CONSUMER ACCEPTANCE OF GM APPLICATIONS IN THE PORK PRODUCTION CHAIN: A CHOICE MODELLING APPROACH

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Summary

This study evaluates consumer acceptance of different GM applications in the pork production chain. In general, results indicate that consumers prefer conventional pork over pork for which genetic modification was applied. However, the negative impact of the GM applications is compensated by improvements in quality, increased animal welfare, a lower impact on the environment, less residues and a price discount. Of these benefits, increased animal welfare has the most positive effect on consumer choices. With substantial monetary compensation and presence of various benefits the consumers will attach higher utility to the GM pork than to the conventional pork. The amount of monetary compensation is dependent on the type of GM application.

Keywords: consumer acceptance, genetic modification, choice modelling
JEL classification: C25, D12, Q13

1. Introduction

The number of ongoing debates in Europe about genetic modification has not decreased over the past years. Different parties like consumers, producers, NGOs, policymakers intensively discuss whether it is ethical, natural and safe to use new technology like genetic modification in food production. Many producers and studies see great potential in the application of genetic modification in food production (Bonneau and Laarveld, 1999). However, at the same time, consumers have concerns towards genetically modified products and technology in general (Bredahl, 1999; Cardello, 2003; Cook *et al.*, 2002; Frewer, 2003) and yet moral considerations play an important role in consumer evaluation of new technologies (Eurobarometer, 2005). The attitude to genetic modification in Europe is still somewhat negative. Many studies have shown that consumers are not in favour of having genetically modified organisms present in their food or even of considering that genetic modification might have been in production of food (Bredahl, 2000).

The question of consumer attitude to genetic modification has been a main objective of many studies for some years already. A lot of research has been done on understanding consumers' driving factors influencing acceptance of genetic modification (Hossain *et al.*, 2003), on the influence of information on consumer choices, especially information related to the risks and benefits of genetic modification (Lusk *et al.*, 2004) and consumer willingness to pay for different genetically modified organisms (Rigby and Burton, 2005). Despite a colossal amount of literature on consumer attitudes towards genetic modification, still a lot is unknown in understanding of consumers' acceptance of different GM applications, especially in animal production.

The current study aims to add new knowledge about consumers' acceptance of genetic modification in meat production, in particular in pork production, and the tradeoffs they make between different GM applications and particular benefits.

Firstly, we explicitly investigate how consumers value the GM applications used in pork production. We confront consumers with four different GM applications in the production of pork: genetic modifications that are feasible for production of pork are genetic modification of animal itself, GM feed, GM additives & medicines, and GM bacteria (Novoselova *et al.*, 2004). Specifically, these applications cover whole range of possible GM applications that are feasible in pork production chain.

Secondly, we analyse how consumers make trade-offs between specific GM applications and benefits that genetic modification can offer to them. In particular, effects of price discount, improved quality, environment, animal welfare and food safety within each GM application are examined. These combinations describe the additional effect attached to the combination of benefits and GM methods. Consumer choice of food attributes is analysed within the choice-modelling framework (Louviere, 1991).

The paper proceeds as follows. Section 2 presents information about previous research on consumer acceptance and attitudes towards genetic modification and choice modelling studies. Section 3 discusses material and methods used in this study. It introduces the survey and experimental designs used to generate pork chop choice sets for consumer evaluation. Next to it, this section provides an empirical model for pork chop choices and a description of the sample. Section 4 presents results of the model and discussion and the last section outlines conclusions and possible policy implications.

2. Previous research

2.1 General consumer attitudes

Previous research suggests that consumers' acceptance of GM technology depends on different areas of applications and type of application (Grunert *et al.*, 2001). Consumers have been shown to have more positive attitudes towards the use of genetic modification for medical applications than for food production purposes (Gaskell *et al.*, 2000). In general, medical applications are perceived to be more beneficial, less risky and more ethically correct than applications of GM technology to food production (Enriquez, 2001). Frewer, et al., (1997) found that GM microorganisms and plants were associated with less risk to health compared to GM animals.

According to the results of various studies (Lusk *et al.*, 2001; Baker and Burnham, 2002; Onyango *et al.*, 2004) consumer acceptance of genetic modification is highly dependent on the benefits that the technology can bring to the consumers. More precisely, their acceptance is strongly related to the amount of offset that consumers see in the offered benefits for perceived risks related to the technology (Lusk *et al.*, 2001). Current research suggests that the consumers tend to see the direct benefits that accrue to them, more easily then those indirect benefits that lead to lower food and production costs (Baker and Burnham, 2002).

Lusk *et al* (2004) found that positive information on possible benefits from genetic modification can change the value that consumers place on GM foods. However, not only the (positive) information is important but also consumers' trust in organizations that disseminate information the information can affect the decisions (Huffman *et al.*, 2004).

Besides analysing consumers' attitude to various GM applications, number of studies concentrated on analysing consumers' willingness to pay for non-GM products versus GM products (Chern *et al.*, 2002; Hossain *et al.*, 2003; Lusk *et al.*, 2003; Rigby and Burton, 2005). Results demonstrate that consumers are willing to pay high amount of extra money for non-GM products, although, sometimes the premiums are too high and unrealistic (see Chern *et al.*, 2002).

2.2 Choice modelling studies

Consumer attitude towards biotechnology was studied by many researchers using different methods. These were the grid method, experimental auctions, attitude questions, contingent valuation and conjoint analysis. Among various methodologies applied to explain and predict consumer behaviour towards GM food, choice modelling/experiments received growing recognition. Choice experiments present a new type of conjoint analysis. It is widely applied in studies when the products are hypothetical. Choice experiments were used for analyzing preferences towards environmental issues (Horne *et al.*, 2005), for studying preferences for food safety improvements in meat sector (Enneking, 2004) and for hormone-treated and imported meat (Alfnes, 2004). In addition, choice experiments are also applied to study preferences towards GM foods (see, for example studies Rigby and Burton, 2005; Hu *et al.*, 2004).

Burton and Pearse (2002) have investigated acceptance of GM beer with reduced costs and health attributes. Using choice modelling approach, hypothetical products were devised and described to the respondents with alternative genetic modification methods. It was found that respondents were not in favour to first-generation modification in plants and microorganisms but some respondents were prepared to pay a premium for a beer with medicinal benefits.

In their study of consumer attitudes to GM organisms in food in the UK, Burton *et al* (2001) used choice experiments to study consumer willingness to pay to avoid GM products. In addition to these, they investigated the effect of different attributes such as level of weekly food bill, level of on-farm chemical use, structure of food system and possible food health risk. Results show that consumers have different preferences for GM food produced from plants that are modified by the introduction of genes from other plants compared to GM food in which plants are modified by the introduction of genes from animals and plants.

Hu *et al* (2004) have applied choice modelling to examine the trade-offs made by consumers between (perceived) risks related to the GM foods and potential benefits to health and environment. They have identified four distinct segments of consumers: Value-Seeking Consumers, Fringe Consumers, Traditional Consumers and Anti-GM consumers. Consumers in different segments have different perceptions with respect to risks associated with GM foods and different views on benefits.

3. Materials and methods

3.1 Survey design

The questionnaire consisted of four parts. First, respondent were asked to answer general questions about their buying behaviour and consumption of pork products: i.e. questions about the consumption frequency of pork as a main product, the variety of pork products consumed and the price at which one typically buys pork, and the importance of pork attributes, for example price, quality, nutritional value, animal friendliness, for the kind of pork people buy. The second part of the questionnaire presented questions related to the respondent's attitude towards genetic modification in pork production chains. Before answering the questions consumers were asked to read first some information about genetic modification in pork production. Genetic modification was defined as "technology that involves the transfer of genes from one plant, animal or micro-organism to another plant, animal or micro-organism. The products produced with help of genetic engineering are called genetically modified products ("**GM products**")".

Consumers were presented with four different GM applications. These were genetic modification (1) of animals (*GM pig*), (2) of feed (*GM feed*), (3) of additives & medicines (*GM additives & medicines*) and (4) bacteria (*GM bacteria*). *GM pig* was defined as pig produced with help of GM technology to change the genes of the pig itself, so future generation of the pigs will be different. *GM feed* was defined as feed that includes crops produced with help of GM technology. *GM additives* (like vitamins, bacteria for digestion) and *medicines* (like vaccines and antibiotics) defined as additives & medicine that are produced with the help of GM technology. *GM bacteria* defined as special bacteria that are produced with the help of GM technology and are to be used after slaughtering of the pigs, during processing of the meat, for preservation of meat. Besides the description of four production methods consumers were presented with possible risks and benefits of genetic modification. Among possible mentioned benefits were leaner and healthier meat, meat that tastes better or is cheaper, reduced harmful residues in meat, reduced phosphorus in manure and healthier and less stressed animals. Possible risks were allergic reactions to some people, or health problems of animals. It was also mentioned that long-term effects are not completely clear yet and genetic modification may also lead to ethical concerns related to changing the genes of animals, crops or bacteria, or to biodiversity concerns of GM organisms affecting wildlife. This explanation part were followed by knowledge questions about genetic modification and several attitude questions towards already previously mentioned methods of genetic modification in pork production. The third part of the questionnaire was a conjoint choice task. The design of the choice experiment is described in the next section. The last part of the questionnaire contained socio-demographic questions.
Before sending questionnaire to the respondents it was pre-tested and corresponding to the pre-test results changes were made in the final version.

3.2 Experimental design

Because the objective of this study was to estimate consumers' acceptance and trade-off with respect to different applications of genetic modification in livestock production chain, it is difficult to use methods that rely on the actual market data. To eliminate this problem we used choice-based conjoint analysis. Choice experiment is frequently used in environmental and marketing literature to estimate the importance of various attributes for consumer choice by analyzing consumers' stated choices from a number of choice sets that are generated according to some experimental design ((Louviere, 1991; Adamowicz *et al.*, 1998; Adamowicz *et al.*, 1998). The CE is based on utility model.

To evaluate consumer acceptance of GM technology in pork production chain we used four **GM applications**. We presented consumers with following GM applications: GM pig, GM feed, GM additives & medicines and GM bacteria. Therefore, the pork produced from these applications was considered as GM pork.

Each choice set consisted of three pork chops: two chops with a particular GM application and one chop for which no GM was applied. In addition, the GM pork chops were varied with respect to five characteristics, i.e. price, quality, animal welfare, impact on environment and amount of residues in the meat (Table 1). The choice of these attributes was determined by two reasons. First, these product characteristics can be improved with help of genetic modification. Second, it was enough evidence of importance of these characteristics to the consumers (see studies: Meuwissen and Lans, 2005; Ngapo *et al.*, 2004; Verbeke and Viaene, 2000).

Table 1. Pork attributes and attributes levels in the choice experiment

Pork attributes	Attribute levels
Price	0% reduction
	10% reduction
	33% reduction
Quality	Current quality
	Substantially improved
Animal welfare	Current level
	Substantially improved
Impact on environment	Current level
	Substantially improved
Presence of residues	Current level
	Substantially reduced

Across the pork chops included in the choice sets, the **price** varied from "no price reduction" to "price reduction of 10%" and to "price reduction of 33%". Conventional pork always had "no price reduction." **Quality** of pork was varied between "current quality" and "improved quality". It was explained that "current quality" means that the pork chop has the same quality as the pork chops one can buy in the supermarket. "Improved" quality means that the quality of the pork chop is substantially improved by one of the applications of genetic modification, for example the meat has become leaner or has a longer shelf life. **Animal welfare** was varied between "current" with no improvements and "improved". It was explained that "improved" animal welfare means that by one of the methods of genetic modification animal welfare is substantially improved, for example animals feel less stressed and grow healthier. **Impact on environment** is presented as "current" impact on environment and "improved". "Improved" impact on environment means that by one of the methods of genetic modification the production of genetically modified pork has less impact on environment, for example, animals produce less phosphorus in manure that reduces the pollution problem. The last characteristic of the pork chop is the presence of the **residues in meat**, so we distinguish "current level of residues in meat" (e.g. antibiotics) and substantially reduced level of residues. All five characteristics were varied across all GM pork chops, except for pork chops produced with *GM bacteria*. By using *GM bacteria* it is not possible to improve animal welfare and environment. Therefore, these attributes were excluded from the choice design for *GM bacteria*.

To generate choice sets we first generated for each GM application 16 hypothetical GM pork chops with a 4 x 3 x 2 x 2 x 2 x 2 orthogonal fractional-factorial main-effects design. Where the first number, 4, refers to the number of blocks in the design, equals to the number of GM applications, and the rest of the multipliers are the number of attributes levels. As a result we obtained 16 choice options. Using a cyclic design we created choice sets with two GM pork chops each. To each of these choice sets we added a third alternative in the form of conventional pork. So, for each GM application, we ended up with 16 choice sets with three options A, B and C (see Figure 1) each.

A: GM pig	**B: GM pig**	**C: Conventional**
Price **reduction of 33%**	No price reduction	No price reduction
Current quality	**Improved** quality	Current quality
Current animal welfare	**Improved** animal welfare	Current animal welfare
Current impact on env.	**Improved** impact on env.	Current impact on env.
Current residues	**Reduced** residues	Current residues
Which pork chop do you prefer? (Tick one box)		
☐	☐	☐

Figure 1. Example of choice set

As a consequence, each respondent would have had to evaluate 64 choice sets, what in practice is impossible. For that reason we created four different versions of the questionnaire. In each version, only four choice sets per GM application were included. We used the blocking factor to assign choice sets to the different versions of the questionnaire. Thus each respondent was presented with four GM applications blocked in four sets of choice sets. Accordingly, four types of questionnaire were created. Each respondent was asked to make choice from 16 choice sets (4 including GM-animal alternatives, 4 including GM-feed alternatives, 4 including GM-additives alternatives, and 4 including GM-bacteria alternatives).

To avoid the problem that in any type of the questionnaires respondent will get the same block with identical order of GM applications we used a Greco-Latin square to vary the order of the GM applications and blocks of choice sets across versions of the questionnaires.

3.3 Choice modelling: underlying theoretical model

The analysis of the choice data is based on the random utility model (Ben-Akiva and Lerman, 1985). This model assumes that consumer choices can be modelled as a process in which attributes of choices are evaluated in terms of the utility that they present to the consumers. Assume that consumers derive utility from consumption of pork chops as shown in Equation (1).

$$U_{ij} = W_j + \varepsilon_{ij} \qquad \text{Equation (1).}$$

where U_{ij} is the ith consumer's utility of choosing option j, W_j is the systematic proportion of the utility function determined by the pork attribute levels for alternative j, and ε_{ij} is the stochastic element. Therefore, it is assumed that one part of the utility is common to all respondents and the other part is respondent-specific. Given that the consumer is faced with three choices in each choice set (options A, B and C), the probability that a consumer will choose alternative j is

$$\text{Prob}\{j \text{ is chosen}\} = \text{prob}\{W_j + \varepsilon_{ij} \geq W_k + \varepsilon_{ik}; \text{ for all } k \in C_i\} \qquad \text{Equation (2)}$$

$$\text{Prob}_{ij} = \text{prob}\{[W_j - W_k] \geq [\varepsilon_{ij} - \varepsilon_{ik}]\} \qquad \text{Equation (3)}$$

Where C_i is choice set for respondent i. Equation (2) means that consumers will choose from among a number of choice options, that option from which they derive the most utility. Thus the probability that a consumer will choose the option j equals the probability that the difference between the random component of the utility function is smaller than the systematic component of the utility function across all alternative choice options under consideration (Equation 3).

If random errors in Equation (2) are independently and identically distributed across the j alternatives and N individuals with extreme value distribution and scale parameter equal to 1, then the probability of consumer *choosing* alternative j becomes:

$$\text{Prob}\{j \text{ is chosen}\} = \frac{e^{Wj}}{\sum_{k \in C} e^{Wk}} \qquad \text{Equation (4)}$$

Assuming W_j is linear in parameters, and then the functional form of the utility function may be expressed as

$$W_j = \beta_1 x_{j1} + \beta_1 x_{j2} + \ldots + \beta_n x_{jn} \quad \text{Equation (5)}$$

where x_{jn} is the *n*th attribute value for alternative option *j* for consumer, and β_n represents the coefficients to be estimated. Equations (4) and (5) describe a multinomial logit model.

3.4 Respondents

In the autumn of 2004, 2600 surveys were mailed to a random sample of addresses in the Netherlands. Addresses were obtained randomly using electronic telephone book. Respondents were selected from 26 regions across the country. We made sure that the sample distribution across regions was proportional to the population distribution across regions. After 10 days a reminder was sent. After adjusting for undeliverable surveys and excluding individuals who did not completely fill in the questionnaire, the response rate was 11%. Such low response rate was not surprising. The difficulty of the topic was mentioned during pre-test of the questionnaire and it was already registered that in the Netherlands the surveys addressed to random respondent did not obtain high response rate (Stoop, 2005).

Table 2. Socio-demographic characteristics of the sample

	Sample (n=253)		Population	P-value
	Number	%	%	
Gender [c]				
Female	135	53.8	50.5	0.298
Male	116	46.2	49.5	
Age (years) [c]				
<24	5	2.0	8.0	0.000
25-39	60	24.0	28.9	
40-49	51	20.4	20.8	
50-59	63	25.2	18.5	
>60	71	28.4	23.8	
Household size (persons) [b]				
1	45	18	34.4	0.000
2	119	47.6	32.7	
3-5	84	33.6	32.9	
>5	2	0.8	--	
Children in household [b]				
Yes	87	35.5	50.5	0.000
No	158	64.5	49.5	
Education [a]				
Primary education	15	6.0	12.5	0.000
Junior general secondary education	15	6.0	10.0	
Senior general secondary education	24	9.7	6.5	
Pre-vocational education	10	4.0	14.8	
Senior vocational education	55	22.2	32.7	
Vocational colleges	96	38.7	16.2	
University education	33	13.3	7.3	
Income (euro)				
<1000	16	6.8	--	--
1000-2000	74	31.2	--	
2000-3000	86	36.3	--	
3000-4000	37	15.6	--	
>4000	24	10.1	--	

[a] Statistics Netherlands, for 2002 year
[b] Statistics Netherlands, for 2004 year
[c] Statistics Netherlands, for 2005 year

Table 4 indicates that the consumption pattern and opinion about genetic modification for both groups are the same. In total 253 usable questionnaires were obtained. The sample (135 females and 116 males) was representative of the Dutch population only regarding gender. The sample was not representative with respect to age, household size, number of children in household and education level, with more highly educated respondents and households of two persons and without children over-represented.

4. Results and discussions

4.1 Main effects results

The analysis is based on 4047 choice sets (i.e., GM animal: 1012; GM feed: 1011; GM additives and medicines: 1012; GM bacteria: 1012). For the analysis we have merged the data for different GM applications.

Table 3 presents the estimated main effects for the kind of GM application and for the benefits. Notice that the estimated utilities are expressed relative to a reference level. The utilities of the "improved" levels of the benefits are taken relative to the utility of the levels that represent no improvement, which were set at zero. The utilities for the different GM applications are taken relative to the utility of conventional pork, which was set at zero.

Table 3. Main effects model

Variable	Utility estimate	Standard error	Chi-Square	P-value
1% Discount	0.01309	0.00178	53.98568	0.0001
Improved quality	0.34991	0.04698	55.4709	0.0001
Improved animal welfare	0.86441	0.05760	225.2188	0.0001
Improved environment	0.15293	0.05320	8.2626	0.0002
Reduced residues	0.41309	0.04730	76.2780	0.0001
GM animal	-2.06525	0.08833	546.7369	0.0001
GM feed	-1.86500	0.08542	476.7291	0.0001
GM additives & medicines	-2.06521	0.08798	550.9898	0.0001
GM bacteria	-1.47825	0.07091	434.5328	0.0001
Model Statistics				
Likelihood Ratio	1123.9043			
Score	1033.7883			
Wald	922.7719			
DF	9			
p-value	<.0001			

All coefficients are significant at 1% level

The chi-squared estimated values for likelihood ratio, score and Wald statistics indicate that the model fits the data well. Across GM applications, there is a significant relation between the benefits and consumers' choices ($p < 0.01$).

All estimated utilities have the expected a priori sign and are highly statistically significant. In general, results indicate that consumers attach positive utility to improvements in quality, animal welfare, environment and residues. Improvements in animal welfare have the strongest effect on consumer choice and improvements in the environment the weakest. According to our expectations, consumers attach positive utility to price discounts[1].

In addition, results show that consumers derive more utility from conventional pork than from GM pork, everything else being equal. All utilities attached to the GM applications are with negative sign. Among four GM application, GM bacteria still has the least negative utility (-1.47825), followed by the utility of GM feed (-1.86500). GM additives & medicines (-2.06521) and GM animal (-

[1] In the table the utility of a price discount of 1 % is presented. From this the utilities of different price discounts can be calculated by multiplying the coefficient for 1% by number of desirable price discount. For example, the price coefficient for 10% will be 0.01309*10%=0.1309

2.06525) have the least utility. These are the utilities that consumers attach to the GM applications without benefits relative to conventional pork. However, the consumers' preference for GM pork would be changed if GM pork is sold with a price discount increases and the improvement on all four benefits over conventional.

4.2 Effects of benefits within specific GM application

Based on the results of previous research, we assumed that respondents could imagine different kind of improvements in quality, animal welfare, environments and residues when we talk about different applications. Therefore, in addition to the previous model we have tested another model that included GM applications specific effects of each of the five benefits across GM applications. Estimates for the effects of each benefit within each GM application and their significance are presented in Table 4. The overall fit of the model was satisfactory, with Likelihood Ratio's, score and Wald's p-values of 0.00001.

The parameters in this model are fairly similar to the main effects model. All effects coefficients have positive sign and significant with the exception of the effects of environment within GM feed, environment within GM additives & medicines and environment within GM bacteria. Thus, the insignificant coefficients on these effects variables implies that reducing impact on environment by using these applications does not increase utility for the consumers still the significant coefficient for environment within GM animal suggests it does have an impact using GM animal application.

The effects of price within each GM application are significant. Although, coefficients are positive they do not add much utility for the consumers. The differences in the utility of price discounts for different GM applications are not significant. It means that the price reduction is valued equally and positively by the consumers, no matter what kind of GM application is applied.

The effects of quality benefit within each GM application are different depending on GM application: with GM bacteria consumers perceive the highest utility of quality improvements, the lowest utility is from quality within GM feed application. Pairwise comparisons revealed that the effect of quality under application GM feed versus effect of quality under application GM bacteria and effect of quality under application additives & medicines versus effect of quality under application GM bacteria are significantly different from each other. Utility that consumers attach to improved quality under GM feed is almost three times and one and half times smaller than under GM bacteria and GM additives & medicines, respectively.

The highest utility among other possible benefits consumers attach to an improvement in animal welfare. Pairwise comparisons of animal welfare within GM animal, GM feed and GM additives & medicines application show that the improvements in animal welfare by GM feed and GM additives & medicines has higher utility and, hence, probability of choosing these methods compared to GM animal. For example, for GM animal and GM feed, GM animal and GM additives & medicines the difference in utility are -0.18755 and -0.26301, respectively.

Contrary to the other significant effects of benefits with specific GM application, the effects related to the improvement in the environment are not significant with exception of GM animal within environment which, however, does not receive high utility. Moreover, neither of the effects of environment within different GM applications was significant.

With regard to the reduced residues benefit, consumers attach the highest utility to the effects of residues within GM bacteria and the lowest utilities to the effects of residues within GM feed and GM additives & medicines. The last two are also not significantly different from each other. Pairwise comparison show that the effect of reduced residues within GM feed and GM additives & medicines is twice lower than within GM animal and three times lower than within GM bacteria.

With respect to the estimates of GM applications, coefficient of application GM animal is significantly different from the GM feed and GM feed is significantly different from the GM additives & medicines.

Table 4. Effects of benefits within GM applications

Variable	Utility estimate	Standard error	Chi-Square	P-value
Main effects of GM applications				
GM animal [a]	-1.99776	0.14370	193.2862	0.0001*** [1)]
GM feed pork [ab]	-1.66556	0.12920	166.1810	0.0001***
GM additives & medicines [b]	-2.03888	0.14634	194.1081	0.0001***
GM bacteria	-1.84016	0.11907	238.8470	0.0001***
GM applications specific effects of benefits				
GM animal x price	0.00966	0.00363	7.0945	0.0077***
GM feed x price	0.01244	0.00330	14.2301	0.0002***
GM additives & medicines x price	0.01599	0.00358	19.9702	0.0001***
GM bacteria x price	0.01396	0.00364	14.7276	0.0001***
GM animal x quality	0.37691	0.09701	15.0943	0.0001***
GM feed x quality [a]	0.18600	0.08728	4.5418	0.0331**
GM additives & medicines x quality [b]	0.30185	0.09698	9.6882	0.0019***
GM bacteria x quality [ab]	0.56356	0.09957	32.0366	0.0001***
GM animal x animal w. [cd]	0.70523	0.10095	48.8009	0.0001***
GM feed x animal w. [c]	0.89278	0.09437	89.5047	0.0001***
GM additives & medicines x animal w. [d]	0.96824	0.10587	83.6491	0.0001***
GM animal x environment	0.17869	0.09594	3.4690	0.0625*
GM feed x environment	0.13350	0.08712	2.3484	0.1254
GM additives & medicines x environment	0.13425	0.09627	1.9446	0.1632
GM animal x residues [fgh]	0.50950	0.09848	26.7685	0.0001***
GM feed x residues [fi]	0.22176	0.08738	6.4414	0.0111**
GM additives & medicines x residues [gj]	0.23143	0.09649	5.7527	0.0165**
GM bacteria x residues [hij]	0.75542	0.10230	54.5250	0.0001***
Model Statistics				
Likelihood Ratio	1158.6998			
Score	1055.9202			
Wald	933.8899			
DF	22			
p-value	<.0001			

[1)] * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

[2)] categories that share the same superscript character are statistically different from each other

4.3 Variation of consumers' utility with different price discounts

Next step in the analysis is a calculation of (1) the effect of price changes on consumers utility and (2) price discount at which utility for GM pork is equal to the utility of conventional pork. The effect of price change on the utility can be calculated by varying price discount. In this case, the utility for each GM applications is calculated according to Equation (5) including all significant estimates. From the results of Table 4 we can also estimate the price decrease (price discount) necessary to offset the negative utility associated with GM applications. As noted above, the price discount at which utility for GM pork is equal to the utility of conventional pork can be computed by taking the ratio of the utility coefficient to the coefficient of the monetary variable.

Figure 2 shows that for different GM applications consumers require different discounts. The price discounts at zero utility level show that these discounts offset the presence of GM applications and therefore the utility for GM pork is equal the utility for conventional pork. With zero utility the price discounts are: for GM animal 22.5%, for GM feed 28.3%, for GM additives & medicines 37.3%, for GM bacteria 36.3%. Under these discounts' levels the utility for GM pork is negative. Discounts of 37.3% for GM additives & medicines and 36.3% for GM bacteria should be interpreted with precaution as the price discounts are too high and out of the discount price range that we asked for.

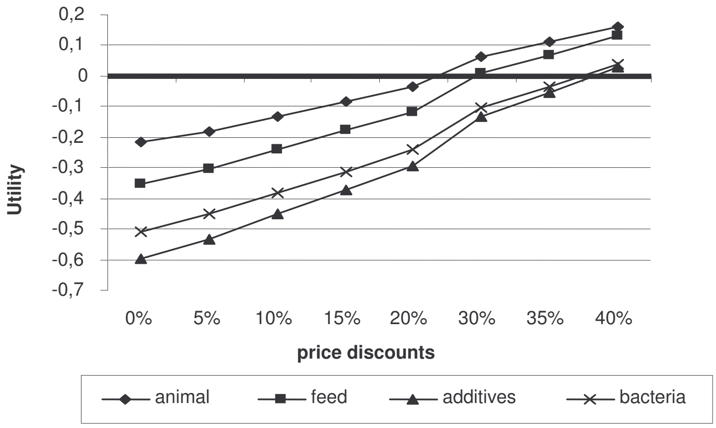

Figure 2. Effect of different price discounts on consumers' utility from different GM applications

For example, with a price discount of 10% and improvements in quality, animal welfare, environment and with reduced residues GM animal receives utility of -0.13083. However, with the same discount of 10% but with no improvements in quality, animal welfare, environment and residues consumers GM-animal pork would have highly negative effect (-1.90116) on consumer choice. Equal utility with conventional pork, the GM pork will achieve if the price discount is equal to 23% and therefore, positive utility consumers will be achieved if the price discount for GM animal pork with all benefits is greater than 22.5% and, for example, would be equal to 23%.

For GM feed, results show that consumers would derive more utility from conventional pork than from GM pork. It can also be seen that, for example, a price decrease of 10% does not compensate for that. With the price discount more than 28.5% and all benefits GM pork receives the positive utility of 0.04604 compared to the conventional pork with the utility of 0. As for GM animal, the GM feed without improvements in quality, animal welfare, environment and residues is considered as a less attractive option compared to the conventional pork.

In case of GM additives and medicines, results show that consumers derive more utility from conventional pork than from GM pork even when the price discount is 30%. To compensate for use of GM application the price for GM pork should be 37% cheaper than conventional pork. For GM Bacteria possible price discounts and improvements in quality and reduced residues in meat don't significantly increase utility of GM pork. Only with discount up to 36% GM pork produced with GM bacteria will receive the same utility as conventional pork.

5. Conclusions

This paper has presented the results of choice modelling approach used to evaluate trade-offs made by consumers between different GM applications and benefits. By examining consumers' preferences, choices with respect to the GM pork, the study adds to knowledge to the existing body of knowledge about potential market and new opportunities for pork production chain.

Results of the analysis indicate that GM applications get less utility compared to the conventional pork. Among all possible benefits consumers value the highest the improvements in animal welfare, improvement in environments receives the lowest utility. In line with the previous studies, results show that consumers have an interest in GM products (produced by using different GM applications) as long as they bring them different benefits and they are substantially cheaper. With substantial monetary compensation and presence of various benefits the consumers will attach higher utility to the GM pork than to the conventional pork. The amount of monetary compensation is dependent on GM application.

This study is important for scientists, industry and policy makers. For scientists, this study provides additional information on how consumers evaluate different benefits. How consumers make a trade-off between different attributes. For industry, it gives the information about the product attributes and GM applications that consumer's value most. For policy makers, this study provides additional view on how consumers evaluate genetic modification in meat production.

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