

# Do They Always Say No? German Consumers and Second-Generation GMO Foods

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**Abstract—** European consumers and, in particular, German consumers are known to be very critical towards the introduction of genetically modified (GM) foods. It is analyzed here whether German consumers do reject second-generation GMO foods, too. Whereas first-generation GM crops induced producer-related benefits, second-generation GM crops are associated with consumer-oriented benefits like an improvement of nutritional quality. The determinants of demand for second-generation GM rapeseed oil are investigated within an online survey of 1556 German consumers. It is elaborated how two functional properties of that product matter; i.e. long-chain  $\omega$ 3 fatty acids and the cholesterol-lowering effect of phytosterols. It turns out that GMO rapeseed oil is neglected by 74 % of all respondents. Output traits, however, will increase the probability of purchases of GMO rapeseed oil. This is more the case for long-chain  $\omega$ 3 fatty acids than for phytosterols.

**Keywords—** consumer behavior, second generation, GMO foods, rapeseed oil.

## 1. INTRODUCTION

European consumers and, in particular, German consumers are known to be very critical towards the introduction of genetically modified (GM) foods. However, there is incidence that consumers react differently to various types of GM food. In particular, the question arises whether the very negative response to GM foods alters with regard to GM foods of the second generation. Whereas first-generation GM crops are associated with producer-related benefits like herbicide tolerance and insect resistance, second-generation GM crops aim to deliver consumer-oriented benefits. Output traits of these crops can improve the nutritional quality, whereas input traits of first-generation GM crops do not directly provide an additional utility for consumers.

A case in point is the development of rapeseed with augmented functional properties. Currently, researchers in industry and academia aim to develop GM rapeseed that contains functional compounds such as long-chain  $\omega$ 3 fatty acids and phytosterols, which translate into increased quality of oil derived from the crop.

The objective of this paper is therefore to identify the factors influencing consumer demand for second-generation GM rapeseed oil. The analysis focuses on consumers' willingness to pay (WTP) for health benefits from two functional properties offered by GM technology. To accomplish this objective a choice experiment (CE) was conducted and data were analyzed with a multinomial-logit (MNL) model. The study was conducted via an online-access panel, whereby 1556 German consumers of rapeseed oil were surveyed in September 2005.

A number of previous studies have already examined consumer acceptance and WTP for second-generation GM foods. Nevertheless, this study makes a unique contribution with regard to at least two major points:

1. Previous studies dealing with second-generation GM foods have vastly been conducted in countries, where consumer acceptance of GM crops is relatively high, such as the USA. The question arises, how consumers in countries with a rather negative sentiment towards GM foods evaluate functional properties induced by GM technology. We have conducted our survey in Germany, where consumers are rather opposed towards the introduction of GM foods.
2. In many previous studies, traits of second-generation GM crops have been defined very generally, such as "good for the heart" or "improved nutritional quality". Overall, not many studies have measured consumer responses towards concrete and comprehensible output traits. We

consider very concretely consumers' evaluation of two functional properties of second-generation GM rapeseed oil that are of special interest for industry and academia.

## II. FUNCTIONAL PROPERTIES OF GM RAPESEED

In this paper, two functional properties of GM rapeseed should be considered, namely the constitutional effect of long-chain  $\omega$ 3 fatty acids and the cholesterol-lowering effect of phytosterols. Both characteristics can be considered as promising, since research efforts towards these traits have been pushed by industry as well as academia in the last years.

### A. Long-chain $\omega$ 3 fatty acids

Human physiology depends in many respects on long-chain  $\omega$ 3 fatty acids (Long Chain Polyunsaturated Fatty Acids, LCPUFA) and it is seen as scientifically proven that their consumption can make an important contribution to the prevention of arteriosclerosis and coronary heart diseases [1]. Consumption is linked to positive effects like a lowering of the triglyceride level of the blood, a decrease in cardiac arrhythmias and phlogistic reactions as well as a lowering of the blood coagulation and viscosity ([2], p. 70 et seq.). Among the most important LCPUFA are the eicosapentaenoic acid (EPA) and the docosahexaenoic acid (DHA), which are almost exclusively injected through the consumption of fatty seafish. Normally LCPUFA are not found in edible oils.

As a consequence, there are efforts all over the world to develop GM plants and especially rapeseed with LCPUFA. Research on LCPUFA in plants is also carried out at the EU level in the context of the integrated project *LipGene*, in which the BASF Plant Science GmbH is the leading industry partner. First achievements were made at the development of rapeseed oils with LCPUFA, although they have not reached the marketing stage yet (see e.g., [3]). It is thought that rapeseed could offer a sustainable and pollutant-free source of EPA as well as DHA. Given this background, it is interesting which acceptance rapeseed oil with LCPUFA will find among consumers.

### B. Cholesterol-lowering phytosterols

The cholesterol-lowering effect was regarded as a further specification. It is known that an increased blood concentration of total and LDL cholesterol and a diminished one of HDL cholesterol represent a higher risk of cardiovascular diseases. The intake of plant sterols can contribute to a lowering of the total and LDL blood cholesterol level [4]. A meta-analysis of all placebo-controlled double-blind intervention studies has shown that a daily intake of 2g plant sterols reduces the LDL blood concentration by 9 to 14% without influencing the HDL Cholesterol concentration. That implies a risk reduction of cardiovascular diseases by approx. 25% within the age class 50-59 [5]. A daily intake of more than 2g does not lead to a further impact.

The daily intake of plant sterols in industrial countries lies with 220-450mg clearly below the optimum [6]. Apart from conventional methods of gaining plant sterols there are ambitions to develop GM plants (e.g. rapeseed) with an increased concentration of phytosterol. The natural concentration of phytosterol in rapeseed oil lies between 480-1130mg/100g [6]. Venkatramesh et al. [7] succeeded in developing GM rapeseed that features a concentration of plant sterols between 2-5g/100g.

## III. METHODOLOGICAL APPROACH

### A. Design of the Choice Experiment

The analysis is based on a survey of 1556 German consumers of rapeseed oil in September 2005. The survey was conducted via an online-access panel. The questionnaire consisted of four major parts: (i) the actual choice experiments; (ii) questions on personal and socio-demographic characteristics of the respondents; (iii) questions on attitudes of the respondents and (iv) questions to be used in a quantitative means-end-chain analysis. In the following analysis, findings from the choice experiments are reported and are related to personal and socio-demographic characteristics and to selected attitude variables of the respondents, which are used as explanatory variables for the choices made.

A choice experiment, during which different rapeseed oil alternatives were shown to the respondents, represents the core of the questionnaire. The first step towards the development of the choice experiment was the selection of relevant characteristics and their specifications for rapeseed oil. Basically an alternative-specific design was chosen, whereby the different alternatives were characterized by the respective cultivation methods, "from GM rapeseed", "from conventional rapeseed" or "from organic rapeseed". Therefore, the parameters of different characteristics can be estimated separately for each cultivation method. This is plausible as particular characteristics and specifications should appear in combination with particular cultivation methods. Moreover, interactions between the characteristics and the cultivation method are to be expected. It is possible, e.g., that the price sensitivity of demand for GM rapeseed oil is lower than demand for organic rapeseed oil. Furthermore, a constant benchmark "neither alternative A nor B nor C" was integrated in each choice set. Thus, the complete decision of the respondents can be pictured, including the possibility to choose none of the rapeseed oils.

The characteristics included in the choice sets represent functional attributes along with other relevant attributes for the buying decision. The constitutional effect of long-chain  $\omega$ 3 fatty acids or the cholesterol-lowering effect of plant sterols, that have been discussed in Chapter 2, are regarded as functional attributes. These attributes are alternative-specific in the choice design. The specifications "with long-chain  $\omega$ 3 fatty acids" as well as "with cholesterol-lowering plant compound", e.g., do only appear along with alternative A, i.e. in combination with GM rapeseed. Additionally, other characteristics that are relevant for the buying decision, i.e. the production process, the origin, the packaging or the price, were included in the choice design with the objective of covering the relevant characteristics of rapeseed oil. While the specifications of the production process, origin and packaging are constant across the different options, Figure 1 shows that the specifications of the characteristic price vary. The characteristics and specifications can be explained as follows:

*With long-chain  $\omega$ 3 fatty acids:* It had to be differentiated between the characteristics with or

without LCPUFA as part of option A in the experimental design. The former received the description "with long-chain  $\omega$ 3 fatty acids" at the front of the label. On the back side of the label the respondents got the following extra information: "produced from rapeseed that features a high concentration of long-chain  $\omega$ 3 fatty acids due to genetic modification" as well as "the regular intake of these fatty acids can demonstrably reduce the risk of cardiovascular diseases". Additionally, nutrition facts were presented to the respondents on the back side of the label that show the exact concentration of LCPUFA (3g/100g).

*With cholesterol-lowering phytosterols:* Further, it was differentiated between the specifications "with or without the enrichment of plant sterols" within alternative A in the experimental design. The former received the description "with cholesterol-lowering phytosterols" on the face of the label. The back side was provided with the information "produced from rapeseed that features an increased concentration of phytosterol due to genetic modification" and "the regular intake of phytosterols can demonstrably reduce the 'bad' LDL cholesterol by up to 15%".

*Production process:* Within the production process, it is generally differentiated between native, that is to say cold-pressed, and refined rapeseed oil. Different studies show that the production process plays a decisive role for the consumers (e.g. [8]). 62% of the respondents declared in a representative CMA consumer study that the production process matters when buying edible oil [9]. Therefore, this characteristic was integrated into the experimental design. The options in the choice set are either categorised as "native" or there is no information on the production process. The latter is identical to refined rapeseed oil, which must not be labelled as such.

Figure 1 Characteristics and specifications of rapeseed oil

Alternatives		<i>Alternative A</i>	<i>Alternative B</i>	<i>Alternative C</i>	<i>Alternative D</i>
		From genetically modified rapeseed	From conventionally cultivated rapeseed	From ecologically cultivated rapeseed	
Characteristics					
Functional Characteristics		<ul style="list-style-type: none"> <li>• With long-chain <math>\omega</math>3 fatty acids</li> <li>• With cholesterol-lowering phytosterols</li> <li>• n.s.</li> </ul>			
Other characteristics that are relevant for the buying decision	Production process	<ul style="list-style-type: none"> <li>• Native</li> <li>• n.s.</li> </ul>	<ul style="list-style-type: none"> <li>• Native</li> <li>• n.s.</li> </ul>	<ul style="list-style-type: none"> <li>• Native</li> <li>• n.s.</li> </ul>	Neither A nor B nor C
	Origin	<ul style="list-style-type: none"> <li>• Produced from German rapeseed</li> <li>• n.s.</li> </ul>	<ul style="list-style-type: none"> <li>• Produced from German rapeseed</li> <li>• n.s.</li> </ul>	<ul style="list-style-type: none"> <li>• Produced from German rapeseed</li> <li>• n.s.</li> </ul>	
	Packaging	<ul style="list-style-type: none"> <li>• Glass bottle</li> <li>• Light-shielded bottle</li> </ul>	<ul style="list-style-type: none"> <li>• Glass bottle</li> <li>• Light-shielded bottle</li> </ul>	<ul style="list-style-type: none"> <li>• Glass bottle</li> <li>• Light-shielded bottle</li> </ul>	
	Price	<ul style="list-style-type: none"> <li>• 1.00 € / 0.5l</li> <li>• 1.75 € / 0.5l</li> <li>• 2.50 € / 0.5l</li> <li>• 3.25 € / 0.5l</li> </ul>	<ul style="list-style-type: none"> <li>• 1.00 € / 0.5l</li> <li>• 1.75 € / 0.5l</li> <li>• 2.50 € / 0.5l</li> </ul>	<ul style="list-style-type: none"> <li>• 2.50 € / 0.5l</li> <li>• 3.25 € / 0.5l</li> <li>• 4.00 € / 0.5l</li> </ul>	

Source: Own presentation.

*Origin:* It can be assumed that the origin plays a role in the choices of the respondents. Many studies have shown that the certificate of origin does influence the decision making of the consumers (e.g. [10]). 40% of the respondents expressed in the CMA study mentioned above that they do pay attention to the producing country of edible oil [9]. In addition, the origin of the rapeseed oils, that are available on the market, is often stressed. In the experimental design, origin is subdivided into two specifications, namely oil from German rapeseed and oil from rapeseed without a specific certificate of origin. The former received the description "made in Germany" at the front of the label. Moreover, the information "produced from German rapeseed" was provided on the backside.

*Price:* It can be assumed that the price strongly influences choices of the consumers. 65% of the respondents expressed in the CMA study that they do pay attention to the price when buying edible oils [9]. Moreover, the price is necessary to compute willingness-to-pay values. The attribute levels of the price were alternative-specific in the choice design, since market prices vary considerably between organic and conventional rapeseed oil. According to the *GfK household panel*, the average consumer price for

declared rapeseed oil was about 1.50 €/0.5l [11] in 2004. The prices for conventional rapeseed oil vary from approx. 1.00 to 2.50 €/0.5l. Therefore, it was differentiated within the conventional rapeseed oil between the three levels 1.00, 1.75 and 2.50 €/0.5l. These price levels were used for the GM rapeseed oil as well. Additionally, a higher price level of 3.25 €/0.5l was added as the production of GM rapeseed oil causes extra costs and would probably be offered at a higher price than the conventional counterpart. Oil from organic rapeseed, with prices between 2.50 up to 7.00 €/0.5l, is typically more expensive than conventional rapeseed oil. Consequently, higher price categories were determined for organic rapeseed oil, namely 2.50, 3.25 and 4.00 €/0.5l.

Prior to the actual presentation of the choice sets the respondents received a brief introduction that made them familiar with the procedure and context of the choice experiment. According to the relevant literature, the so-called "cheap-talk" proved to be effective in order to remind the respondents of their budget constraint and, thus, to avoid hypothetical distortions [12]. Therefore, the following "cheap-talk" instruction was integrated into the introductory text: "Please make your choice as if you really went

shopping in a supermarket and had to pay the price of the chosen alternative. Ask yourself: 'Would I spend my money on this product if I went shopping in a supermarket?'" Afterwards, the choice sets were presented to the respondents with pictures of different rapeseed oils.

### B. Choice Experiment Model

Choice experiments are consistent with random utility theory. Assume that consumers derive utility from consumption of rapeseed oil as shown in the following equation (1):

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

where  $U_{iq}$  is the  $q$ th consumers's utility of choosing option  $i$ .  $V_{iq}$  is the observable, deterministic component of utility. It is typically measured as a function of several explanatory variables, e.g. in the present case by the rapeseed oil attribute levels for alternative  $i$ . The unobservable component of utility is the residual  $\varepsilon_{iq}$ .

Given that the consumer is faced with four discrete choices in each CE question (option A, B, C or D), the probability that a consumer  $q$  will choose alternative  $i$  is:

$$P_{iq} = P(V_{iq} + \varepsilon_{iq}) > (V_{jq} + \varepsilon_{jq}), \quad \forall j \neq i. \quad (2)$$

This formulation is simply based on a utility-maximizing approach, i.e. consumers will make the choice (options A, B, C or D) from which they derive the highest utility.

If the random errors in equation (2) are assumed to be independently and identically distributed across the  $i$  alternatives and  $q$  individuals with a type I extreme value distribution and a scale parameter equal to 1, then the probability of consumer  $q$  choosing alternative  $i$  becomes:

$$P_{iq} = \frac{e^{V_{iq}}}{\sum_j e^{V_{jq}}}. \quad (3)$$

$V_{iq}$  is assumed to be linear in parameters. Thus, the functional form can be expressed as

$$V_{iq} = \beta_i + \beta_i' Z_{iq} + \beta_i' S_q + \beta_i' (Z_{iq} \times S_q). \quad (4)$$

where  $Z_{iq}$  are *attributes* of alternative  $i$ ,  $S_q$  are individual characteristics  $S$  of the respondents,  $Z_{iq} \times S_q$  interactions between  $Z$  and  $S$ , and  $\beta_i$  represents the

coefficients to be estimated. According to equation (4), these variables directly determine the utility of each alternative and the option is selected that maximizes utility. The theory and the foundations of probability theory in MNL estimation is described in much detail elsewhere (e.g. [13]).

Appendix 1 describes the variables  $Z$  and  $S$  used as well as their coding. Nominally scaled variables were effect coded, i.e. the value -1 was attributed to the respective reference categories. In general, effect coding is preferred to dummy coding within discrete-choice analyses, as effect-coded variables maintain the orthogonality of the design. Thus, the effects of the coefficient are not correlated with the constant(s)<sup>1</sup> [14], [15]. Additionally, an orthogonal-polynomial coding was used for the continuous variable  $PRICE^2$  [16]. This coding is recommended in the literature if the analyst intends to estimate non-linear relationships. An orthogonal-polynomial coding eliminates the collinearity between the elements of a polynomial, here between  $PRICE$  and  $PRICE^2$  ([16], p. 267 et seq.). Moreover, the continuous variable  $AGE$  was rescaled. Since algorithms, such as *BHHH*, *DFP*, or *BFGT*, are sensitive to the size of the variables, it is important for the estimation of the log-likelihood function that they possess roughly the same dimension ([16], p. 269).

Furthermore, four indices to the perceived benefits and risks of GMF and FF were constructed. These indices represent the average over both positively and negatively formulated attitude items. Having used a factor and reliability analysis the one-dimensionality of each index could be confirmed. Cronbach's alpha was – as a measure for the inner consistency of an index – 0.90 in case of  $I\_GEN\_POS$ , 0.91 in case of  $I\_GEN\_NEG$ , 0.83 in case of  $I\_FUN\_POS$  and 0.70 in case of  $I\_FUN\_NEG$ .

## IV. EMPIRICAL FINDINGS

Apart from the model results, descriptive statistics showed that GMO rapeseed oil is neglected by 74% of all respondents. This magnitude of rejection is typical for other GMO foods, too [17]. It is also important for respondents that the characteristic "*NATIVE*" is given (71%), followed by a low price (63%), from ecological production (51%) and *LIGHT SHIELD*

(51%). More differentiated results are available from the model.

Three models were estimated. One is limited to alternative-specific constants and characteristics of the alternatives as explanatory variables. Personal characteristics were integrated into a second model, whereas the third one contains quadratic price parameters and interactions additionally. The estimation results of these models are presented in Appendix 2. Only statistically significant variables are included in the results. As measured by the likelihood ratio<sup>3)</sup> the accuracy of the estimation models amounts to 0.166, 0.227 or 0.229 respectively. Since values between 0.2 and 0.4 indicate a high accuracy of an estimation model ([16], p. 54), the results can be regarded as satisfactory. The influence of the characteristics was estimated separately for each cultivation method, as the calculated coefficients differ strongly between the alternatives<sup>4)</sup>. Likelihood-ratio tests confirmed that the estimation of alternative-specific tests would improve the accuracy of the estimation. The influence of the individual determinants on consumers' choices can be summarized as follows:

*Alternative-specific constants:* The maximum number of alternative-specific constants was integrated into the estimated MNL models. With  $J$  options,  $(J-1)$  constants are maximally identifiable ([13], p. 25 et seq.), so that in the present case the alternative "Neither A nor B nor C" was normalized to zero. The various constants then reflect the influence of the excluded characteristics on the utility of each option *relative* to the alternative "Neither A nor B nor C". The alternative-specific constants then measure the utility which the respondents – irrespective of the characteristics – associate with the particular cultivation method: "genetically modified", "conventional" or "ecological". It becomes apparent from the results of the first model that the respondents link the highest utility to the ecological cultivation method, followed by the conventional and genetically modified ones. Accordingly, processors of conventional and genetically modified rapeseed oil would have to allow discounts on their products, which is consistent with existing studies.

*Characteristics of the alternatives:* Appendix 2 shows that nearly all coefficients of the characteristics

are significant and possess plausible signs. Especially the variables *OMEGA* and *PHYTO* are of vital importance for the question at hand. It turns out that long-chain  $\omega$ 3 fatty acids increase the utility and, thus, the probability of choosing the alternative "genetically modified" significantly. To a minor degree, phytosterols have a positive impact on the utility, too<sup>5)</sup>. As a consequence, the original assumption that functional utility components increase the consumer acceptance can be sustained in principle. The question arises why long-chain  $\omega$ 3 fatty acids were rated more positively than phytosterols. It is conceivable that a smaller consumer segment which looks for a cholesterol-conscious diet is attracted by the cholesterol-lowering effect of phytosterols. By means of an interaction term between the variables *PHYTO* and *FOOD\_CHOL* it was tried to depict this effect and it turned out to be significant.

As expected, the variables *NATIVE*, *ORIGIN* and *LIGHT SHIELD* have a significantly positive influence in almost all cases, too. The relative size of the coefficients implies that the characteristic "native" plays a more important role within the decision process than the attributes "origin" and "light-shielded bottle". Differences between the alternatives can be detected, too. It is remarkable that the coefficients for the variables *NATIVE* and *LIGHT SHIELD* are far lower in case of the alternative "ecological", i.e. they are much less important for the choice of bio rapeseed oil<sup>6)</sup>.

Moreover, the significantly negative price coefficients imply that a price increase results, *ceteris paribus*, in a lower utility and, therefore, a diminished probability of choosing the product. The influence of the variable *PRICE* was modelled both linearly and quadratically. The quadratic specification of price is more appropriate for the alternatives "conventional" and "ecological". Accordingly, the price sensitivity of the consumers varies with the price level as far as these alternatives are concerned. The price sensitivity rises with an increasing price in case of the alternative "conventional", whereas it declines in view of the alternative "ecological". Consumers generally seem to react sensibly to changes in prices of ecological rapeseed oil if the price range of conventional rapeseed oil remains constant. Regarding the magnitude of the price coefficients, it becomes

apparent that those of the alternatives “genetically modified” and “conventional” are similar. The price coefficient of the alternative “ecological” is much higher.

*Individual characteristics:* Unlike the oil attributes, the personal characteristics do not vary across the different options. The alternative “conventional” is used as a benchmark towards which the estimated coefficients are to be interpreted.

The results indicate that the variable *SEQUENCE* has a significantly positive influence on the choice of the alternative “genetically modified” (relative to the alternative “conventional”). This implies that the respondents are rather willing to choose GM rapeseed oil if they have not answered the attitude questions before. This suggests that the patterns follow the principle of social desirability. It is possible that the respondents, without having become sensitive before, might not read the label thoroughly and, as a consequence, do not recognise GM food as such [18]. Additionally, the food patterns of the respondents do matter. If used for salad the choice probability of eco rapeseed oil increases. This is intuitively evident, as in case of a salad the use of subjectively high-class rapeseed oil seems to be more comprehensible than its use for baking purposes. Furthermore, consumers who pay attention to a healthy diet strongly prefer eco rapeseed oil. As expected, health-conscious consumers choose “Eco” more often. Moreover, it is more likely that higher educated respondents refuse GM food. No consistent trend concerning the influence of the educational level could be observed in previous studies. This result matches with other European studies (e.g. [19]). The outcome that students prefer conventional to GM rapeseed oil is consistent with the previous results, too. Interestingly, the choice probability of GM rapeseed oil is smaller than for non-students. This can be traced back to the fact that students have limited funds at their disposal and, consequently, their willingness to pay more for eco rapeseed oil is low. The significant interaction effect between the variables *PRICE* and *STUDENT* in case of the alternative “ecological” shows the same. Students are particularly responsive to changes in prices concerning eco rapeseed oil.

Finally, the attitude indices have a strong influence on the choices, too. Respondents who are more open-

minded about functional food have a significantly higher preference for GM rapeseed oil. In view of the present question, this result seems to be relevant as it suggests to combine functional and GM food.

As expected, the indices of the perceived risks/benefits have a significantly negative/positive impact on the choice of the alternative “genetically modified”. The reverse is true for the alternative “ecological”. Interestingly, some variables turned out to be insignificant, too. Especially the variables *MALE* and *AGE* have, as opposed to previous studies, no influence on the choice.

*Interaction effects:* A second possibility to integrate personal characteristics into discrete-choice models is to generate interaction effects with the attributes. The interaction terms that turned out to be significant were retained in the MNL models. As already mentioned, the interaction term between the variables *PHYTO* and *FOOD\_CHOL* has a significantly positive influence. Respondents who pay attention to a cholesterol-conscious diet value the characteristic “with cholesterol-lowering phytosterols” more strongly. Apart from this, a higher price sensitivity occurs in case of students and men.

*Willingness to pay:* To quantify the value that consumers place on the different alternatives as well as on the attributes of the different alternatives, we also estimated WTP values. The change of the consumer surplus by adding an alternative to the choice-set, or changing attributes of alternatives can be calculated in the MNL model as ([16], p. 340, [17], p. 60):

$$WTP_q = \frac{-1}{\alpha_q} \left[ \ln \left( \sum_{j=1}^{J^1} e^{V_{jq}^1} \right) - \ln \left( \sum_{j=1}^{J^0} e^{V_{jq}^0} \right) \right], \quad (5)$$

whereby the superscripts 0 and 1 refer to the initial and new conditions, respectively.  $\alpha$  is the marginal utility of money that is identical in the MNL model to the negative price coefficient.

According to equation (5), the mean WTP for the alternatives “GM rapeseed oil” and „organic rapeseed oil“ relative to the alternative „conventional rapeseed oil“ has been calculated. It turned out that consumers have a negative WTP of 2.18 €/0.51 for GM rapeseed oil (without output traits), and a positive WTP of 1.56 €/0.51 for organic rapeseed oil relative to conventional rapeseed oil (Appendix 3). These values can be interpreted as the price decrease (increase)

necessary to offset the negative (positive) utility associated with GM (organic) rapeseed oil. Assuming an average market price of about 1.75 €/0.5l for conventional rapeseed oil, the estimated WTP values would imply a price premium of -124.3% for GM rapeseed oil and +89.3% for organic rapeseed oil. Thus, on average consumers strongly oppose GM rapeseed oil.

In addition, WTP values for the attributes of the different alternatives have been calculated. Interestingly, consumers have on average a positive WTP of 1.37 and 0.80 €/0.5l for the functional properties *OMEGA* and *PHYTO*, respectively (Appendix 3). The basic hypothesis that functional compounds can moderate consumer concerns about GM foods can be partly confirmed. However, the positive WTP values for the functional compounds do not fully compensate consumer concerns. Suppliers of functional GM rapeseed oil would still have to discount their product relative to conventional rapeseed oil.

## V. SUMMARY

It can be concluded that the consumers of second-generation GMO foods would not generally say no. But it turns out that the supply of GMO rapeseed oil with output traits would be confronted with a strong general rejection of GMO rapeseed oil by consumers. Output traits like cholesterol-lowering phytosterols and long-chain  $\omega$ 3 fatty acids will raise utility according to the discrete-choice approach presented and will increase the probability of purchases of GMO rapeseed oil. Additional modelling with other approaches has shown, however, that the characteristic "genetically modified" implies for many consumers to say generally no to GMO rapeseed oil. For them, positive oil attributes will not matter within the option GMO rapeseed oil.

## NOTES

1. The interpretation of effect-coded variables differs slightly from that of dummy-coded variables: Within the effect coding, the estimated coefficients represent the deviation from the general average as opposed to the deviation from the reference

category in case of the dummy coding. The coefficient of the reference category is not zero as under dummy coding, but the negative sum of the included variables, so that the total average equates to zero.

2. For the exact implementation of an orthogonal-polynomial coding see [16], p. 267 et seq.
3. The likelihood-ratio is defined as  $\rho = 1 - (LL(\hat{\beta})/LL(0))$ , where  $LL(\hat{\beta})$  denotes the LL value using the estimated parameters and  $LL(0)$  the LL value if all parameters are equated to 0 ([16] pp. 53). The corrected likelihood-ratio is adjusted by the number of degrees of freedom. A definition can be found in [16], p. 55.
4. The coefficient of the variable *NATIVE*, e.g., is much higher for the alternative "conventional" than for the "ecological" one.
5. Interpreting the coefficients the effect coding is to be taken in account, i.e. the value of the reference categories is not 0 like with the dummy coding, but the negative sum of the included variables. In case of the first MNL model, for instance, the reference category "without extra utility" amounts to the following value: "without extra utility" =  $-(OMEGA+PHYTO) = -(0.229+0.028) = -0.257$ .
6. In general, it has to be borne in mind that a superior situation of decision-making between the different cultivation methods is examined in the present study. Therefore, it is quite possible that the characteristic "native" would play a more important role if the respondents had to decide between two ecological rapeseed oils. In the present analysis, however, it is rather irrelevant.

## REFERENCES

- [1] Demaison L, Moreau D (2002) Dietary n-3 Polyunsaturated Fatty Acids and Coronary Heart Disease-Related Mortality: A Possible Mechanism of Action. In: Cell Mol Life Sci 59(3):463-477
- [2] Mukherjee K D, Warwel S, Weber N (2002) Omega-3-Fettsäuren und funktionelle Lebensmittel. In: Warwel S, Weber N (Hrsg.): Lipide als Funktionelle Lebensmittel. Landwirtschaftsverlag Münster-Hiltrup, Münster

- [3] Froman B, Ursin V (2002) Genetic Modification of Oils for Improved Health Benefits: Production of Long Chain Omega-3 Acids in Plants. In: Abstracts Papers of American Chemical Society 223:031-AGFD Part1
- [4] Yankah V V, Jones P J H (2001): Phytosterols and Health Implications - Efficacy and Nutritional Aspects. *Inform* 12:899-903
- [5] Law M (2000) Plant Sterol and Stanol Margarines and Health. *Brit Med J* 320:861-864
- [6] Ragotzky K (2001) Pflanzensterole. In: Erbersdobler, H F, Meyer, A H (Hrsg.): *Praxishandbuch Functional Food*. Behr's Verlag, Hamburg
- [7] Venkatramesh M, Karunanandaa B S, Gunter C, Thorne G, Crowley J (2000) Increased Sterol Content in Oilseeds through Biotechnology. Annual Meeting of the American Society of Plant Physiologists, July 15-19, San Diego, CA
- [8] Nielsen N A, Bech-Larsen T, Grunert K G (1998) Consumer Purchase Motives and Product Perceptions: A Laddering Study on Vegetable Oil in Three Countries. *Food Qual Prefer* 9:455-466
- [9] Sulzer S (2005a) Einkaufskriterien für Speiseöl. Centrale Marketinggesellschaft der deutschen Agrarwirtschaft (CMA), Bonn, written responses
- [10] Wirthgen B, Kuhnert H, Altmann M, Osterloh J und Wirthgen A (1999) Die regionale Herkunft von Lebensmitteln und ihre Bedeutung für die Einkaufsentscheidung der Verbraucher. In: *Berichte über Landwirtschaft* 77(2):243-261
- [11] Sulzer S (2005b) Preise von Rapsöl. Centrale Marketinggesellschaft der deutschen Agrarwirtschaft (CMA), Bonn, written responses
- [12] Lusk J L (2003) Effects of Cheap Talk on Consumer Willingness-to-Pay for Golden Rice. *Am J Agr Econ* 85:840-856
- [13] Train K (2002) *Discrete Choice Methods with Simulation*. Cambridge University Press, Cambridge, UK
- [14] Adamowicz W, Louvière J, Williams M (1994) Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. *J Environ Econ Manag* 26:271-292
- [15] Bech M, Gyrd-Hansen D (2005) Effects Coding in Discrete Choice Experiments. *Health Econ* 14:1079-1083
- [16] Louvière J J, Swait J, Hensher D A (2001) *Stated Choice Methods: Analysis and Applications*. Cambridge University Press, Cambridge, UK
- [17] INRA (2001) *Europeans, Science and Technology, Eurobarometer 55.2*. European Commission, Brussels, Belgium
- [18] Noussair C, Robin S, Ruffieux B(2002) Do Consumers not care about Biotech Foods or Do They Just Not Read the Labels. *Econ Lett* 75:47-53.
- [19] Springer A, Mattas K, Papastefanou G, Tsioumanis A (2002) Comparing Consumer Attitudes towards Genetically Modified Food in Europe. Xth Congress of the European Association of Agricultural Economics, August 28-31, Zaragoza, Spain

## APPENDIX 1: DEFINITION OF THE VARIABLES

	Variables	Description	
OSCs	<i>OSC<sub>CON</sub></i>	= 1, if conventional rapeseed oil,	= -1, if “Neither A nor B nor C “, = 0 otherwise
	<i>OSC<sub>GEN</sub></i>	= 1, if GM rapeseed oil,	= -1, if “Neither A nor B nor C “, = 0 otherwise
	<i>OSC<sub>ECO</sub></i>	= 1, if eco rapeseed oil,	= -1, if “Neither A nor B nor C “, = 0 otherwise
Characteristics Z	<i>OMEGA</i>	= 1, if rapeseed oil with ω3 fatty acids,	= -1, if rapeseed oil without extra utility, = 0 otherwise
	<i>PHYTO</i>	= 1, if rapeseed oil with phytosterols,	= -1, if rapeseed oil without extra utility, = 0 otherwise
	<i>NATIVE</i>	= 1, if native rapeseed oil,	= -1 otherwise
	<i>ORIGIN</i>	= 1, if German origin,	= -1 otherwise
	<i>LIGHT SHIELD</i>	= 1, if light-shielded bottles,	= -1 otherwise
	<i>PRICE</i>	= price x in €/0.5l [rescaled: (x-2.5)/0.75]	
	<i>PRICE<sup>2</sup></i>	= squared price [rescaled: (PRICE) <sup>2</sup> -2]	
Individual Characteristics S	<i>SEQUENCE</i>	= 1, if choice-task before attitudes	= -1 otherwise
	<i>DAILY</i>	= 1, if daily consumption,	= -1 less frequently, = 0 otherwise
	<i>WEEKLY</i>	= 1, if consumption several times a week,	= -1 less frequently, = 0 otherwise
	<i>MONTHLY</i>	= 1, if consumption several times a month,	= -1 less frequently, = 0 otherwise
	<i>BAKING</i>	= 1, if used for baking,	= -1 otherwise
	<i>FRYING</i>	= 1, if used for frying,	= -1 otherwise
	<i>SALAD</i>	= 1, if used for salad,	= -1 otherwise
	<i>COOKING</i>	= 1, if used for cooking,	= -1 otherwise
	<i>FOOD_HEALTHY</i>	= Answer on a seven-point Likert scale as to the relevance of a healthy diet	
	<i>FOOD_CHOL</i>	= Answer on a seven-point Likert scale as to the relevance of a low cholesterol diet	
	<i>CHILD</i>	= 1, if children < 15 in the household,	= -1 otherwise
	<i>MALE</i>	= 1, if male,	= -1 otherwise
	<i>AGE</i>	= Age x in years (rescaled: x/10)	
	<i>O-LEVEL</i>	= 1, if O-level,	= -1, if GCSE, = 0 otherwise
	<i>A-LEVELS</i>	= 1, if A-levels,	= -1, if GCSE, = 0 otherwise
	<i>UNIVERSITY</i>	= 1, if university degree,	= -1, if GCSE, = 0 otherwise
	<i>STUDENT</i>	= 1, if student,	= -1, employee, = 0 otherwise
	<i>HOUSEWIFE</i>	= 1, if housewife,	= -1, employee, = 0 otherwise
	<i>WORKER</i>	= 1, if worker,	= -1, employee, = 0 otherwise
	<i>SELF-EMPLOYED</i>	= 1, if self-employed,	= -1, employee, = 0 otherwise
	<i>CIVIL SERVANT</i>	= 1, if civil servant,	= -1, employee, = 0 otherwise
	<i>RETIRED</i>	= 1, if retired,	= -1, employee, = 0 otherwise
	<i>MISCELLANEOUS</i>	= 1, if other engagement,	= -1, employee, = 0 otherwise
	<i>I_FUN_POS</i>	= Index for perceived utility of FF (Mean over 6 positive attitude items)	
	<i>I_FUN_NEG</i>	= Index for perceived risks of FF (Mean over 6 negative attitude items)	
	<i>I_GEN_POS</i>	= Index for perceived utility of GMF (Mean over 6 positive attitude items)	
	<i>I_GEN_NEG</i>	= Index for perceived risks of GMF (Mean over 6 negative attitude items)	

## APPENDIX 2: ESTIMATION RESULTS OF THE MNL MODELS (1)

	<i>Variables</i>	<i>Alternatives</i>	<i>Linear . only Z</i>			<i>Linear. Z. S</i>			<i>Squared. Z. S. S*Z</i>		
			Coeff.	(std. error) <sup>a)</sup>		Coeff.	(std.error) <sup>a)</sup>		Coeff.	(std.error) <sup>a)</sup>	
<i>OSCs</i>	<i>OSC<sub>GEN</sub></i>	Genetical	-0.454	(0.02)	***	-0.390	(0.13)	**	-0.438	(0.14)	**
	<i>OSCCON</i>	Conventional	0.346	(0.02)	***	0.216	(0.07)	**	-0.193	(0.10)	<sup>S</sup>
	<i>OSCECO</i>	Ecological	1.203	(0.02)	***	0.801	(0.09)	***	1.184	(0.12)	***
<i>Characteristics Z</i>	<i>OMEGA</i>	Genetical	0.229	(0.03)	***	0.260	(0.04)	***	0.270	(0.04)	***
	<i>PHYTO</i>	Genetical	0.028	(0.02)		0.032	(0.04)		0.017	(0.04)	
	<i>NATIVE</i>	Genetical	0.194	(0.02)	***	0.218	(0.03)	***	0.222	(0.03)	***
	<i>NATIVE</i>	Conventional	0.312	(0.01)	***	0.323	(0.02)	***	0.329	(0.02)	***
	<i>NATIVE</i>	Ecological	0.066	(0.01)	***	0.074	(0.02)	***	0.071	(0.02)	***
	<i>ORIGIN</i>	Genetical	0.086	(0.02)	***	0.091	(0.03)	***	0.093	(0.03)	***
	<i>ORIGIN</i>	Conventional	0.163	(0.01)	***	0.171	(0.02)	***	0.164	(0.02)	***
	<i>ORIGIN</i>	Ecological	0.130	(0.01)	***	0.145	(0.02)	***	0.143	(0.02)	***
	<i>LIGHT SHIELD</i>	Genetical	0.136	(0.02)	***	0.163	(0.03)	***	0.156	(0.03)	***
	<i>LIGHT SHIELD</i>	Conventional	0.046	(0.01)	***	0.057	(0.02)	**	0.060	(0.02)	**
	<i>LIGHT SHIELD</i>	Ecological	-0.004	(0.01)		-0.005	(0.02)		-0.011	(0.02)	
	<i>PRICE</i>	Genetical	-0.273	(0.02)	***	-0.303	(0.02)	***	-0.495	(0.06)	***
	<i>PRICE</i>	Conventional	-0.247	(0.02)	***	-0.260	(0.02)	***	-0.725	(0.08)	***
	<i>PRICE</i>	Ecological	-0.599	(0.02)	***	-0.655	(0.02)	***	-1.017	(0.08)	***
	<i>PRICE</i> <sup>2</sup>	Genetical							-0.018	(0.03)	
	<i>PRICE</i> <sup>2</sup>	Conventional							-0.213	(0.04)	***
	<i>PRICE</i> <sup>2</sup>	Ecological							0.170	(0.04)	***

## APPENDIX 2: ESTIMATION RESULTS OF THE MNL MODELS (2)

	<i>Variables</i>	<i>Alternatives</i>	<i>Linear . only Z</i>	<i>Linear. Z. S</i>	<i>Squared. Z. S. S*Z</i>
			Coeff. (std. error) <sup>a)</sup>	Coeff. (std.error) <sup>a)</sup>	Coeff. (std.error) <sup>a)</sup>
<i>Individual Characteristics S</i>	<i>SEQUENCE</i>	Genetical		0.213 (0.03) ***	0.215 (0.03) ***
	<i>SALAD</i>	Ecological		0.127 (0.02) ***	0.118 (0.02) ***
	<i>COOKING</i>	Ecological		-0.079 (0.02) ***	-0.088 (0.02) ***
	<i>FOOD_HEALTHY</i>	Genetical		0.129 (0.02) ***	0.126 (0.02) ***
	<i>FOOD_HEALTHY</i>	Ecological		0.292 (0.02) ***	0.286 (0.02) ***
	<i>O-LEVEL</i>	Genetical		0.004 (0.04)	0.008 (0.04)
	<i>A-LEVELS</i>	Genetical		0.036 (0.04)	0.039 (0.04)
	<i>UNIVERSITY</i>	Genetical		-0.267 (0.05) ***	-0.276 (0.05) ***
	<i>STUDENT</i>	Genetical		-0.404 (0.07) ***	-0.586 (0.09) ***
	<i>SELF-EMPLOYED</i>	Genetical		0.333 (0.06) ***	0.452 (0.07) ***
	<i>STUDENT</i>	Ecological		-0.320 (0.05) ***	-0.366 (0.05) ***
	<i>SELF-EMPLOYED</i>	Ecological		0.467 (0.05) ***	0.501 (0.05) ***
	<i>INDEX_FUNPOS</i>	Genetical		0.149 (0.02) ***	0.150 (0.02) ***
	<i>INDEX_FUNNEG</i>	Genetical		-0.044 (0.02) *	-0.042 (0.02) <sup>S</sup>
	<i>INDEX_GENPOS</i>	Genetical		0.210 (0.02) ***	0.222 (0.02) ***
	<i>INDEX_GENNEG</i>	Genetical		-0.316 (0.02) ***	-0.311 (0.02) ***
<i>INDEX_GENPOS</i>	Ecological		-0.128 (0.02) ***	-0.107 (0.02) ***	
<i>INDEX_GENNEG</i>	Ecological		0.069 (0.02) ***	0.079 (0.02) ***	
<i>Interactions S*Z</i>	<i>PHYTO*FOOD_CHOL</i>	Genetical			0.072 (0.02) ***
	<i>PRICE*STUDENT</i>	Ecological			-0.076 (0.02) ***
	<i>PRICE*MALE</i>	Genetical			-0.057 (0.02) **
	<i>PRICE*MALE</i>	Conventional			-0.157 (0.05) **
	<i>PRICE*MALE</i>	Ecological			-0.066 (0.02) **
N:			14004	14004	14004
Mean loglikelihood:			-1.156	-1.074	-1.070
Adjusted likelihood ratio:			0.166	0.225	0.228

a) \*\*\*, \*\*, \*, <sup>S</sup> significant at the 99.9%-, 99%-, 95%-, 90%-level.

Source: Own presentation.

## APPENDIX 3: MEAN WILLINGNESS-TO-PAY FOR DIFFERENT RAPESEED OIL ALTERNATIVES

	Genetically modified (€/0.5l)	<i>Alternative</i> Conventional (€/0.5l)	Organic (€/0.5l)
<i>ORGANIC</i>	---	---	1.56
<i>GENETICALLY MODIFIED</i>	-2.18	---	---
<i>OMEGA</i>	1.37	---	---
<i>PHYTO</i>	0.80	---	---
<i>NATIV</i>	1.08	1.86	0.17
<i>ORIGIN</i>	0.45	0.99	0.33
<i>LIGHT SHIELD</i>	0.81	0.33	0.01

Source: own presentation.

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