findings of previous studies (Mayer

Table 2. Estimation of values of alternative GM benefits

Scenario 1: Nutrition vs. Shelf life extension benefits in GM wheat bread	Alternative A	Alternative B
Price	118 yen/100 g	118 yen/100 g
GM benefit	Nutrition benefit	Extended shelf life
Probability of choice	83%	7.6%
Price change required for indifference		−9.9%
Value of nutrition benefit compared to shelf life extension benefits	9.9 % Price premium	
Scenario 2: Nutrition vs. No pesticide benefits from GMO	Alternative A	Alternative B
Price	118yen/100 g	118 yen/100 g
GM benefit	Nutrition benefit	Low pesticide use (Producer benefit)
Probability of choice	79.8%	11.2%
Price change required for indifference		−8.5%
Value of nutrition benefit compared to low pesticide use benefit	8.5 % Price premium	
Scenario 3: No pesticide vs. medical benefits from GMO	Alternative A	Alternative B
Price	118 yen/100 g	118 yen/100g
GM benefit	Medical benefit	Low pesticide use (Producer benefit)
Probability of choice	78.3%	9.7%
Price change required for indifference		−7.5%
Value of medical benefit compared to low pesticide use	7.5% Price premium	

2002, Biane 2001, Wilson *et al* 2003, Riley and Hoffman 1999, Adelaja and Schilling 1999) that potential consumer benefits may improve consumer acceptance for GM food.

Conclusion and Marketing Implications

This study employed stated preference method (SPM) to elicit and to compare Japanese consumers' interest and willingness to pay a premium for GM wheat bread with specific consumer benefits (2nd generation GM food) versus producer benefits (1st generation GM food), using a mail survey instrument. In order to optimally communicate and promote GM food products, it is imperative to understand which particular aspects of the functional benefits in the GM foods consumers are likely to accept and prefer as this will ultimately determine the consumer acceptance and viable commercialization of the GM foods in future.

The SPM approach allows researchers to assess the potential demand for a new product or attribute, such as a GM label, based on buyers'perceptions of that product. The approach can also be used to estimate the response to a change in an existing product. The SPM is particularly appealing for this study as the 2nd generation GM wheat products with consumer benefits has not been fully developed. Thus, the SPM method enabled the projection of potential demand for new generation GM food products which may be used as a guideline for the policy makers, marketers and producers of 2nd generation GM food products.

Recent food safety scares increased Japanese consumers' concerns for food safety and genetically modified (GM) foods as they perceive uncertainty associated with the GM food as potential risk. However, this risk perception can be considerably reduced as the consumers observe or experience the benefits in the GM foods directly. Technical advancement in genetically modified (GM) food development and manufacturing led to emergence of GM functional foods that provide physiological benefits or reduce the risk of chronic disease, above and beyond their basic nutritional functions. Some have speculated that new generation of GM foods with enhanced quality attributes or nutritional benefits will see much greater public acceptance (Hossain and Onyango 2004, Riley and Hoffman 1999, Feldman *et al* 2000, Gamble *et al* 2002, Schmidt 2000).

Finding in our study showed that Japanese respondents were willing to pay 9.9 percent price premium for the GM food with nutrition benefit compared to the one with extended shelf life. This finding supports that the evidence that health issues constitute a large part of consumer choice behaviour in today's food consumption pattern. This result also suggests that by enhancing the nutrition benefits in GM food products, the GM producers and marketers may be able to alter consumer behaviour regarding GM food choice.

The finding also suggest that the respondents were willing to pay 8.5 percent price premium for the nutrition benefits (consumer benefit) in the GM food compared to lower pesticide usage (producer benefit) in the GM food production. This implies that consumers' attitude toward these "2nd generation" GM foods may be different as these foods provide the health, nutritional and the economic benefits 'directly' to the consumers. This result should be of interest to GM producers, policy makers and marketers who are interested in investing capital to implement. More capital should be invested toward R & D of consumer-oriented GM food production and the consumer benefits of GM food should be strategically communicated and emphasized among the interested target consumers.

Recently, the 2nd generation GM foods with the functional attributes are being categorized as "novel foods" that are produced by the processes that have not previously applied, or that cause a major change in the food (Veeman 2002). This type of GM foods is also termed as 'functional foods' that provide physiological benefits or reduce the risk of chronic disease, above and beyond their basic nutritional functions. Functional foods are becoming increasingly popular at retail stores. For example, pork with genetically enhanced omega-3 fatty acids is a functional food product that is commercially available in the retail sector (Atkinson 2007). This illustrates a good example of how genetically modified food products can be marketed to promote health and nutrition.

Functional foods can be further narrowed down to a 'nutraceutical' that is in a form of a pill or capsule with substances extracted from a functional food, providing pharmaceutical functions. The functional foods can provide economic benefits to the society for improved health and well-being of the population and reduced health care costs. The world's functional food market is estimated to be approximately US $ 70 billion annually and growing at 7 to 10 percent annual growth rate (Atkinson 2007). Given the enormous size of this market, appropriate orientation and targeting of 2nd generation

GM food pose significant market potentials.

Results from this study suggest that the Japanese consumer preferences for the new generation functional food vary considerably. Respondents in the study perceived and differentiated the value of functional benefits of the GM foods and were willing to pay different price premium for different functional benefits in the GM foods. The nutritional benefit of the GM food products was perceived as 'added value' to health and nutrition-conscious consumers. Therefore, these distinct and tangible aspects of the GM foods may need to be actively communicated and marketed to raise the consumer awareness and the acceptance of the GM foods.

The GM functional food marketers must assemble collective efforts with various stakeholders to establish an effective supply chain of GM food products through implementation of effective regulatory policy regarding safety and labeling, clear understanding of the consumer market trends, and introduction of GM functional food products that match consumer preference for health and food safety issues.

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