

Consumer Preferences for Functional GM Foods in the UK: A Choice Experiment

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The aim of this study is to investigate consumer preferences for functional GM foods in the United Kingdom. A choice experiment methodology was utilized to elicit respondents' purchase intentions with regard to GM bread with functional shelf life, vitamin content, and environmental quality attributes. Results from multinomial logit and random parameter logit modelling indicate that for parity, respondents would require a mean monetary discount of 13% on functional GM bread compared to standard bread; however, 65% of the sample would be willing to buy GM bread and 33.3% would be willing to pay a premium for functional GM bread. Environmental quality and vitamin content attributes substantially increased bread valuations, but the effect of enhanced shelf life was insignificant. The modelling also indicates that respondents with the highest willingness to pay for functional GM bread are typically young, male, and with a high knowledge of GM, while high-income respondents are more averse to GM foods.

Key words: choice experiment, second generation 'functional' GM foods, UK consumers, willingness to pay.

Introduction

Biotechnology and the development of genetically modified (GM) crops emerged in the early 1990s. The 'first generation' of GM foods was developed to assist farmers in the production process by increasing crop yields and their resistance to adverse weather conditions, pests, and weeds, as well as reducing fertilizer costs. These products met with opposition in the UK with consumer worries over potential health and environmental risks and the perception of only minimal private benefits. Currently, a 'second generation' of 'functional' GM foods are being developed with a focus on direct benefits to consumers, such as enhanced taste and increased vitamin content. This study aims to investigate consumer preferences for these foods. If the benefits are found to outweigh the perceived risks, a potential market for such products could emerge (Marin & Notaro, 2007).

Studies into consumer preferences for GM foods tend to identify a spectrum of opinion. For example, in the UK, the Consumers' Association found that approximately 30% of the UK public would find GM foods acceptable, while 30% were entirely opposed to such foods (Consumers' Association, 2002). Rigby and Burton (2005) used random parameter logit (RPL) modelling on choice experiment data. They found that 30% to 40% of the UK public are indifferent towards GM and GM-free foods that are equally priced. Spence and Townsend (2006) evaluated willingness to pay (WTP) for GM food using an equivalent gain task in which par-

ticipants actually received the options they chose. They found that most participants would choose GM food over some amount of money (74.5%), though GM food was found to be valued significantly less than non-GM food. (See Yao and Wang [2012] and Costa-Font, Gil, and Trill [2008] for reviews and Dannenberg [2009] and Lusk, Jamal, Kurlander, Roucan, and Taulman [2005] for meta-analyses of past valuation studies.)

In terms of 'functional' GM foods, studies have almost always found that the value placed on GM products is dependent on the particular beneficial attribute it offers. For example, in the United States, an International Food Information Council survey conducted in 2002 found that 71% of consumers would likely buy produce enhanced by biotechnology to require fewer pesticide applications, compared to 54% who indicated a willingness to purchase GM produce enhanced to taste better. In the UK, Frewer, Howard, and Shepherd (1997) analyzed consumers' real purchasing behavior for yogurt, tomatoes, and chicken drumsticks and found that consumers were more willing to accept genetic modification to produce foods with beneficial health and environmental traits but less likely to accept genetic modification used to increase shelf life of a product or to reduce the purchase price. Other studies have found that consumers are willing to pay significantly more for functional foods that entail genetic modification within species as compared to modification across species (e.g., Colson, Huffman, & Rousu, 2011, Hossain & Onyango, 2004). Further, several studies have examined

the link between the acceptance of GM and functional GM foods and a respondent's socio-demographic attributes such as age, gender, and income level, as well as the respondent's knowledge of the GM process. (See Siegrist [2008] and Siró, Kápolna, Kápolna, and Lugasi [2008] for reviews of factors influencing public acceptance of functional foods.) An important common thread in this literature is that consumer demand is not homogeneous, and that identifying consumer segments that have different preferences towards GM and functional GM foods is vital in understanding the future prospects and dynamics of GM food markets.

This study aims to identify consumer preferences for functional GM foods in the UK through the use of a choice experiment. Specifically, consumer preferences for hypothetical GM loaves of bread with functional shelf life, vitamin content, and environmental quality attributes are explored. Using this methodology, the impact of individual characteristics on consumer preferences for functional GM foods is analyzed. Empirical evidence into UK preferences for functional GM foods using robust methods such as choice experiment or conjoint analysis is limited. Preferences for GM foods have been found to vary by country and over time (see Dannenberg, 2009; Lusk et al., 2005). This makes regional-specific and up-to-date studies into consumer preferences for GM foods important. This study therefore serves to offer a timely exploration into consumer preferences for functional GM foods in the UK.

Methodology

The study analyzes preferences for functional GM foods using a stated preference methodology since there isn't sufficient revealed preference data (e.g., from supermarket scanner data) that would allow for an alternative approach. The specific stated preference method adopted is the choice experiment (CE), or conjoint analysis method, as this has clear advantages over other methods such as conventional contingent valuation in terms of minimizing various bias (Hanley, Mourato, & Wright, 2001). The CE method has become the prevailing empirical approach in consumer research into GM foods (see Dannenberg, 2009).

After an extensive literature survey, the product selected for the CE survey was a medium-sized (800g) loaf of bread. This product should be familiar to respondents and can plausibly be modified through genetic engineering to provide certain benefits. The GM loaves of bread presented in the survey were allowed to vary in terms of three attributes: shelf life, environmental qual-

ity, and vitamin content. The three attributes were specified as dummy variables (0, 1) in order to minimize the cognitive burden facing respondents. The definitions of these attributes were presented in the survey as follows.

1. *Shelf life*—The GM bread has a shelf life of two weeks as opposed to the five-day shelf life of non-GM bread.
2. *Vitamin content*—Two slices of GM bread contain 100% of the recommended daily allowance of all essential vitamins required for good health.
3. *Environmental quality*—The land on and in the area close to where GM wheat is grown contains a larger quantity and variety of plants and animals than the land on and in the area close to where non-GM wheat is grown.

Including these definitions in the survey leads respondents to believe that the attributes could actually be provided. In many previous studies, attributes of second-generation GM foods have been defined very generally, such as “good for the heart” or “improved nutritional quality.” The attributes can therefore lack credibility (as they can be leading respondents) or are too vague for respondents (Hartl & Herrmann, 2009). A short outline of the GM process involved in the provision of each attribute was included in the survey to address this problem. For example, the shelf life attribute was explained as follows.

‘Particular enzymes cause foods to rot and go moldy. Through genetic engineering these enzymes can be silenced.’

Price was also included as a variable attribute with five price levels increasing in incremental steps of £0.30 from £0.50 to £1.70. These values were selected to span the range over which respondents are expected to have preferences as informed by a pilot study. We also included an opt-out or ‘status-quo’ option of a non-GM loaf of bread set at a price of £1.10, which is the average price of a medium sized, soft 800g loaf of bread in the four largest UK supermarkets. An example choice set taken from the final survey is given in Table 1. Each choice set includes three options (two hypothetical functional GM loaves of bread and the opt-out option).

SPSS Conjoint software was used to create an orthogonal fractional factorial design that would produce the optimal amount of choices (i.e., a subset of choice sets derived from the universe of choice sets that have a low level of correlated attributes within and

Table 1. Example choice set.

Attribute	Three loaves of bread to choose from		
	GM option A	GM option B	Standard option
ShelfLife	5 days	2 weeks	5 days
VitaminContent	Standard	Enhanced	Standard
EnvironmentalQuality	Standard	Enhanced	Standard
Price	£0.50	£0.80	£1.10
Which option do you prefer? (please tick 1 box)			

between alternatives and enough degrees of freedom for estimation purposes). In total, 16 choice sets were generated and then randomly blocked into two groups of eight choice sets each. The choice sets were constructed by randomly pairing profiles drawn from the fractional factorial design. The ‘status quo’ (standard option) was not included in the orthogonal design but was included in each choice set (as a fixed alternative) so that WTP values for GM loaves of bread with different combinations of attributes could be compared to the price of the standard loaf of bread. In order to test the reliability of the survey responses, a dominating alternative was included in each block of eight choice sets.

Following common practice in CE studies, behavioral follow-up questions such as ‘do you donate to any environmental charities?’ were included. These allow us to test the internal validity of the choice set responses, such as identifying lexicographic or inconsistent preferences.¹

In order to explore the determinants of consumer preferences for GM foods, we also asked five attitudinal statements where responses were ascertained using a five-point Likert scale (ranging from 1=strongly opposed to 5=strongly approve). Finally, to determine whether the survey sample is representative of the UK population and to account for preference heterogeneity in the analysis, basic socio-demographic questions were included (age, gender, income, etc). These variables are described further in the modelling section.

1. *By identifying inconsistent responses, follow-up questions can determine whether lexicographic preferences are genuine. For example, if a respondent displays lexicographic preferences for environmental quality in the choice sets but shows ambivalence towards the environment in the follow-up questions, then their preferences are unlikely to be genuinely lexicographic. Data derived from respondents who displayed this behavior was not included in the analysis.*

Survey Implementation

The survey was administered in June 2012 via door-to-door, face-to-face interviews. Randomly selected roads in the Nottinghamshire boroughs of Rushcliffe, Broxtowe, Nottingham City, and Gedling were visited. Nottinghamshire was selected because it lacks GM research centers and was not disproportionately impacted by the bovine spongiform encephalopathy (BSE) crisis. The particular boroughs were selected because they offer a cross section of income groups and are representative of income diversity and average income in the UK based on 2001 national census data (Office for National Statistics [ONS], 2003). Every third house on the selected roads was visited. If there was no reply or if the respondent was unwilling to complete the survey then the proceeding house was visited.

In total, 32 respondents from each borough completed the survey, yielding 128 responses. A further 201 individuals refused to complete the survey, so the overall response rate was 39%. Following the advice of Canavari and Nayga (2009), the topic of the survey (i.e., GM) was mentioned only after a respondent agreed to participate in the survey, thus refusals were not influenced by the survey topic. Of the 128 responses, 14 were discarded for violating the internal rules of validity created in the survey. These consisted of five respondents that failed to select the dominating alternative presented in the survey and nine respondents that displayed lexicographic preferences inconsistent with their responses to the follow-up questions. This low violation rate offers support to the validity of the survey instrument.

After discarding the unusable surveys, 114 responses remained. With each respondent answering eight choice set questions, the total number of observations on the dependent variable was 912. A caveat of our study is that the number of respondents is relatively modest. Yet, as our sampling strategy was carefully constructed and we opted for face-to-face interviews (which enhance the credibility of the exercise), the quality of the data is very high. Further, the demographic make-up of the respondents corresponds well with national levels. The gender balance was fairly even (55% female). The mean and median age of respondents was 40 and 37 years, respectively, compared to 39 and 37 years nationally, and the mean pre-tax household income of respondents was £35,789, slightly higher than the national mean of £32,779 (ONS, 2003). The number of respondents who had attained a university degree in the sample was 43 (31%). This is higher than the national level of 20%

(ONS, 2003). Burton and Pearse (2002) explain that this could reflect a degree of self-selection when respondents are faced with a relatively complex survey instrument.

Econometric Modelling

The data was initially analyzed using the standard random utility theory framework and the multinomial logit model (McFadden, 1974) whereby alternatives are compared and the one that yields the highest level of utility is chosen by an individual. Assume that consumers derive utility from the consumption of bread as in Equation 1.

$$U_{iq} = V_{iq}(Z_{iq}) + \varepsilon_{iq}, \quad (1)$$

where U_{iq} is the q^{th} consumer's utility from choosing the i^{th} loaf of bread from the choice set. V is the observable deterministic component of utility. It is measured as a function of Z_{iq} , a parameter capturing the attribute levels for alternative i as well as individual q_s personal characteristics. The unobservable component of utility is the residual ε_{iq} . This is the difference between U_{iq} and $V_{iq}(Z_{iq})$ and captures all the factors not included in $V_{iq}(Z_{iq})$ (Train, 2003).

By assuming that the relationship between utility and characteristics is linear in the parameters and that the error terms are identically and independently distributed (IID assumption) with a Weibull distribution, the probability of any particular alternative, i being chosen can be expressed in terms of a logistic distribution, as in Equation 2.

$$P_{iq} = e^{V_{iq}} / (\sum_j e^{V_{jq}}) \quad (2)$$

Assuming that V_{iq} is linear in parameters, a 'simple' multinomial logit (MNL) model can be estimated, as in Equation 3.

$$V_{GMA \text{ or } GMB} = \beta_0 + \beta_1 ShelfLife + \beta_2 VitaminContent + \beta_3 EnvironmentalQuality + \beta_4 Price$$

$$V_{Standard} = 0, \quad (3)$$

where $V_{GMA \text{ or } GMB}$ represents the mean utility gained from choosing a GM option, $V_{Standard}$ represents the utility from choosing a standard option, $ShelfLife$, $VitaminContent$, and $EnvironmentalQuality$ represent the attribute parameters and β_0 and $\beta_1, \beta_2, \beta_3,$ and β_4 represent the attribute parameter and constant coefficients.

Table 2. Individual characteristic variables.

Variable	Variable description
Gender	1 if respondent is female; 0 otherwise
Young	1 if respondent is <37; 0 otherwise
MiddleAge	1 if respondent is between 37 and 52; 0 otherwise
LowIncome	1 if respondent's annual pre-tax household income is <£35,000; 0 otherwise
MediumIncome	1 if respondent's annual pre-tax household income is between £35,000 and £70,000; 0 otherwise
LowGMKnowledge	1 if 0 to 2 GMKnowledge questions answered correctly; 0 otherwise
MediumGMKnowledge	1 if 3 or 4 GMKnowledge questions answered correctly; 0 otherwise

Note: Baseline profile: male, pre-tax household income of at least £70,000, older than 52; 5 or 6 correct answers out of 6 to the GMKnowledge questions (high GM knowledge)

Setting $V_{Standard} = 0$ allows the sample mean value of selecting a non-functional GM loaf of bread to be estimated.

Individual characteristics are incorporated into the 'simple' MNL model through constant interaction terms to form the following MNL model with individual characteristics (see Equation 4). The individual characteristics interactions are defined in Table 2.

$$V_{GMA \text{ or } GMB} = \beta_0 + \beta_1 ShelfLife + \beta_2 VitaminContent + \beta_3 EnvironmentalQuality + \beta_4 Price + \beta_5 Gender + \beta_6 Young + \beta_7 MiddleAge + \beta_8 LowIncome + \beta_9 MediumIncome + \beta_{10} LowGMKnowledge + \beta_{11} HighGMKnowledge$$

$$V_{Standard} = 0, \quad (4)$$

where

$$Gender = (\beta_0 \times Gender)$$

$$Young = (\beta_0 \times Young)$$

$$MiddleAge = (\beta_0 \times MiddleAge)$$

$$LowIncome = (\beta_0 \times LowIncome)$$

$$MediumIncome = (\beta_0 \times MediumIncome)$$

$$LowGMKnowledge = (\beta_0 \times LowGMKnowledge)$$

$$HighGMKnowledge = (\beta_0 \times HighGMKnowledge)$$

In addition to the standard MNL, we ran a random parameter logit (RPL) model, as this relaxes the restric-

tive IID assumption and is more flexible in how it incorporates preference heterogeneity into the analysis (Train, 2003). Under the RPL model, the probability that a given individual chooses alternative j is given by Equation 5:

$$P_{nj} = \frac{1}{R} \sum_{r=1}^{r=R} \left[\frac{e^{(\lambda_{nj} \phi_{nr})}}{\sum_{k=1}^{k=m} e^{(\lambda_{nk} \beta_{nr})}} \right], \quad (5)$$

where P_{nj} is conditional on the distribution of β and represents the average value obtained from R repeated draws of β from the distribution $f(\beta)$. The challenge in estimating an RPL model is to correctly identify the attributes that have random parameters (random β 's) and to assign the correct random parameter distribution (Hensher, Rose, & Greene, 2005). The RPL model specification is the same as that given in Equation 4, but now estimated coefficients are the means of a probability distribution random rather than simple point estimates.

The econometric approach allows us to estimate part-worth measures that give the marginal price that consumers would be willing to pay to gain more of an attribute and can be calculated by applying Equation 6 (Bennett & Adamowicz, 2001).

$$Partworths_i = -\beta_i / \beta_{price}, \quad (6)$$

where β_i is the coefficient of the i^{th} attribute and β_{price} is the coefficient of the price attribute estimated in the choice model. By summing coefficient estimates from Equation 6 it is also possible to calculate total WTP values for a change from the status quo (standard loaf of bread) to a GM loaf with the same or differing combination of the attribute levels.

Finally, it is also useful to know how the probability of a respondent choosing a GM loaf of bread in the CE changes based on their observable characteristics. To address this question, marginal effects are calculated by derivation of the choice probabilities as given in Equation 7:

$$M_{X_{ikq}}^{P_{iq}} = \frac{\partial P_{iq}}{\partial X_{ikq}}, \quad (7)$$

where M represents the marginal effect, P_{iq} is the probability of choosing alternative i for decision maker q , and X_{ikq} is the level of the k^{th} attribute of the i^{th} alternative, as observed by decision maker q (Hensher et al., 2005).

Table 3. Basic multinomial logit model estimates.

Parameter	Coefficient (standard error)	P [Z >z]
Constant	0.643*** (0.116)	0
ShelfLife	-0.073 (0.106)	0.492
VitaminContent	0.361*** (0.100)	0
EnvironmentalQuality	0.256*** (0.100)	0.009
Price	-1.310*** (0.149)	0
Log likelihood=-948.488		
Likelihood ratio=106.89***		
Pseudo R²=0.053		

Note: *** Indicates significance at the < 0.01 level

Results

Examination of the 114 usable survey responses shows that 63 respondents (55%) chose a GM option in every choice set. These respondents can be termed the 'GM embracing' group. They were willing to choose one of the GM options given any beneficial attribute or reduction in price relative to the standard option. A further 11 respondents (10%) chose a mixture of standard and GM options. This group can be termed 'GM cautious;' members of this group were only willing to choose a GM option if the benefits (in terms of the attributes) were large enough to override their concerns. If the benefits were only small, they often deferred to selecting the standard loaf of bread. The remaining 40 respondents (35%) choose the standard option in all eight choice sets. This group's members were unwilling to buy GM bread and can be termed the 'anti-GM' group.

Of the 114 respondents surveyed, 38 (33.3%) would be willing to pay a premium for functional GM foods. This indicates that their WTP for a GM bread loaf with a particular functional attribute or combination of attributes is greater than the price of the standard loaf of bread (£1.10). These 38 respondents represent 51% of the 'GM embracing' and 'GM cautious' groups. The remaining 36 respondents (49%) in these groups simply chose the GM option in each choice set because it was cheaper than the standard option. This indicates that they always choose the cheapest loaf of bread and were not influenced by the functional attributes.

To compare the WTP for functional GM foods with standard non-GM foods, a 'simple' MNL model is estimated and the corresponding marginal effects are analyzed. Parameter estimates, standard errors, and P-values from the 'simple' MNL are reported in Table 3.

The model is statistically significant by a likelihood-ratio test that makes a comparison to a base model with equal shares among the alternatives. Further, following

Table 4. Attribute parameter part-worths.

Parameter	Coefficient (standard error)	P [Z >z]
Constant	0.490*** (±0.170)	0
ShelfLife	-0.055 (±0.160)	0.497
VitaminContent	0.275*** (±0.156)	0.001
EnvironmentalQuality	0.195*** (±0.148)	0.010

Note: *** Indicates significance at the < 0.01 level

Hensher et al. (2005), an alternative test was also undertaken making a comparison to a base model that represents actual shares based on the data (base model estimated with alternative specific constants only). This test utilizes all the information available to the analyst. All subsequent models included in the results section are significant based on both likelihood ratio tests. The pseudo R^2 of 0.053 is to be expected given the parsimonious model specification.

In regards to the coefficient outputs, as expected, price has a negative and significant impact upon the utility derived from choosing a GM option. In other words, respondents will tend to choose the least expensive option holding everything else constant. The impact of the *VitaminContent* and *EnvironmentalQuality* parameters is positive and significant, indicating that respondents (*ceteris paribus*) tend to pay more for GM options that have these benefits. The magnitude of the coefficients shows that enhanced vitamin content has a higher impact on utility than environmentally friendly GM wheat. The *ShelfLife* coefficient is slightly negative and highly insignificant. The parameter part-worths corresponding to the previous model are reported in Table 4 with their 95% confidence intervals and p-values.

Given the model specification, the Constant parameter part-worth indicates that the sampled respondents' mean WTP for a GM loaf of bread that possesses none of the functional benefits is £0.49. The 'standard' alternative is valued at £1.10; therefore, respondents require a mean discount of £0.61 (55% discount) to be indifferent between identical GM and non-GM loaves of bread. Enhanced vitamin content and environmental quality attributes increase the mean value of a GM option by £0.28 (57% increase) and £0.20 (41% increase), respectively (see part-worths). Respondents' total mean WTP for GM bread with enhanced vitamin content and environmental quality can be calculated by summing the three corresponding part-worths. The total mean WTP value is £0.961 (± 0.366 at a 95% confidence interval and a p-value=0.000); this is the mean WTP for a GM loaf of bread with enhanced vitamin content and environmental quality attributes.² Respondents therefore

Table 5. Multinomial logit model with individual characteristics.

Parameter	Coefficient (standard error)	P [Z >z]
Constant	1.045 (0.590)	0.077
ShelfLife	-0.050 (0.112)	0.656
VitaminContent	0.406*** (0.103)	0
EnvironmentalQuality	0.292*** (0.103)	0.004
Gender	-0.357 (0.168)	0.033
Young	1.917*** (0.276)	0
MiddleAge	-0.671*** (0.228)	0.003
LowIncome	2.316*** (0.485)	0
MediumIncome	2.344*** (0.481)	0
LowGMKnowledge	-2.358*** (0.438)	0
MediumGMKnowledge	-1.512*** (0.434)	0
Price	-1.395*** (0.154)	0
Log likelihood=-822.00436		
Likelihood ratio=359.86***		
Pseudo $R^2=0.181$		

Notes: Baseline profile—as in Table 2; *** Indicates significance at the < 0.01 level

indifferent between the 'standard option' (price of £1.10) and this functional GM option. It must be remembered, however, that this is a mean value and, in fact, 33.3% of respondents would be willing to pay a premium for GM foods with varying combinations of the functional attributes.

To determine the individual characteristics that affect consumer preferences for GM foods in the UK, a MNL with interacted individual characteristics is estimated. Parameter estimates, standard errors and p-values from the MNL model with individual heterogeneity are reported in Table 5.

The pseudo R^2 of 0.1796 is compatible with the limited number of attributes specified in the model. The signs on the price and functional attributes are consistent with those in the 'simple' MNL model. The magnitudes of the attributes have all increased slightly, though not enough to question the stability of the model. All of the individual characteristic parameter coefficients estimated by the MNL model are significant at the <0.01 level with the exception of gender, which is significant at the <0.05 level. The marginal effects of the individual

2. The GM loaf possesses the *EnvironmentalQuality* and *VitaminContent* attributes. It is otherwise identical to a standard loaf. Following Hensher et al. (2005), the *ShelfLife* parameter is not considered in a total WTP profile because of the insignificance of the estimate.

Table 6. Marginal effects of individual characteristic.

Parameter	dy/dx (standard error)	P [Z >z]
Gender	-0.051 (0.024)	0.033
Young	0.366*** (0.067)	0
MiddleAge	-0.092*** (0.031)	0.003
LowIncome	0.409*** (0.097)	0
MediumIncome	0.433*** (0.100)	0
LowGMKnowledge	-0.270*** (0.053)	0
MediumGMKnowledge	-0.186*** (0.051)	0

Notes: dy/dx is for discrete change of dummy variable from 0 to 1

Baseline profile—see Table 2

*** Indicates significance at the < 0.01 level

characteristic variables from the MNL model with individual heterogeneity are reported in Table 6.

The marginal effect estimate for *Gender* indicates that, on average, male respondents are approximately 5% more likely to choose a GM option than female respondents. In other words, men are found to be less averse to GM foods than women. The age-related marginal effect estimates are larger in magnitude. They show that, on average, middle-aged respondents are approximately 9% less likely to choose a GM option than the older respondents, and the younger respondents are approximately 37% more likely to purchase GM bread than the older respondents. Thus, young respondents have a substantially larger WTP for GM foods than the older respondents, and middle-aged respondents have the lowest WTP. In addition, younger respondents are found to be—by far—the least averse.

The *LowIncome* and *MediumIncome* marginal effect estimates are larger still and indicate that the low-income and medium-income respondents are approximately 41% and 43% more likely to choose a GM option than the high income group, respectively. These figures suggest that low- and middle-income groups are similar in their WTP for GM foods but that the WTP of the high-income group is substantially lower. A possible explanation for this finding is that the functional benefits offered to respondents in this study did not appeal to the high-income respondents, who understood that their income could allow them to purchase the benefits in other forms (for example, by donating to an environmental charity). Thus, given any doubt over selecting a GM option, it was an easy decision to defer to the standard option. The lower income groups may be financially unable to afford these alternatives and therefore may have been more inclined to select a GM option.

Table 7. Random parameter logit model estimates.

Parameter	Coefficient (standard error)	P [Z >z]
Mean		
Constant	1.093 (0.621)	0.078
ShelfLife	-0.032 (0.121)	0.789
VitaminContent	0.369*** (0.118)	0.002
EnvironmentalQuality	0.342*** (0.118)	0.004
Gender	-0.362 (0.175)	0.039
Young	1.961*** (0.289)	0
MiddleAge	-0.693*** (0.240)	0.004
LowIncome	2.431*** (0.516)	0
MediumIncome	2.439*** (0.509)	0
LowGMKnowledge	-2.481*** (0.464)	0
MediumGMKnowledge	-1.589*** (0.453)	0
Price	-1.509*** (0.189)	0
Standard deviation		
VitaminContent	-0.867 (0.414)	0.036
Log likelihood=-821.072		
Likelihood ratio=22.32***		
Pseudo R²=0.172		

Notes: Baseline profile—see Table 2

*** Indicates significance at the < 0.01 level

The *LowGMKnowledge* and *MediumGMKnowledge* marginal effect estimates suggest that there is a positive relationship between an increasing knowledge of GM foods and technology and an increasing WTP for GM foods. The estimates indicate that respondents with low GM knowledge and medium GM knowledge are, on average, approximately 27% and 19% less likely to choose a GM option than members of the high-GM-knowledge group, respectively. It must be pointed out that this study considers ‘objective knowledge,’ which can be defined as what respondents actually know about genetic modification and GM foods. As Costa-Font et al. (2008) point out, this is different from ‘subjective knowledge,’ which refers essentially to what consumers *think* they know about genetic modification and GM foods.

Results from the RPL model can be used to substantiate the findings from the preceding models. The parameter estimates, standard errors, and p-values from the final RPL model are reported in Table 7.³ The vitamin content standard deviation estimate (-0.867) is significant at the <0.05 level, which indicates the existence of heterogeneity in the parameter estimate over the sampled population around the mean (Hensher et al., 2005).

The pseudo R^2 of 0.1721 is to be expected given the limited number of attributes specified in the model. The signs and significance of the coefficient estimates are all consistent with those from the MNL model in Table 5, and the magnitudes of the individual characteristic parameters are almost identical. The magnitude of the *VitaminContent* and *EnvironmentalQuality* coefficients has changed very slightly; the *VitaminContent* coefficient decreases by 0.037, and the *EnvironmentalQuality* coefficient increases by 0.05. However, the impact of the *EnvironmentalQuality* attribute on choice utility remains larger. The given RPL model estimates strongly support the findings from the preceding models.

Finally, analysis of the attitudinal statements was used to substantiate the model findings further and offer additional insights into consumer preferences for functional GM foods. These included question on attitudes about the use of genetic modification in the production of food (either plant or animal sourced), pharmaceuticals, environmentally friendly crops, foods with a longer shelf-life, and foods with added health benefits. For brevity, the results are not presented here, but they provide support to the validity of the CE findings. In accordance with the CE results, the ‘anti-GM’ group shows a greater aversion to GM in response to each of the attitudinal statements than the ‘GM embracing’ group. Further, 52 respondents (83%) in the ‘GM embracing’ group either approve or strongly approve of the use of genetic modification to produce medically beneficial foods; 53 respondents (84%) approve or strongly approve of the use of genetic modification to produce more environmentally friendly crops. This substantiates the CE results where the *VitaminContent* and *EnvironmentalQuality* coefficients were both positive and similarly large in magnitude. The level of approval for GM foods with an extended shelf life identified through the attitudinal statement responses is far lower. Only 32 respondents (51%) from the ‘GM embracing’ group and 0 respondents from the ‘anti-GM’ group stated either approval or strong approval to Statement 6, a trend which supports the CE results.

Respondents also expressed a substantially higher aversion towards using GM technology in the produc-

tion of animal-sourced food compared to its use in plant-sourced foods. At the same time, 60% of the ‘GM embracing’ respondents either approved or strongly approved of the use of genetic modification of plants for food production. This suggests that the results identified in the CE experiment will be difficult to generalize. For example, valuations for GM beef will likely be lower than valuations for GM bread, a finding also reported by Onyango and Govindasamy (2004) and Lusk et al (2004).

Conclusions

The aim of this study was to investigate consumer preferences for functional GM foods in the UK, focusing specifically on second-generation ‘functional’ GM foods that offer direct benefits to consumers. A CE survey and follow-up questioning was proposed to a representative sample of the UK population. MNL and RPL models were then used to estimate WTP values for three hypothetical functional attributes of GM bread—shelf life, vitamin content, and environmental quality. The marginal effects of individual characteristics on choice probabilities were also derived and follow-up questions were utilized to substantiate the findings and offer further insight into consumer preferences for functional GM foods.

The results suggest that there is a significant market for functional GM foods in the UK and that a large portion of consumers may be willing to pay a premium for such products. There is also a portion of consumers unwilling to purchase functional GM foods at any price. The findings add to the body of knowledge regarding the relative WTP values of functional GM attributes, suggesting that environmental quality and vitamin content attributes have a large impact on consumer valuations but that the effect of enhanced shelf life is insignificant. The significance of individual characteristics on consumer preferences identified in some studies is reinforced, namely that respondents with the highest WTP for GM foods tend to be young, male, and have high knowledge of GM technology. The results also indicate that high-income respondents had the lowest WTP for GM foods, though this could be due to the substitutability of the bread attributes presented in the survey.

This study suggests that functional GM foods could play a significant role in the UK food industry. The high mean WTP value that young respondents place on functional GM foods is particularly promising in this regard, and based on the findings, improving consumer knowl-

3. Several preliminary models were estimated in which all attributes were considered to have random normal and random lognormal distributions. Only the *VitaminContent* parameter justified being specified as a random parameter, specifically a random normally distributed parameter. Following Bhat (2001), 1,000 random draws were utilized in estimating the final model in order to ensure good model accuracy.

edge of genetic modification could be a means of increasing WTP values for GM and functional GM foods in the future.

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