How do Concerns about Pesticides Impact Consumer Willingness to Buy Genetically Modified French Fries in Germany? Results from a Purchasing Experiment

Thea Nielsen
Department of Agricultural Economics and Social Sciences in the Tropics and Subtropics, University of Hohenheim, Wollgrasweg 43, 70593 Stuttgart, Germany
Thea.Nielsen@uni-hohenheim.de

Abstract

A purchasing experiment in which genetically modified (GM) and conventional french fries were offered for sale at fast food stands in Germany was conducted to assess whether a market exists for GM fries and to identify factors influencing the willingness to buy such fries. The GM and conventional fries were offered for sale at the same price at eight different locations. The GM fries were labelled as being made from "environmentally-friendlier genetically modified potatoes (much less sprays)" while the regular fries were labelled as being made from "conventional potatoes". Consumers were not aware of their participation in the purchasing experiment until after their purchasing decisions were made. The goal of the experimental set-up was to mimic an actual buying situation to the fullest extent possible. Therefore, information, such as the percentage in reduction of pesticide application or genetic information on the GM potato, were not provided to customers. Of the 331 customers who made a purchasing decision, 56.5% decided to purchase conventional fries and 22.4% GM fries, while 21.1% had no preference between conventional fries and GM fries. A short questionnaire was administered after purchasing decisions were made to better understand factors impacting purchasing decisions. Results from a logistic regression model revealed that worry about pesticides, frequency of organic food purchases, perceptions of the risk of GM foods on health, and the acceptability of GM foods for the environment significantly impact the probability that a customer is willing to buy GM fries. A surprising result is that people who purchase organic food often or always have much higher odds of being willing to purchase GM fries compared to people who purchase organic food less often. The main implication of this study is that a market for fries made from GM potatoes with less pesticide applications currently exists in Germany and could be expanded by providing more information about their genetic origin and reduced pesticide usage.

Keywords: *consumer acceptance; genetically modified foods (GMFs); logistic regression model; purchasing experiment.*

1 Introduction

This study analyzes buying behavior of consumers in Germany of french fries made from genetically modified (GM) potatoes resistant to late blight, the most common fungal disease affecting potato species worldwide (Song et al., 2003). Although not yet available on the market, scientists at BASF Plant Science, the John Innes Center, and Wageningen University have been developing GM potatoes with a built-in resistance against late blight, significantly reducing fungicide use on potato fields and resulting in several benefits for both farmers and the environment. Just recently, BASF Plant Science applied for European Union (EU) approval for such a potato, called *Fortuna*, for use as both food and feed within the EU (Biotechnologie, 2011). Whether consumers in Germany are willing to purchase fries made from these GM potatoes has been unknown.

Although GM foods (GMFs) have existed for over two decades and are allowed to be sold in Germany upon regulatory approval, labelled GMFs remain generally unavailable. This stems from a variety of reasons. First, major retailers and discounters have been effectively pressured to create self-imposed bans of GMFs (European Commission, 2008). Second – as revealed in surveys and bidding experiments – many Germans are not only opposed to GMFs, but are also unwilling to purchase such foods (Dialego, 2009; Springer et al., 2009; European Commission, 2008; European Commission, 2010) or would purchase them only if they were offered at a steep discount (cf., Dannenberg et al., 2011); these results confirm for retailers and critics of GMFs that Germans neither agree with GMFs nor intend to buy them. Third, studies on consumer purchasing behavior of GMFs in non-hypothetical, non-laboratory settings are lacking in Germany and in other countries – most studies assessing whether consumers are willing to buy GMFs are conducted in laboratory settings (cf., Dannenberg et al., 2011). Thus, retailers and others within the food supply chain cannot accurately predict the share of consumers willing to purchase GMFs if offered for sale.

There have been just two studies analyzing consumer buying behavior of GMFs in Germany in retail settings. One of these studies offered "pretend" GM, conventional, and organic fruit for sale at roadside stands (Knight et al., 2007): when equally priced, 50% of consumers chose organic, 28% conventional, and 22% "spray-free" GM fruit. The other study offered "pretend" GM bread and GM fries for sale: four times more of the "pretend" GM bread and over 20 times more of the "pretend" GM fries were sold compared to the more-expensive conventional bread and fries (*Südwestrundfunk* in European Commission, 2008). Neither of these purchasing experiments or field experiments, to adopt the terminology of Harrison and List (2004), included questionnaires to analyze determinants of the willingness to purchase GMFs. Therefore, an analysis of factors influencing purchasing decisions is not possible.

Research in India with urban consumers provides insight into how consumers may react to GM fries labelled as being made from potatoes with "much less sprays". Krishna and Qaim (2008) use contingent valuation methods to evaluate the WTP for pesticide-free vegetables and for *Bacillus thuringiensis* (Bt) vegetables, finding that the mean WTP for pesticide-free vegetables is a premium of 56.5% and that 55% of respondents would purchase Bt vegetables if they were sold at the same price as conventional vegetables. Respondents who had never heard of genetic modification before (83% of all respondents) were provided basic information about genetic modification and stated the benefit of *Bt* vegetables as having less pesticide use. Surprising, the correlation between the WTP for pesticide-free vegetables and the WTP for Bt vegetables is negative. Moreover, consumers most concerned about pesticide residues require a discount to buy Bt vegetables. According to the authors, "While (risk-averse consumers) would clearly value a reduction in pesticide residues, the dislike GM attribute weights heavier and seems to overshadow the benefits" (Krishna and Qaim, 200: 246). The finding that concern about pesticides negatively impacts the WTP for GM vegetables which utilize a technology resulting in fewer pesticides sheds light on the complexity of issues impacting consumer preferences. The study, however, differs from our study in several aspects. For example, Krishna and Qaim (2008) use contingent valuation methods, information about genetic modification was given to most consumers, consumers

were asked about their willingness to purchase vegetables (in general) rather than a specific food product, the study was conducted in a developing country, and most participants had not heard of GMFs before.

Our study aims to fill an existing knowledge gap – the lack of information on consumer purchasing behavior of GMFs in retail settings in Germany. Although there have been several surveys and a few bidding experiments which have attempted to elucidate consumer purchasing behavior of GMFs in Germany, it is our belief – based on an extensive literature review – that due to possible differences between stated and revealed preferences, these studies cannot accurately predict whether consumers are indeed willing to purchase GMFs.[1] Thus, to determine whether consumers in Germany are willing to purchase GM fries labelled as being made from "environmentally-friendlier genetically modified potatoes (much less sprays)", a purchasing experiment was conducted at eight already existing fast food stands in the Rhein-Neckar region in Germany. Furthermore, to better understand significant determinants of the willingness to purchase GM fries, questionnaires which had been filled-out by participants immediately after they had made their purchasing decisions are analyzed using a logistic regression model.

This paper proceeds as follows: the second section describes the methodology, including the experimental set-up and the statistical methodology; the third section presents results from the purchasing decisions, questionnaire responses, and logistic regression model; and the fourth section discusses the results and their implications as well as offers advice on how foods made from GM crops requiring less pesticides could be better marketed.

2 Methodology

The purchasing experiment took place at eight mobile fast food stands in the Rhein-Neckar region with a well-established local company. The eight locations included two large city centers and three adjacent suburbs, as well as two smaller cities and a village. The sale of the conventional and "pretend" GM fries was indicated by a display located on the counter of the booth. On the display was written: *Today there are fries from 2 types of potato varieties – with the same taste! 1. From conventional potatoes 2. From environmentally-friendlier genetically modified altered potatoes (much less sprays)… Which fries would you like?* The display was colourful and realistic in terms of advertising a new offer (see Appendix 1 for a picture of the display). The term "gentechnisch verändert" (which translates to "biotechnologically modified" in English, though we use "genetically modified" here as this is the most common translation of the phrase in English) was chosen as it is an unbiased phrase to convey the information that the potatoes are genetically modified. "Gentechnisch verändert" is also the phrase more frequently used in German media when discussing GMFs (Müller et al., 2010).

When consumers stated that they would like to purchase fries but did not specify which type, the researcher pointed to the display and said, "Today there are fries from two types

[1] See, for example, Belk (1985); Cummings et al., (1995); Kalaitzandonakes et al., (2005); Knight et al., (2005a, 2005b, 2007); List (2006); Lusk and Norwood (2009); Lusk et al., (2006); Noussair et al., (2004); and Shogren et al., (1999).

of potatoes: environmentally-friendlier genetically modified potatoes or conventional potatoes. Which fries would you like?" After consumers had decided which type of fries they would like to purchase or said that they had no preference between the two varieties,[2] they were made fully aware that they were participating in an experiment, that GM fries were not actually for sale, and – if they had chosen GM fries – that they could purchase conventional fries. Furthermore, they were asked to fill-out a short questionnaire. Participants filled-out the questionnaires on their own; however, the researcher was available to answer any questions. The gender and the approximate age of consumers choosing not to fill out the questionnaire were recorded. This was done so that differences in purchasing decisions between women and men as well as between different age groups could be analyzed using a sample size larger than the number of respondents willing to complete the questionnaire.

Data from the questionnaires was examined using both basic statistical methods and a binary logistic regression model to analyze the willingness to purchase GM fries as well as its determinants. In the binary logistic regression model the dependent variable, WTBGM, represents the willingness to purchase GM fries, equalling 1 if the participant is willing to purchase GM fries and 0 if the participant is not willing to purchase GM fries. Participants are labelled as being willing to purchase GM fries if they either chose GM fries or had no preference. On the other hand, participants are labelled as not being willing to purchase GM fries if they chose conventional fries. Parameter coefficients of predictors are based on responses in the questionnaire about worry about pesticides versus genetic engineering, health perceptions of GMFs, frequency of organic food purchases, acceptability of GMFs with environmental benefits, as well as the participant's age grouping and gender. Predictors, which are listed and defined in Table 1, are coded to equal 0, 1, 2, or 3, yet most are binary variables.

Table 1.
Definition of Predictors in the Logistic Regression Model

Predictor	Description
WPEST	= 0 if more worried about genetic engineering or worried about neither = 1 if more worried about pesticides or equally worried about pesticides and genetic engineering
HRISK	= 0 if thinks GMFs are neither risky nor beneficial, beneficial, or very beneficial for health = 1 if thinks GMFs are very risky or risky for health
BIOOFT	= 0 if purchases organic food less than often = 1 if purchases organic food often or always
GMENV	= 1 if thinks GMFs with environmental benefits are acceptable = 2 if thinks GMFs with environmental benefits are not acceptable = 3 if does not know if GMFs with environmental benefits are acceptable
AGE	= 1 if between 12 and 29 years of age = 2 if between 30 and 49 years of age = 3 if over 50 years of age
GENDER	= 0 if female = 1 if male

[2] Participants labelled as having no preference told the researcher "I do not care", "I have no preference", or "It does not matter to me".

The empirical form of the binary logistic regression model is:

$$Zi = \log(odds) = \ln(p/(1-p)) = ß0 + ß1*WPEST + ß2*HRISK + ß3*BIOOFT + ß4*GMENV + ß5*AGE + ß6*GENDER + \varepsilon \quad (1)$$

Once the parameter coefficients in Equation (1) are estimated based on the questionnaire data, we can analyze significant factors determining the willingness to purchase GM fries.

3 Results

Purchasing decisions were made by a total of 331 customers in the spring of 2010 at the eight fast food stands hosting the experiment: 187 (56.5%) chose conventional fries, 74 (22.4%) chose GM fries, and 79 (21.1%) had no preference between the conventional and GM fries. Questionnaires were filled out by a total of 235 french fry customers, yielding a response rate of 71%. The purchasing decisions of participants filling-out the questionnaire are similar to those of all participants: 53.3% of those filling-out the questionnaire chose conventional fries, 26% chose GM, and 18.7% had no preference. The main reasons for choosing to buy the GM fries include wanting to try a novelty food item and believing that the GM fries are healthier than conventional fries.

Although prices could not be rotated because all but one of the mobile fast food stands hosting the experiment were present at each location once a week with mostly regular customers, consumers deciding to purchase GM fries were asked whether or not they would purchase GM fries sold at a 12.5% premium. A slight majority of GM buyers indicated that they would still purchase GM fries if sold at a premium, whereas 23% said they would not, and 26% did not know.

Because two of the three late blight resistant potato varieties currently being developed rely on genes from a wild Mexican potato variety, the final question related to GMFs given to consumers who chose not to buy GM fries provided additional information about these GM potato varieties (that the GM potato was created from genes of a wild Mexican potato, significantly reducing the need for pesticides) and then asked if they would change their purchasing decision and buy GM fries after learning this information. Surprisingly, after knowing this information, nearly one-fourth of conventional buyers and three-fourths of no preference buyers responded they would purchase GM fries after learning this additional information.

An analysis of the purchasing decisions and questionnaire responses using a binary logistic regression model was undertaken to determine factors significant in explaining the willingness to purchase GM fries. The binary logistic regression model includes 219 observations – all 235 questionnaires were not included as some were incomplete. The estimation results are shown in Table 2. Three goodness-of-fit tests were employed: the likelihood ratio test, the Hosmer and Lemeshow's goodness-of-fit test, and a test using linear predictors to rebuild the model. Multicollinearity was tested using a Variance Inflation Factor (VIF) and by examining the conditioning of the matrix of predictors. Results from these tests are in the notes of Table 2. Having affirmed that the selected logistic regression

model appropriately fits the data and does not have specification errors or multicollinearity problems, we interpret the results.

The odds ratio of the variable indicating worry about pesticides, WPEST, is greater than one, indicating that when this variable increases by one-unit, the odds that a person is willing to purchase GM fries increase with all other predictors held constant at certain values. This means that the odds that someone is willing to purchase GM fries increase by 87% when the variable WPEST increases from zero to one. In other words, people who are more or equally worried about pesticides compared to genetic engineering have higher odds of being willing to purchase GM fries compared to someone who is more worried about genetic engineering or not worried about either pesticides or genetic engineering. The odds ratio for the variable BIOOFT indicates that the odds that a person is willing to purchase GM fries increases by 90.2% when the variable BIOOFT increases from 0 to 1. Thus, people who purchase organic food often or always have much higher odds of being willing to purchase GM fries compared to people who purchase organic food less often. This result and others presented above are discussed in the following section.

Table 2.
Estimation Results from the Binary Logistic Regression Model

Variable	ß	Mean	S.E.	z	P>|z|	Odds Ratio
WPEST*	.6258147	.6849	.3370331	1.86	0.063	1.869769
HRISK***	-1.008141	.5799	.3413816	-2.95	0.003	.3648969
BIOOFT*	.6429699	.2511	.3582072	1.79	0.073	1.902122
GMENV***	-.7114759	1.6849	.2465858	-2.89	0.004	.4909191
AGE	-.030975	1.9954	.2093961	-0.15	0.885	.9700599
GENDER	-.0100268	.6849	.3290809	-0.03	0.976	.9900233
_cons	1.011703		-.6860412	1.47	0.140	2.356319

Notes: *** indicates the variable is significant at the 99% level and * at the 90% level. The log-likelihood intercept-only equals -150.5892; the log-likelihood full model equals -130.1788; and, the likelihood ratio chi-square equals 40.82 with 6 degrees of freedom. The Adjusted Count R-squared equals 0.337. The Homer and Lemeshow's goodness-of-fit chi-square test statistic equals 10.96 with 8 degrees of freedom and a p-value of 0.2042. The goodness-of-fit test using linear predictors to rebuild the model found that _hat P > |z| = 0.000 and _hatsq P > |z| = 0.429. All VIFs are between 1.02 and 1.36, with a mean VIF of 1.14. The condition number for the matrix of predictors is 6.15.

4 Discussion of Results

Overall purchasing decisions indicate that although a majority of consumers did not prefer GM fries, 43.5% were willing to purchase them. Furthermore, half of GM buyers stated that they would be willing to purchase GM fries at a premium, indicating that a niche market for GM fries may exist in Germany.

It is surprising that 13% of GM buyers chose GM fries because they considered them to be healthier than conventional fries. Exactly what health aspect these GM buyers believed to be better in GM fries compared to conventional fries remains unknown. Nevertheless, it is reasonable that these GM buyers believed that potatoes produced with fewer pesticides are

healthier. Even though potatoes are highly processed and peeled before making fries, thereby significantly reducing pesticide residues (Geetanjali et al., 2009; Soliman, 2001), it is possible that respondents harbored fears that any pesticides incorporated into the developing potato tuber would persist in the final product – french fries. Thus, it follows that some people may have chosen GM fries produced with "much less sprays" because of their concern for possible adverse health effects from pesticides. Furthermore, estimated predicted probabilities (not shown) of being willing to purchase GM fries also support the idea that people may have chosen GM fries over conventional fries because of pesticide concerns.

There are several explanations why such a high proportion of conventional and no preference buyers responded that they would change their purchasing decision after receiving the additional information that the GM fries are made from a GM potato variety produced with the genes of a wild Mexican potato variety, significantly reducing pesticides. One explanation is that these buyers found it appealing that the GM potato variety was created using genes from another potato variety, thereby augmenting the perception of the GM potatoes' "naturalness". Another explanation is that participants did not fully comprehend the pesticide reduction when making their purchasing decision, but then became more aware of this fact when reading the additional information. Thus, it is possible that environmental and/or health benefits of reduced pesticide usage was the determinant for why these buyers indicated that they would change their purchasing decision after knowing the additional information. There is also the possibility that consumers do not have much scientific information about GMFs and were able to form their own opinions when presented scientific information on the GM potato variety. For example, an analysis of media coverage in Germany after two major GMF events took place there in the spring of 2009 found that scientists are rarely represented in the media and quoted either directly or indirectly the least of any other stakeholder (Müller et al., 2010). Our results indicate that more information given to the public on the origin and reduced pesticide usage of GM potatoes resistant to late blight could increase acceptance of GM fries made from these potatoes. Nevertheless, providing such information to the public via labelling, for example, may have little impact on consumer's willingness to purchase GMFs. Few consumers read labels when purchasing food and may not want to invest the time to read any additional information on the product label (cf., Noussair et al. (2002)). Therefore, allowing scientists more coverage in the media on discussions about GMFs may be a better approach.

The logistic regression model found that participants who buy organic food often or always are more likely to be willing to purchase GM fries than those who buy organic food less often. This may be because organic food buyers in Germany may be more concerned about pesticide residues on foods and the environmental impact of pesticide use. In fact, a study conducted in 1999 found that for 74% of organic food customers in Germany, a key influence for their purchasing organic food is health reasons, while for 51% a key influence is environmental considerations (CMA, 1998 cited in Fuchshofen and Fuchshofen, 2000). Dannenberg et al. (2011) found that organic food buyers were the only respondents to change bids for GM soy oil when given neutral information: they bid significantly more for GM soy oil than organic buyers not receiving the information.

More studies examining the willingness of purchase GMFs are encouraged to better understand the willingness of consumers to purchase GMFs and the dynamics behind purchasing decisions. Further research could focus on the willingness to buy fresh versus processed GMFs, for example. We encourage the use of purchasing experiments or field experiments rather than laboratory experiments. In purchasing experiments, purchasing decisions are very similar to those in an actual buying situation and therefore results are likely to be more accurate compared to studies conducted in laboratory settings or studies relying on contingent valuation methods. Although this study could not rotate prices of GM fries, analyzing market shares when GM fries are sold at a discount and premium would be of interest to manufacturers, retailers, and others in the supply chain. Moreover, the impact of the media on the willingness to purchase GMFs is another study area of interest. Krishna and Qaim (2008) for example, found that exposure to mass media negatively impacts the willingness to pay for pesticide-free Bt vegetables in India.

In conclusion, this purchasing experiment represents an addition to the small handful of other purchasing experiments analyzing the willingness of consumers to purchase GMFs. The study provides evidence that a market for GM fries currently exists in Germany as nearly half of consumers were willing to purchase GM fries. Moreover, the market could be expanded by providing very little additional information on the origin of the GM potato variety.

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Appendix 1: English-version of the display offering conventional and GM french fries

Today there are French Fries from 2 types of Potato Varieties – with the same taste!

1. From conventional potatoes

or

2. From environmentally-friendly genetically modified potatoes (sprayed much less)

Which fries would you like?