Journal of Agricultural and Resource Economics 47(1):128–144 ISSN: 1068-5502 (Print); 2327-8285 (Online)

doi: 10.22004/ag.econ.309882

Identifying Motivations for Acceptance of Cisgenic Food: Results from a Randomized Controlled Choice Experiment

Elisa De Marchi, Alessia Cavaliere, and Alessandro Banterle

European consumers have generally been reluctant to accept genetically modified food. Novel breeding technologies that avoid transgenic manipulations seem to be more positively perceived by consumers, opening new horizons for the market. This paper investigates the motivations of consumer acceptance for cisgenic products. By comparing four information treatments (i.e., basic information, naturalness, health, and environment), we demonstrate that information on health-related benefits and especially on environmental benefits contributes to generate a positive communication landscape around cisgenic food. The results provide insights for the development of food policies and communication strategies aimed at increasing consumer acceptance for edited food.

Key words: edited food, food choices, food information, information treatment

Introduction

Since the 1994 introduction of the first genetically modified (GM) food, the famous "Flavr Savr" delayed-ripening tomato, GM food production has become the core of one of the most divisive debates in modern agriculture. Especially in the European Union (EU), early GM foods obtained through transgenesis have struggled with consumers' generalized negative perception. Over the past decades, consumers have shown (and continue to demonstrate) concerns about GM-related ethical issues, about their naturalness, and about their potential harmful effect on the environment and on human health (Radas, Teisl, and Roe, 2008; Dannenberg, 2009; Frewer et al., 2013; Zilberman et al., 2013; Delwaide et al., 2015; Pakseresht, McFadden, and Lagerkvist, 2017; Ventura et al., 2017; Pham and Mandel, 2019). Up to now, the lack of public acceptance of these GM products has represented a troublesome issue for their development and commercialization, since consumers play a key role in influencing the market with their consumption choices (McFadden, 2016; Voigt and Münichsdorfer, 2019). As a result, potential efficiency gains deriving from biotechnology applications in agriculture—such as contributing to food security (i.e., sufficient calories) of future generations, improving diet quality, and reducing environmental impact (Potrykus, 2017; De Marchi et al., 2019; Pham and Mandel, 2019)—have been remarkably hampered. Further, EU consumer rejection of GM food has become a barrier in terms of trade between EU and extra-EU countries (Voigt and Münichsdorfer, 2019; Oliveira, Silveira, and Bullock, 2020). For all these reasons, technological innovations that could align with consumer preferences to a greater extent could represent a remarkable opportunity to open new horizons for the market and lead to welfare gains for society.

Elisa De Marchi is an assistant professor, Alessia Cavaliere (corresponding author) is an associate professor, and Alessandro Banterle is a professor in the Department of Environmental Science and Policy at the University of Milan.

Review coordinated by Richard T. Woodward.

Over the past decade, research in agricultural biotechnology has led to the development of new breeding techniques (n-BT) that avoid transgenic manipulation (i.e., avoid crossing genes of different species). Among these n-BT, which include RNAi and gene-editing, cisgenesis has emerged as a viable and promising alternative to the old transgenesis, in that it allows improved traits to be obtained without crossing species barriers. Cisgenic (CIS) breeding is realized using genes exclusively belonging to sexually compatible organisms (e.g., wild relatives). Essentially, all changes that can be obtained through CIS breeding can also be obtained (over a longer period) by natural genetic variation (Schouten, Krens, and Jacobsen, 2006; Telem et al., 2013). Thanks to this specific feature, cisgenesis is less controversial and seems to be more positively regarded by the general public. To date, the literature on consumer preferences for/acceptance of CIS food is still scant compared to that on GM products. However, existing evidence is consistent in indicating that consumers are more favorably inclined toward the cisgenic technology, being willing to pay more for CIS foods than for transgenic ones (Delwaide et al., 2015; Dalla Costa, Malnoy, and Gribaudo, 2017; Rousselière and Rousselière, 2017; De Marchi et al., 2019). Another key insight emerging from these studies is that providing information can play a crucial role in shaping consumer preferences. When informing them about the various benefits that could derive from cisgenic applications, preferences for such products tend to increase (Siegrist, 2008; Lusk, McFadden, and Rickard, 2015; Pakseresht, McFadden, and Lagerkvist, 2017).

This paper aims to provide further evidence on consumer preferences and choice behavior for CIS food. Building on previous studies, we investigated the role of information provision, testing the effect of different information treatments to verify whether and the extent to which they affect consumer preferences. Specifically, the effect of basic, objective information on CIS breeding were compared with information on naturalness, possible health benefits, and environmental benefits that could be obtained through cisgenesis application. To this purpose, we designed a hypothetical choice experiment (CE) using apples as the product of interest to examine choice behavior across cisgenic and conventional fruit alternatives. Unlike previous studies, we did not include GM options. This was motivated by the fact that most of previous literature on cisgenic food has already demonstrated that consumers prefer this latter option over the old GM food products (Delwaide et al., 2015; Dalla Costa, Malnoy, and Gribaudo, 2017; Rousselière and Rousselière, 2017).

The results of this study contribute to the literature on several points. First, they provide novel evidence on how consumers value cisgenic over conventional food alternatives and shed new light on how consumers trade off product attributes in this choice context. This allows us to better understand whether CIS food alternatives—and food produced via n-BT more generally—may gain some space in the market in a way that the old GM products struggled to in the past. Second, the study sheds new light on which could be the most effective way to develop communication strategies and polices for food products edited through the application of cisgenesis and other n-BT. To the best of our knowledge, this is the first study that simultaneously compares the effectiveness of four information treatments, building on the main insights from previous studies of this type. By doing so, the results contribute to identifying which type of information could be more effective in positively affecting consumer preferences.

Study Background

EU Regulatory Environment: State of the Art and Criticisms

The current European regulatory framework on GM products is very complex, with regulations based on the precautionary principle and imposing strict rules for the authorization, commercialization, and consumption of GM products (Voigt and Münichsdorfer, 2019). There is only one GM crop currently authorized for commercial cultivation (i.e., Bt-maize line MON810.3), which is cultivated in Spain and Portugal. No other member states cultivate GM seeds and, in many countries (e.g., Italy, France, Germany), their cultivation has been prohibited at the national level in line with the Directive (EU) 2015/412.

The debate on how to regulate cisgenesis and other emerging n-BT has been ongoing for more than 10 years, with supporters arguing that these new technologies should be regulated by specific laws, independent of those already existing on GM organisms (i.e., Directive 2001/18/EC on the deliberate release into the environment of GM organisms and Regulation (EC) N. 1829/2003 on genetically modified food and feed) (Eriksson et al., 2018). Their reasons are grounded on the fact that cisgenesis and other n-BT differ substantially from the old transgenesis, thus implying the need for tailored regulations (Schouten, Krens, and Jacobsen, 2006). The final say on this matter came in June 2018 with a decision of the European Court of Justice establishing that cisgenesis and other n-BT must, *de facto*, be considered as GM. The decision is based on the definition of GM organisms provided in Article 2 of Directive 2001/18/EC reporting that a GM organism is “an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination.” This definition, which defines the scope of applicability of the EU’s GM organism’s regulatory framework, leaves space to open questions and criticisms. Cisgenesis induces changes that can, in fact, be obtained in nature. The Court of Justice decision seems mainly grounded in a process-based interpretation, according to which the application of an unnatural technique itself is sufficient to classify an organism as GM (Voigt and Münichsdorfer, 2019).

The absence of tailored regulations for cisgeneis and other n-BT may have some drawbacks that continue to raise concerns. For instance, the absence of a regulatory distinction between transgenesis and emerging n-BT could result in consumers transferring negative attitudes toward the former to the latter (Schouten, 2014). Further, the fact that cisgenesis and n-BT products are subject to Directive 2001/18/EC implies the same labeling rules. In this way, consumers would not be able to distinguish CIS products from GM ones at the moment of purchase. The current EU regulatory approach seems to be aligned with consumers’ generalized lack of acceptance. According to past studies, such a stringent regulatory environment further fuels consumers’ generalized suspicion of GM products (Pakseresht, McFadden, and Lagerkvist, 2017).

Consumer Preferences

Consumer acceptance of GM food has been widely explored. According to past literature, consumer acceptance of GM food is strongly affected by ethical concerns, limited perceived benefits, high perceived risks for both the human health and the environment, and low perceived naturalness, among other things (for a complete review, see Lusk and Coble, 2005; Costa-Font, Gil, and Traill, 2008; Frewer et al., 2013; Hess et al., 2016). When evaluating GM products, country of origin also plays an important role. While consumers tend to prefer non-GM foods overall, they have less negative preferences for domestic GM products compared to foreign ones. Moreover, significant preference differences have been observed when comparing GM products of different countries. This is likely due to the way in which consumers evaluate a country’s image, its stability and politics, and its technology level (Gao et al., 2019). Another factor that seems to induce people to form negative beliefs about GM foods is represented by consumer level of knowledge. Some studies have reported that the feeling of uncertainty determined by limited knowledge and information makes consumers incapable of properly evaluating the degree to which these products are associated with concrete risks, thus overestimating possible consequences (Siegrist, 2008; McFadden and Lusk, 2016). Fernbach et al. (2019) found that scarce objective knowledge of science and genetics is associated with extreme levels of opposition to GM foods, while higher objective knowledge on these topics leads people to form less negative judgements about GM products. In line with these results, McFadden and Lusk (2016) showed that when individuals have higher objective knowledge about GM food, they tend to be more agreeable toward these products. Information plays a crucial role in that it represents the means through which consumers can increase their knowledge, potentially changing their opinions. As demonstrated in previous studies, providing consumers with specific information about health-, nutrition-, and environment-related benefits can increase their preferences and willingness to pay for GM food alternatives (Siegrist, 2008; Lusk, McFadden, and Rickard, 2015; Pakseresht, McFadden, and Lagerkvist, 2017).

With specific regard to CIS food, evidence is still limited. Taken together, existing results consistently indicate that consumers prefer CIS over transgenic products. Delwaide et al. (2015) conducted the first cross-country study involving five EU countries. Using rice as a case study, they investigated consumer acceptance of CIS versus transgenic alternatives as well as consumer willingness to pay (WTP) for such products testing the effect of different labels and information treatments, specifically GM information only, information about possible environmental benefits deriving from new breeding technologies, and specific information about CIS rice. They reported that European consumers are able to distinguish CIS and transgenic technologies but claim not to have enough information to decide whether they would be willing to consume transgenic or CIS food. However, WTP estimates revealed that respondents were willing to pay more to avoid transgenic rice than CIS, which suggests that CIS rice is overall preferred, especially when associated with environmental benefits.

In a subsequent study, Shew et al. (2016) investigated the acceptance of CIS rice in India and showed that 73% of respondents were willing to consume CIS rice, which was perceived to be more natural. Moreover, although they found no difference in WTP between CIS and transgenic alternatives, they showed that consumers' WTP rose when respondents were informed that the biotechnology was associated with no fungicide use. Their results are corroborated by Edenbrandt, Gamborg, and Thorsen (2018), who examined consumer preferences and WTP for rye bread made with CIS or transgenic rye, conventionally grown or without pesticide use, compared with bread made with conventional rye grown using conventional or organic methods. Their findings stress that, although European consumers overall prefer conventional food, they are able to distinguish between transgenesis and CIS and prefer the latter option, which is also reflected in the WTP measurement. Further, they once again highlighted that consumer preference increased when cisgenesis was coupled with "pesticide-free" information. Using 2010 Eurobarometer data, Rousselière and Rousselière (2017) found that, despite some country-based differences, European consumers tend to prefer CIS over transgenesis, particularly when the biotechnology application allows avoiding pesticide treatments. Higher preference for CIS over transgenic food were also elicited by Tsiboe et al. (2017) and Edenbrandt et al. (2018). Edenbrandt et al. analyzed WTP variations for CIS food over transgenic and conventional alternatives under different information conditions; in line with other studies, they found that conventional products are preferred overall but that consumers find CIS more acceptable than transgenic. Further, they provided confirmatory evidence that associating genetic manipulation with information about attributes that can be of concrete value for consumers, and their acceptance for such products increases considerably. Overall, these results suggest that providing consumers with information about the benefits that could be derived from cisgenesis application may notably increase their acceptance of these food alternatives.

Methodology

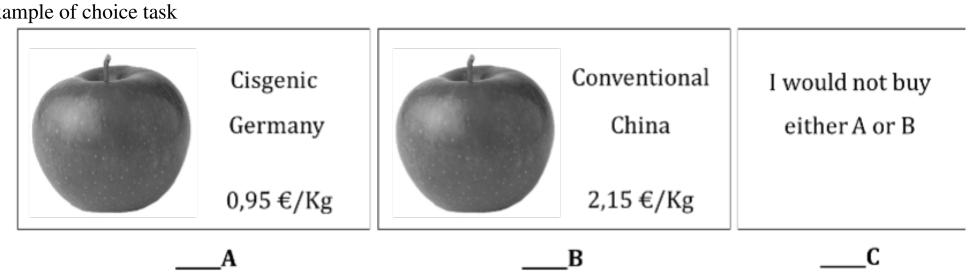
Choice Experiment Design

This study uses a randomized controlled hypothetical choice experiment (CE) in which apples are the product of interest. Apples were chosen because they are a modestly priced product with which Italian consumers are familiar and are available year-round. Moreover, importantly, although they are not commercialized in Italy, CIS apples have been already developed for both environmental- and health-related purposes (Huynh, Araña, and Prior, 2018; De Marchi et al., 2019).

Table 1. Choice Experiment Attributes and Choice Task Example

	Attributes			
	Price (per 1 kg)	**Technology of Production**	**Brand**	**Country of Origin**
Levels	€0.95	Conventional	Melinda	Italy
	€1.35	Cisgenic	Unbranded	Germany
	€1.75			China
	€2.15			

Example of choice task



In a CE task, respondents complete a set of choices typically composed of two or more experimentally designed alternatives differing in terms of attribute allocation plus an opt-out option. In this study, the selected attributes were represented by price, production technology, country of origin (COO), and brand (Table 1). Price levels were based on the average market price for 1 kilogram of apples, with the four price intervals set to reflect market variability. Technology represented the key attribute for our analysis and characterized apple alternatives obtained by conventional breeding or CIS breeding. Brand and COO were chosen as they are among the most important features that characterize fresh fruit in the Italian market. Brand was represented by the logo of one of the most popular apple brands in northern Italy, named Melinda. COO options were Italy, Germany, and China; the latter two are among the biggest producers of apples in the world (Food and Agriculture Organization of the United Nations, 2017).

The allocation of attributes and levels to the experimentally designed alternatives was based on a Bayesian design (Sándor and Wedel, 2001), performed using Ngene version 1.1.2. Since we could not conduct a pilot test, the prior values were set following an alternative approach, as proposed by Bliemer and Collins (2016). The procedure allowed us to set prior values starting from the average attribute level range by assuming equal contribution of all attributes to the utility function (Bliemer and Collins, 2016). Given that Melinda is an Italian brand, the design was constrained such that the brand logo was only paired with Italy as country of origin. The final design (i.e., D_b-error = 0.26, S-estimate = 31.41) resulted in 24 choice sets, divided in three different blocks of eight choice sets, each comprising two experimentally designed apple alternatives and a “no-buy” option (i.e., the possibility for respondents to opt out). The choice sets were randomly and evenly presented to respondents. The order of choice sets within each block was also randomized.

Further, to reduce hypothetical bias, a cheap talk script was shown before beginning the CE (Cummings and Taylor, 1999; Lusk, 2003; Carlsson, Frykblom, and Lagerkvist, 2005). Hypothetical bias can be described as the extent to which individuals might behave inconsistently when facing a hypothetical choice situation in which they are not required to actually translate their choices to real commitments. Adopting a cheap talk script has proven effective in reducing hypothetical bias, thus producing more reliable results (Tonsor and Shupp, 2011).

Data Collection, Experimental Procedure, and Treatment Description

The data for the analysis were collected using face-to-face consumer surveys in the Milan metropolitan area (northern Italy) between March and June 2017. The interviews were collected following a simple random sampling approach. In total, 972 adult (i.e., at least 18 years old) consumers were approached. The response rate was 85% and the final sample comprised 826 responses.

The information treatments (i.e., control treatment, in which only basic information on cisgenesis was provided to respondents; naturalness; health; and environment treatments) consisted of providing respondents with different information before completing the CE task. Individuals were randomly assigned to one of these four experimental treatments. Information treatments were structured to compare a baseline information on cisgenesis (i.e., technical explanation of the technology) with information about the naturalness of this breeding method and on possible private and public benefits that could be obtained through this biotechnology application. The control treatment was mainly aimed at providing respondents with some essential information about cisgenesis, such that they could more reliably complete the CE tasks and make trade-offs across product alternatives. This was necessary because CIS apples (or other CIS products) are not available on the Italian market and consumers are unfamiliar with this type of technology. The naturalness treatment reported the same information as the control, with additional information specifying that the result of CIS breeding could potentially occur in nature over a longer period. The rationale behind this information was based on evidence demonstrating that the perceived naturalness is a key factor for consumer acceptance of modified food products. The health and environment treatments were structured to stress some potential benefits of the technology application in food production. These two information treatments were associated with a private utility dimension (i.e., health improvement) and to a social utility dimension (i.e., reduction of environmental impact). More precisely, the health treatment provided the same statement as the control, with the addition of health-related information about the increased amounts of anthocyanins in the fruit, which improve apples' nutritional profile and have a beneficial effect on consumer health. Similarly, the environment treatment contained the same basic information as in the control, with additional information on the possibility of avoiding pesticide use for controlling common apple infections, thus reducing the environmental impact (Busdieker-Jesse et al., 2016). All information treatments are illustrated in detail in Table 2. Information contents were checked for accuracy by an expert in biotechnologies.

After receiving the information treatment, each respondent was asked to read the cheap talk script and to complete the CE task on apples. This procedure was aimed at allowing a comparison across the effects of the different information provision on preferences for cisgenic over conventional apples, in order to identify which information mostly affects consumer choice behavior.

Econometric Approach

While completing the hypothetical CE task, respondents were asked to choose their preferred alternative among those available in the proposed choice sets. The choice process is explained by the assumptions of random utility theory (McFadden, 1974), according to which individuals choose the alternative that, given its combination of attributes, provides the highest utility level. In other words, the probability of an experimentally designed alternative i being chosen by individual n in choice situation t can be described as

$$\text{Prob}_{nit} = \text{Prob}[(U_{nit} \geq U_{njt}) \; \forall \; i \neq j]. \tag{1}$$

That is, the probability of an individual n choosing alternative i (after having evaluated each alternative in the choice set) is equal to the probability that the utility of alternative i is greater than—or equal to—the utility of an alternative j, with U_{nit} and U_{njt} representing the utilities associated i and j, respectively.

Table 2. Information Treatment Description

Treatment 1 CONTROL (N = 230)	Treatment 2 NATURALENESS (N = 200)	Treatment 3 HEALTH (N = 200)	Treatment 4 ENVIRONMENT (N = 196)
Cisgenic apple is bred using a process in which genes are transferred between crossable organisms that belong to the same species (like for instance wild apple varieties) or closely related species.	Cisgenic apple is bred using a process in which genes are transferred between crossable organisms that belong to the same species (like for instance wild apple varieties) or closely related species.	Cisgenic apple is bred using a process in which genes are transferred between crossable organisms that belong to the same species (like for instance wild apple varieties) or closely related species.	Cisgenic apple is bred using a process in which genes are transferred between crossable organisms that belong to the same species (like for instance wild apple varieties) or closely related species.
	The same result may be reached by cross-breeding that occurs in nature or by traditional breeding, but it would require a longer time frame. The use of this technique allows to obtain results in less time.	*The transferred genes allow to increase the content of anthocyanins, which are powerful antioxidants exerting a protective action on the cells of our organism preventing ageing processing. Particularly, anthocyanins are very useful to prevent problems related to blood circulation.*	*The transferred genes make apples resistant to two important diseases, namely "scab" (caused by a fungus), and "fire blight", which force farmers to use pesticides. Therefore, the cultivation of cisgenic apples allows to reduce the use of fungicide sprays, with important benefits for the environment.*

Random utility theory assumes that the utility associated with the ith alternative can be divided into two main components. One is a nonrandom component that is observed by the analyst (denoted as V_{nit}), while the other is a random unobservable component commonly referred to as error (denoted as ε_{nit}), which is assumed to be *i.i.d.* Gumbel distributed over alternatives and independent from V_{nit}. Accordingly, the utility that consumer n derives from choosing alternative i can be illustrated as

$$U_{nit} = V_{nit} + \varepsilon_{nit} = \text{Prob}[(V_{nit} + \varepsilon_{nit}) \geq (V_{njt} + \varepsilon_{njt}) \; \forall \; i \neq j]. \tag{2}$$

The observable component of U_{nit} is related to the attribute coefficients to be estimated by the analyst based on consumer choices. Therefore, in the present study, V_{nit} is defined as

$$V_{nit} = \alpha \times \textit{No-buy} + \beta \times \textit{Price}_{nit} + \gamma \times \textit{Technology}_{nit} + \delta \times \textit{Brand}_{nit} + \sum_{k=1}^{3} \lambda_k \times \textit{COO}_{nitk}. \tag{3}$$

It follows that U_{nit} can be rewritten as

$$\begin{aligned} U_{nit} = {} & \alpha \times \textit{No-buy} + \beta \times \textit{Price}_{nit} + \gamma \times \textit{Technology}_{nit} + \delta \times \textit{Brand}_{nit} \\ & + \sum_{k=2}^{3} \lambda_k \times \textit{COO}_{nitk} + \varepsilon_{nit}, \end{aligned} \tag{4}$$

where *No-buy* is a dummy variable assuming a value of 1 when respondents chose to opt out and 0 otherwise; α is the related alternative-specific constant; $\textit{Price}_{nit}$ represents the market price for 1 kilogram of apples; $\textit{Technology}_{nit}$ is a dummy variable assuming a value of 1 for CIS apples and 0 for apples obtained by conventional breeding; $\textit{Brand}_{nit}$ is a dummy variable assuming a value of 1 when alternatives carry the Melinda logo and 0 otherwise; and $\textit{COO}_{nitk}$ corresponds to the effects coded country-of-origin dummy variables, with Italy used as base category and k representing the related kth attribute levels (i.e., Germany and China) (Bech and Gyrd-Hansen, 2005).

It is possible to analyze different model specifications based on the assumptions made on the distribution of the random component of the utility function and on consumer preferences. We used a random parameter logit with error component (RPL-EC), which allows coefficients to vary randomly across individuals deviating from the population mean, thus accounting for heterogeneous preferences. The RPL-EC specification also includes an additional error component (EC) in the utility function (normally distributed with 0 mean), which is associated with the buying alternatives in the choice set and not with the no-buy option. The EC accounts for correlation of random effects between utilities of the experimentally designed product alternatives. In fact, the buying alternatives available in each choice set are characterized by given combinations of attribute levels that are not present in the no-buy option (Scarpa, Ferrini, and Willis, 2005; Scarpa, Campbell, and Hutchinson, 2007). As such, the buying alternatives are likely correlated with one another but not with the opt-out. The utility function of the RPL-EC, in which preference parameters vary across individuals and the EC (η_{it}) varies across product alternatives, is expressed as

$$U_{nit} = \alpha_n \times \textit{No-buy} + \beta_n \times \textit{Price}_{nit} + \gamma_n \times \textit{Technology}_{nit} + \delta_n \times \textit{Brand}_{nit} + \sum_{k=2}^{3} \lambda_{nk} \times \textit{COO}_{nitk} + \varepsilon_{nit} + \eta_{it}. \quad (5)$$

The price coefficient is assumed to be constant across individuals, while the coefficients of the nonprice attributes are specified as random variables with normal distribution. The assumption of fixed price implies that respondents have homogeneous preferences for this attribute, which might be untrue in reality. However, fixing the price coefficient allows us to avoid the identification problems that can occur in models in which all coefficients are random (Ruud, 1996; Train and Weeks, 2005) and ensures that the estimated price coefficient will be normally distributed and negative, consistent with economic theory (i.e., consumers prefer lower prices, *ceteris paribus*). Given the methodological implications, this approach has been commonly applied in previous studies on consumer food choice behavior (Van Loo et al., 2011; Van Wezemael et al., 2014; De Marchi et al., 2016; Bazzani et al., 2017). Further, the RPL-EC specification in this study also accounted for full correlation (i.e., correlation of random parameters of the attributes that are common across alternatives).

Results

Sample Description

Table 3 reports the main sociodemographic and economic characteristics of the respondents in each treatment. In the control group, individuals aged 18–24 years were underrepresented with respect to the other experimental groups, while those aged 45–64 years were slightly overrepresented. In the other three treatments, age classes were homogeneously distributed, with only slight differences across groups. The same holds for gender, with a higher number of men in the environment group with respect to the other treatment conditions. The high school diploma and the medium monthly income (i.e., 1,500€–3,000€) were the most-represented education level and income, respectively, in all groups.

Choice Experiment Results

To compare differences in preference intensities across treatments for the different product attributes, we estimated four models using data from respondents in the control (Model 1), naturalness (Model 2), health (Model 3), and environment (Model 4) treatments. Multiple specifications—including MNL, RPL,[1] RPL-EC, and RPL-EC with full correlation—were tested for each model. As demonstrated by the model fit (see Appendix A), the RPL-EC with full correlation performed

[1] The results of the MNL, RPL, and RPL-EC models are fully available upon request.

Table 3. Sociodemographic and Economic Characteristics of the Sample across Treatments

Characteristics	Control (%)	Naturalness (%)	Health (%)	Environment (%)	Total Sample (%)
Age					
18–24 years	13.47	25.50	24.50	22.44	21.18
25–34 years	17.39	28.00	21.25	27.03	23.25
35–44 years	16.95	12.00	14.00	15.81	14.77
45–54 years	21.29	19.50	17.00	17.85	19.01
55–64 years	18.69	11.00	16.50	12.24	14.76
>65 years	12.21	4.00	6.75	4.63	7.03
Gender					
Male	47.39	50.50	50.50	57.14	51.21
Female	52.61	49.50	49.50	42.86	48.79
Education					
Primary school	3.91	3.00	4.00	3.06	3.51
Secondary school	16.96	26.00	28.00	22.45	23.12
High school	44.78	48.50	49.00	54.08	48.91
Bachelors degree	29.57	18.00	15.00	17.86	20.46
Masters degree	4.78	4.50	4.00	2.55	4.00
Monthly household income					
<800€	6.99	7.33	9.55	10.71	8.59
800–1,500€	23.14	28.27	29.65	23.98	26.13
1,500–3,000€	42.79	46.07	46.23	46.94	45.40
3,000–5,000€	21.40	15.18	13.57	12.76	15.95
>5,000€	5.68	3.14	1.01	5.61	3.93
No. of obs.	230	200	200	196	

better, which was highlighted by the lower log-likelihood values and the lower values of the Bayesian information criterion (BIC) and Akaike information criterion (AIC). Accordingly, these models were selected for presentation and discussion.

Table 4 reports the results of the models' estimates. The error component was significant in all models, which corroborates the appropriateness of the selected model specification. The price coefficient was significant and negative in all models, meaning that—consistent with economic theory—respondents on average preferred apple alternatives with lower prices (i.e., increasing price decreases respondents' utility). The coefficient of the no-buy option was significant and negative in Models 2, 3, and 4, indicating that respondents in these groups preferred to choose one of the two proposed apple alternatives rather than opting out.

With regard to the technology attribute, the results showed that respondents in the control, naturalness, and health treatments overall preferred conventional over CIS apples, as demonstrated by the negative and significant estimated coefficients. However, the magnitude of the technology coefficient progressively decreased from Model 1 to Model 3 (−3.670, −3.328, 0.995 respectively) and eventually lost statistical significance in Model 4. These results indicate that the different information provided was able to affect the way in which respondents evaluated the production technology, making preferences for CIS apple alternatives less negative. In this regard, the strongest effect was observed for the health and environment treatments, while the magnitude of the technology coefficient of the naturalness group was only slightly lower than that of the control. Additionally, in both the control and the naturalness treatments, the production technology was the

Table 4. RPL-EC Estimation Results

Product Attributes	Model 1 Control	Model 2 Naturalness	Model 3 Health	Model 4 Environment
Technology				
Mean	−3.669***	−3.328***	−0.995**	−0.456
	(0.447)	(0.514)	(0.421)	(0.510)
St. dev.	4.967***	4.953***	5.009***	5.570***
	(0.483)	(0.556)	(0.492)	(0.652)
Brand				
Mean	0.767***	0.874***	0.502***	1.326***
	(0.234)	(0.284)	(0.191)	(0.272)
St. dev.	0.739*	1.655***	0.050	1.522***
	(0.391)	(0.355)	(0.359)	(0.402)
COOGermany				
Mean	1.750***	0.885**	1.020***	1.419***
	(0.492)	(0.349)	(0.321)	(0.450)
St. dev.	2.507***	1.572***	2.168***	2.137***
	(0.503)	(0.459)	(0.360)	(0.357)
COOChina				
Mean	−7.830***	−5.253***	−5.078***	−6.014***
	(1.077)	(0.739)	(0.671)	(1.011)
St. dev.	4.327***	2.553***	3.468***	3.160***
	(0.682)	(0.563)	(0.525)	(0.844)
Price				
Mean	−1.160***	−2.141***	−1.431***	−1.534***
	(0.323)	(0.441)	(0.241)	(0.352)
No-buy				
Mean	−0.931	−3.400***	−1.300**	−2.088**
	(0.781)	(0.892)	(0.539)	(0.837)
Error component				
Mean	3.005***	2.175***	1.242***	2.265***
	(0.348)	(0.360)	(0.289)	(0.351)
Model fit				
Log-likelihood	−949.47	−835.78	−910.83	−770.17
AIC[a]	1,932.9	1,705.6	1,855.7	1,574.3
No. of obs.	1,840	1,600	1,600	1,568

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.
[a]Akaike information criterion.

attribute that contributed most to consumer choices, whereas in models 3 and 4 consumers selected their preferred product alternatives, giving more importance to the other product characteristics.

In all models, the presence of the Melinda logo was positively evaluated by respondents, although it was not considered the most important product attribute.

The results also revealed that that COO played a key role in consumer choices of fresh apples. This product attribute was highly evaluated by respondents of all treatments, showing strong negative preferences for Chinese products with respect to Italian ones. German alternatives were positively evaluated in all models. This result is in line with previous findings reporting that GM domestic products are generally preferred to those imported from foreign countries (Gao et al., 2019). Further, this result seems to indicate that the image of the producing country affects preferences (Gao et al.,

Table 5. Hypothesis Test of Equality across Treatments

Treatment	Parameters	Choices	RPL-EC Correlation
Control	17	1,840	−947.47
Naturalness	17	1,600	−835.78
Health	17	1,600	−910.83
Environment	17	1,568	−770.16
Pooled	17	6,608	−3,524.57
H0: test of equality across treatments		120.66^{***}	

Notes: The result of the likelihood ratio test of the null hypothesis that coefficients are equal across treatments, calculated on 51 degrees of freedom, rejects H_0 at the $p < 0.01$ level.

2019). Italy is well known worldwide for the high reputation of its food industry and food products (Banterle, Cavaliere, and De Marchi, 2016).

As the RPL-EC models accounted for full correlation, additional information can be derived by looking at the Cholesky decomposition matrix. The significant below-diagonal elements in the Cholesky matrix indicate a positive significant cross-correlations between *Brand* and $COO_{Germany}$, as well as a negative correlation between COO_{China} and *Technology*.[2] Such cross-correlations indicate that (i) the positive evaluation of COO could be strengthened by the simultaneous presence of a popular brand and that (ii) n-BT foods are more negatively evaluated when they are produced in foreign countries, especially when consumers regard the country image with skepticism.

To further examine the effectiveness of information in influencing respondents' preferences, the null hypothesis (H_0) that the estimated coefficients are equal across treatments was tested using a likelihood ratio (LR) test, which we performed by comparing the sum of the log-likelihood estimate of each treatment to the pooled data model. The results, reported in Table 5, demonstrate that the null hypothesis is rejected at the $p < 0.01$ level, confirming that the additional information provided to consumers in the naturalness, health, and environment treatments significantly affected the parameter estimates.

Discussion and Conclusions

This paper explored the possible effect of information on consumers' preferences for food products edited through n-BT, focusing on CIS apples as a case study. Specifically, we formulated four information treatments to test how they shape preferences for CIS versus conventional apples. Each respondent was randomly assigned to one of the four experimental conditions: (i) a basic information treatment on cisgenesis (the control); (ii) information on the fact that the results of CIS breeding could also be obtained through natural genetic variation; (iii) information on the increased amount of anthocyanins, which are beneficial to health, found in CIS apples; and (iv) information on reduced pesticide use in the production of CIS apples, which reduces the environmental impact of cultivation. After receiving the information treatment, we then asked respondents to complete a hypothetical CE task. This procedure allowed us to compare differences in preferences based on the information provided. While the control treatment was only aimed at providing basic knowledge of the CIS technology, the other information emphasized naturalness as a specific feature of cisgenesis as well as the health- or environmental benefits that could be derived from CIS apple cultivation. Previous studies on both GM and CIS food had identified these three aspects as important determinants of consumer acceptance (see, e.g., Mielby, Sandøe, and Lassen, 2013; Delwaide et al., 2015; Lusk, McFadden, and Rickard, 2015; Pakseresht, McFadden, and Lagerkvist, 2017; Rousselière and Rousselière, 2017; Edenbrandt et al., 2018).

[2] (Cholesky correlation matrices available upon request).

The main novelty of this study is that it combines in a single analysis a set of information that had previously been tested in separate studies. This is important in that it allows us to directly compare information treatments and assess which is most effective, thus providing guidance for the development of future policies and communication strategies geared at increasing consumer preferences for n-BT edited food.

The results of the CE indicated that respondents in all treatments preferred conventional over CIS alternatives, which is in line with the majority of previous studies of this type (Delwaide et al., 2015; Edenbrandt, Gamborg, and Thorsen, 2018; Edenbrandt et al., 2018). However, the model estimates revealed that the information provided was effective in driving respondents' preferences for CIS apples toward less negative values. Although "less negative" is not the equivalent of "positive" preferences, this is still an important result in that it indicates that providing information to consumers may lead them to form favorable judgements of n-BT food alternatives, potentially opening new opportunities in the market.

Compared to the control condition, the information provided to the naturalness group positively affected preferences, but less than the information provided to both the health- and environment-related information treatment groups. This is demonstrated by the magnitude of the technology coefficient, which decreased progressively from the control to the health treatment, eventually losing statistical significance in the environment experimental condition. Consistent with past studies (Delwaide et al., 2015; Shew et al., 2016; Pakseresht, McFadden, and Lagerkvist, 2017; Edenbrandt, Gamborg, and Thorsen, 2018), we may argue that consumers seem to be more open to adopting technology applications when these are associated with private or social benefits. Environmental information seems to exert the strongest effect on respondents' preferences. A possible explanation could be that consumers consider reducing environmental impact to be a more urgent need than improving the nutritional profile of food. Further, it has to be considered that the Italian food market already offers a number of functional foods, some of them already enriched in anthocyanins, which may reduce the perceived benefits of the proposed apples. In contrast, the use of n-BT for reducing the use of pesticides may be perceived as one of a few possibilities to lower the environmental impact of agricultural production.

Taken together, these findings provide guidance for implementing communication strategies and possibly policy intervention geared at communicating and promoting n-BT food products to consumers. Disclosing the environmental- and/or health-related benefits, as described in the present study, might be a winning approach.

These results may suffer from some limitations that need to be acknowledged. First, we did not check for consumers' prior knowledge of cisgenesis and other n-BT. Typically, consumer knowledge on these topics is low, and we would be unlikely to find differences across population segments, but it is still possible that some bias has occurred. Second, although we used a cheap talk script, our estimates may suffer from hypothetical bias, which is likely to occur in hypothetical choice contexts. Third, the assumption of fixed price coefficients followed in this paper and the relatively small number of price levels could pose some limits to the empirical analysis in that they might not be able to accurately reflect how consumers would behave in a real purchasing setting. Further, the face-to-face nature of the survey may have produced social desirability bias. Future studies on n-BT foods should account for these issues in order to provide additional behaviorally informed and robust evidence for policy makers. Future studies could also extend the scope of this research by testing the additive effect of the different information treatments tested in this study and by verifying whether consumer product evaluation might be affected by halo effects, especially in association with health or environment treatments.

Europe's stringent regulatory framework and media coverage have significantly contributed to European consumers' general reluctance to accept GM products. The public debate around GM food has always emphasized the potential risks of these technologies rather than potential benefits (Gaskell et al., 1999; Bardin et al., 2017). For this reason, in a forward-looking perspective, it appears essential to distinguish between the old GM and the more recent n-BT technologies to avoid transferring consumer skepticism to these promising new breeding techniques. To this purpose, information of the type analyzed in this study could be of help for the development of targeted and effective communication strategies and policies on cisgenesis and on n-BT more generally.

Overall, it seems that information could remarkably contribute to generate a more positive landscape around novel n-BT foods, possibly leading to desirable consequences. First, increasing consumer acceptance would generate a demand pull on the market. From a producer standpoint, this may represent an incentive to invest more in this market segment instead of delocalizing research and development activities in extra-EU countries (Halford, 2019; Voigt and Münichsdorfer, 2019). Further, increased openness of the general public toward n-BT would also have a positive impact on the international competitiveness of the EU agri-food system. The EU is one of the world's leading exporters and importers of agri-food products; to date, the widespread rejection of GM products has negatively affected international trade (Halford, 2019; Voigt and Münichsdorfer, 2019).

[First submitted April 2020; accepted for publication January 2021.]

References

Banterle, A., A. Cavaliere, and E. De Marchi. "The Italian Food Industry in the Era of the TTIP Negotiate." *British Food Journal* 118(2016):1930–1945. doi: 10.1108/BFJ-05-2016-0191.

Bardin, B., S. Perrissol, L. Facca, and A. Smeding. "From Risk Perception to Information Selection and Not the Other Way Round: Selective Exposure Mechanisms in the Field of Genetically Modified Organisms." *Food Quality and Preference* 58(2017):10–17. doi: 10.1016/j.foodqual.2016.12.015.

Bazzani, C., V. Caputo, R. M. Nayga, and M. Canavari. "Testing Commitment Cost Theory in Choice Experiments." *Economic Inquiry* 55(2017):383–396. doi: 10.1111/ecin.12377.

Bech, M., and D. Gyrd-Hansen. "Effects Coding in Discrete Choice Experiments." *Health Economics* 14(2005):1079–1083. doi: 10.1002/hec.984.

Bliemer, M. C., and A. T. Collins. "On Determining Priors for the Generation of Efficient Stated Choice Experimental Design." *Journal of Choice Modelling* 21(2016):10–14. doi: 10.1016/j.jocm.2016.03.001.

Busdieker-Jesse, N. L., L. Nogueira, H. Onal, and D. S. Bullock. "The Economic Impact of New Technology Adoption on the U.S. Apple Industry." *Journal of Agricultural and Resource Economics* 41(2016):549–569. doi: 10.22004/ag.econ.246254.

Carlsson, F., P. Frykblom, and C. J. Lagerkvist. "Using Cheap Talk as a Test of Validity in Choice Experiments." *Economics Letters* 89(2005):147–152. doi: 10.1016/j.econlet.2005.03.010.

Costa-Font, M., J. M. Gil, and W. B. Traill. "Consumer Acceptance, Valuation of and Attitudes towards Genetically Modified Food: Review and Implications for Food Policy." *Food Policy* 33(2008):99–111. doi: 10.1016/j.foodpol.2007.07.002.

Cummings, R. G., and L. O. Taylor. "Unbiased Value Estimates for Environmental Goods: A Cheap Talk Design for the Contingent Valuation Method." *American Economic Review* 89(1999): 649–665. doi: 10.1257/aer.89.3.649.

Dalla Costa, L., M. Malnoy, and I. Gribaudo. "Breeding Next Generation Tree Fruits: Technical and Legal Challenges." *Horticulture Research* 4(2017):17,067. doi: 10.1038/hortres.2017.67.

Dannenberg, A. "The Dispersion and Development of Consumer Preferences for Genetically Modified Food: A Meta-Analysis." *Ecological Economics* 68(2009):2182–2192. doi: 10.1016/j.ecolecon.2009.03.008.

De Marchi, E., V. Caputo, R. M. Nayga, and A. Banterle. "Time Preferences and Food Choices: Evidence from a Choice Experiment." *Food Policy* 62(2016):99–109. doi: 10.1016/j.foodpol.2016.05.004.

De Marchi, E., A. Cavaliere, J. Bacenetti, F. Milani, S. Pigliafreddo, and A. Banterle. "Can Consumer Food Choices Contribute to Reduce Environmental Impact? The Case of Cisgenic Apples." *Science of the Total Environment* 681(2019):155–162. doi: 10.1016/j.scitotenv.2019.05.119.

Delwaide, A.-C., L. L. Nalley, B. L. Dixon, D. M. Danforth, R. M. Nayga, E. J. Van Loo, and W. Verbeke. "Revisiting GMOs: Are There Differences in European Consumers' Acceptance and Valuation for Cisgenically vs Transgenically Bred Rice?" *PLOS ONE* 10(2015):e0126,060. doi: 10.1371/journal.pone.0126060.

Edenbrandt, A. K., C. Gamborg, and B. J. Thorsen. "Consumers' Preferences for Bread: Transgenic, Cisgenic, Organic or Pesticide-Free?" *Journal of Agricultural Economics* 69(2018):121–141. doi: 10.1111/1477-9552.12225.

Edenbrandt, A. K., L. A. House, Z. Gao, M. Olmstead, and D. Gray. "Consumer Acceptance of Cisgenic Food and the Impact of Information and Status Quo." *Food Quality and Preference* 69(2018):44–52. doi: 10.1016/j.foodqual.2018.04.007.

Eriksson, D., W. Harwood, P. Hofvander, H. Jones, P. Rogowsky, E. Stöger, and R. G. Visser. "A Welcome Proposal to Amend the GMO Legislation of the EU." *Trends in Biotechnology* 36(2018):1100–1103. doi: 10.1016/j.tibtech.2018.05.001.

Fernbach, P. M., N. Light, S. E. Scott, Y. Inbar, and P. Rozin. "Extreme Opponents of Genetically Modified Foods Know the Least but Think They Know the Most." *Nature Human Behaviour* 3(2019):251–256. doi: 10.1038/s41562-018-0520-3.

Food and Agriculture Organization of the United Nations. "FAOSTAT Database." 2017. Countries: China, Germany, Italy. Elements: Production Quantity. Items: Apples. Available online at http://www.fao.org/faostat/en/#data/QC/.

Frewer, L. J., I. A. van der Lans, A. R. Fischer, M. J. Reinders, D. Menozzi, X. Zhang, I. van den Berg, and K. L. Zimmermann. "Public Perceptions of Agri-Food Applications of Genetic Modification—A Systematic Review and Meta-Analysis." *Trends in Food Science & Technology* 30(2013):142–152. doi: 10.1016/j.tifs.2013.01.003.

Gao, Z., X. Yu, C. Li, and B. R. McFadden. "The Interaction between Country of Origin and Genetically Modified Orange Juice in Urban China." *Food Quality and Preference* 71(2019): 475–484. doi: 10.1016/j.foodqual.2018.03.016.

Gaskell, G., M. W. Bauer, J. Durant, and N. Allum. "Worlds Apart? The Reception of Genetically Modified Foods in Europe and the U.S." *Science* 285(1999):384–387. doi: 10.1126/science.285.5426.384.

Halford, N. G. "Legislation Governing Genetically Modified and Genome-Edited Crops in Europe: The Need for Change." *Journal of the Science of Food and Agriculture* 99(2019):8–12. doi: 10.1002/jsfa.9227.

Hess, S., C. J. Lagerkvist, W. Redekop, and A. Pakseresht. "Consumers' Evaluation of Biotechnologically Modified Food Products: New Evidence from a Meta-Survey." *European Review of Agricultural Economics* 43(2016):703–736. doi: 10.1093/erae/jbw011.

Huynh, E., J. E. Araña, and J. Prior. "Evaluating Residents' Preferences for Remediation Technologies: A Choice Experiment Approach." *Science of the Total Environment* 621(2018): 1012–1022. doi: 10.1016/j.scitotenv.2017.10.125.

Lusk, J. L. "Effects of Cheap Talk on Consumer Willingness-to-Pay for Golden Rice." *American Journal of Agricultural Economics* 85(2003):840–856. doi: 10.1111/1467-8276.00492.

Lusk, J. L., and K. H. Coble. "Risk Perceptions, Risk Preference, and Acceptance of Risky Food." *American Journal of Agricultural Economics* 87(2005):393–405. doi: 10.1111/j.1467-8276.2005.00730.x.

Lusk, J. L., B. R. McFadden, and B. J. Rickard. "Which Biotech Foods Are Most Acceptable to the Public?" *Biotechnology Journal* 10(2015):13–16. doi: 10.1002/biot.201400561.

McFadden, B. R. “Examining the Gap between Science and Public Opinion about Genetically Modified Food and Global Warming.” *PLOS ONE* 11(2016):e0166,140. doi: 10.1371/journal.pone.0166140.

McFadden, B. R., and J. L. Lusk. “What Consumers Don’t Know about Genetically Modified Food, and How That Affects Beliefs.” *FASEB Journal* 30(2016):3091–3096. doi: 10.1096/fj.201600598.

McFadden, D. “Conditional Logit Analysis of Qualitative Choice Behavior.” In P. Zarembka, ed., *Frontiers in Econometrics,* Economic Theory and Mathematical Economics. New York, NY: Academic Press, 1974, 105–142.

Mielby, H., P. Sandøe, and J. Lassen. “Multiple Aspects of Unnaturalness: Are Cisgenic Crops Perceived as Being More Natural and More Acceptable Than Transgenic Crops?” *Agriculture and Human Values* 30(2013):471–480. doi: 10.1007/s10460-013-9430-1.

Oliveira, P. R. S., J. M. F. J. d. Silveira, and D. S. Bullock. “Innovation in GMOs, Technological Gap, Demand Lag, and Trade.” *Agribusiness* 36(2020):37–58. doi: 10.1002/agr.21622.

Pakseresht, A., B. R. McFadden, and C. J. Lagerkvist. “Consumer Acceptance of Food Biotechnology Based on Policy Context and Upstream Acceptance: Evidence from an Artefactual Field Experiment.” *European Review of Agricultural Economics* 44(2017):757–780. doi: 10.1093/erae/jbx016.

Pham, N., and N. Mandel. “What Influences Consumer Evaluation of Genetically Modified Foods?” *Journal of Public Policy & Marketing* 38(2019):263–279. doi: 10.1177/0743915618818168.

Potrykus, I. “The GMO-Crop Potential for More, and More Nutritious Food Is Blocked by Unjustified Regulation.” *Journal of Innovation & Knowledge* 2(2017):90–96. doi: 10.1016/j.jik.2017.03.003.

Radas, S., M. F. Teisl, and B. Roe. “An Open Mind Wants More: Opinion Strength and the Desire for Genetically Modified Food Labeling Policy.” *Journal of Consumer Affairs* 42(2008):335–361. doi: 10.1111/j.1745-6606.2008.00111.x.

Rousselière, D., and S. Rousselière. “Decomposing the Effects of Time on the Social Acceptability of Biotechnology Using Age-Period-Cohort-Country Models.” *Public Understanding of Science* 26(2017):650–670. doi: 10.1177/0963662515622394.

Ruud, P. “Approximation and Simulation of the Multinomial Probit Model: An Analysis of Covariance Matrix Estimation.” 1996. Working Paper. University of California, Berkeley, Department of Economics.

Sándor, Z., and M. Wedel. “Designing Conjoint Choice Experiments Using Managers’ Prior Beliefs.” *Journal of Marketing Research* 38(2001):430–444. doi: 10.1509/jmkr.38.4.430.18904.

Scarpa, R., D. Campbell, and W. G. Hutchinson. “Benefit Estimates for Landscape Improvements: Sequential Bayesian Design and Respondents’ Rationality in a Choice Experiment.” *Land Economics* 83(2007):617–634. doi: 10.3368/le.83.4.617.

Scarpa, R., S. Ferrini, and K. Willis. “Performance of Error Component Models for Status-Quo Effects in Choice Experiments.” In R. Scarpa and A. Alberini, eds., *Applications of Simulation Methods in Environmental and Resource Economics,* Dordrecht, Netherlands: Springer, 2005, 247–273.

Schouten, H. “Reply to the Slippery Slope of Cisgenesis.” *Nature Biotechnology* 32(2014):728–728. doi: 10.1038/nbt.2981.

Schouten, H. J., F. A. Krens, and E. Jacobsen. “Do Cisgenic Plants Warrant Less Stringent Oversight?” *Nature Biotechnology* 24(2006):753–753. doi: 10.1038/nbt0706-753.

Shew, A. M., L. L. Nalley, D. M. Danforth, B. L. Dixon, R. M. Nayga, A.-C. Delwaide, and B. Valent. “Are All GMOs the Same? Consumer Acceptance of Cisgenic Rice in India.” *Plant Biotechnology Journal* 14(2016):4–7. doi: 10.1111/pbi.12442.

Siegrist, M. "Factors Influencing Public Acceptance of Innovative Food Technologies and Products." *Trends in Food Science & Technology* 19(2008):603–608. doi: 10.1016/j.tifs.2008.01.017.

Telem, R., S. Wani, N. Singh, R. Nandini, R. Sadhukhan, S. Bhattacharya, and N. Mandal. "Cisgenics - A Sustainable Approach for Crop Improvement." *Current Genomics* 14(2013):468–476. doi: 10.2174/13892029113146660013.

Tonsor, G. T., and R. Shupp. "Cheap Talk Scripts: Effectiveness in Online Choice Experiments and Private Good, Niche Market Assessments." *American Journal of Agricultural Economics* 93(2011):1015–1031. doi: 10.1093/ajae/aar036.

Train, K., and M. Weeks. "Discrete Choice Models in Preference Space and Willingness-to-Pay Space." In R. Scarpa and A. Alberini, eds., *Applications of Simulation Methods in Environmental and Resource Economics,* No. 6 in Economics of Non-Market Goods and Resources. Dordrecht, Netherlands: Springer, 2005, 1–16. doi: 10.1007/1-4020-3684-1_1.

Tsiboe, F., L. L. Nalley, B. L. Dixon, D. Danforth, A.-C. Delwaide, and R. M. Nayga. "Ghanaian Consumers' Attitudes toward Cisgenic Rice: Are All Genetically Modified Rice the Same?" *Ghana Journal of Development Studies* 14(2017):1. doi: 10.4314/gjds.v14i1.1.

Van Loo, E. J., V. Caputo, R. M. Nayga, J.-F. Meullenet, and S. C. Ricke. "Consumers' Willingness to Pay for Organic Chicken Breast: Evidence from Choice Experiment." *Food Quality and Preference* 22(2011):603–613. doi: 10.1016/j.foodqual.2011.02.003.

Van Wezemael, L., V. Caputo, R. M. Nayga, G. Chryssochoidis, and W. Verbeke. "European Consumer Preferences for Beef with Nutrition and Health Claims: A Multi-Country Investigation Using Discrete Choice Experiments." *Food Policy* 44(2014):167–176. doi: 10.1016/j.foodpol.2013.11.006.

Ventura, V., D. G. Frisio, G. Ferrazzi, and E. Siletti. "How Scary! An Analysis of Visual Communication Concerning Genetically Modified Organisms in Italy." *Public Understanding of Science* 26(2017):547–563. doi: 10.1177/0963662516638634.

Voigt, B., and A. Münichsdorfer. "Regulation of Genome Editing in Plant Biotechnology: European Union." In H.-G. Dederer and D. Hamburger, eds., *Regulation of Genome Editing in Plant Biotechnology,* Cham, Switzerland: Springer, 2019, 137–238.

Zilberman, D., S. Kaplan, E. Kim, G. Hochman, and G. Graff. "Continents Divided: Understanding Differences between Europe and North America in Acceptance of GM Crops." *GM Crops & Food* 4(2013):202–208. doi: 10.4161/gmcr.26981.

Appendix A. Model Fit

Model Specification	*N*	Log-Likelihood	Par	BIC[a]	BIC/N	AIC[b]	AIC/N	3AIC	3AIC/N	crAIC	crAIC/N
MNL											
1 Control	1,840	−1,301.02	6	2,647.10	1,439	2,614.00	1,421	2,620.00	1,424	2,614.40	1,439
2 Naturalness	1,600	−1,121.12	6	2,286.50	1,429	2,254.20	1,409	2,260.20	1,413	2,254.70	1,429
3 Health	1,600	−1,215.31	6	2,474.90	1,547	2,442.60	1,527	2,448.60	1,530	2,443.00	1,547
4 Environment	1,568	−1,083.54	6	2,211.20	1,410	2,179.10	1,390	2,185.10	1,394	2,179.50	1,410
RPL											
1 Control	1,840	−1,124.40	10	2,324.00	1,263	2,268.80	1,233	2,278.80	1,238	2,270.20	1,263
2 Naturalness	1,600	−966.86	10	2,007.50	1,255	1,953.70	1,221	1,963.70	1,227	1,955.40	1,255
3 Health	1,600	−1,039.67	10	2,153.10	1,346	2,099.30	1,312	2,109.30	1,318	2,101.00	1,346
4 Environment	1,568	−905.06	10	1,883.70	1,201	1,830.10	1,167	1,840.10	1,174	1,831.80	1,201
RPL-EC											
1 Control	1,840	−977.36	11	2,037.40	1,107	1.976.70	1,074	1,987.70	1,080	1,978.60	1,107
2 Naturalness	1,600	−844.57	11	1,770.30	1,106	1.711.10	1,069	1,722.10	1,076	1,713.30	1,106
3 Health	1,600	−925.2	11	1,931.60	1,207	1.872.40	1,170	1,883.40	1,177	1,874.60	1,207
4 Environment	1,568	−780.93	11	1,642.80	1,048	1,583.90	1,010	1,594.90	1,017	1,586.10	1,048
RPL-EC Correlation											
1 Control	1,840	−949.47	17	2,026.74	1,101	1,932.90	1,051	1,949.90	1,060	1,939.30	1,101
2 Naturalness	1,600	−835.79	17	1,797.00	1,123	1,705.60	1,066	1,722.60	1,077	1,712.90	1,123
3 Health	1,600	−910.83	17	1,947.08	1,217	1,855.70	1,160	1,872.70	1,170	1,863.00	1,217
4 Environment	1,568	−770.17	17	1,665.42	1,062	1,574.30	1,004	1,591.30	1,015	1,581.80	1,062

Notes: [a]Bayesian information criterion.
[b]Akaike information criterion.