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A Comparison of EU and US consumers' willingness to pay for gene-edited food: evidences from apples

Abstract: We compare consumers' attitude towards and willingness to pay (WTP) for gene-edited (GE) apples in Europe and the US. Using virtual choices in a lab and different technology messages, we estimate WTP of 162 French and 166 US consumers for new apples, which do not brown upon being sliced or cut. Messages center on (i) the social and private benefits of having the new apples, and (ii) possible technologies leading to this new benefit (conventional hybrids, GE, and genetically modified (GMO)). French consumers do not value the innovation and actually discount it when it is generated via biotechnology. US consumers do value the innovation as long as it is not generated by biotechnology. In both countries, the steepest discount is for GMO apples, followed by GE apples. Furthermore, the discounting occurs through "boycott" consumers who dislike biotechnology. However, the discounting is weaker for US consumers compared to French consumers. Favorable attitudes towards sciences and new technology totally offset the discounting of GE apples.

Keywords: Gene editing; genetically modified organisms; hybrids; consumer information; experimental economics; willingness to pay.

JEL Codes: C91, D12, Q18, Q16

1. Introduction

New biotechnology tools have emerged to create novel foods or attributes in agricultural goods. These "new breeding techniques" are instrumental to maximize agriculture's productivity, profitability and sustainability, to supply a continually increasing world demand for feed, fuel and food (Anderson et al., 2019). These techniques also improve the food quality for consumers by providing new attributes like a better taste, a longer shelf life and/or the absence of browning for fruits and vegetables, naturally decaf coffee beans, gluten-free wheat, and others. These techniques include those based on clustered regularly interspaced short palindromic repeats (CRISPR), transcription activator-like effector nucleases (TALEN), and others, often referred to as gene-editing (GE) techniques. They are precise tools to change the genome of plants, using the plant's own genome or the genome of related plants through cisgenesis.[1] Despite the safety of these techniques, new evidence suggests they may be controversial with environmental groups, and consumers (NAS, 2016; ECJ, 2018; and Caputo et al., 2020). These concerns cross borders and are internationally present (Qaim, 2020). The social acceptability of these new breeding techniques is an important issue.

There are emerging and significant domestic, international, and trade frictions over these new breeding techniques use to innovate in agriculture and food markets (Bain et al., 2019; Bunge et al., 2018; NAS, 2016; and Martin-Laffon et al., 2019). Novel food and attributes in agricultural goods have to be assessed for the potential risk they may create for human health and the environment. Regulations in many countries are process-oriented rather than product oriented. Even in the US, novel foods obtained through transgenic biotechnology are regulated differently than the similar novel foods obtained through conventional breeding, or GE techniques. In addition, countries differ on labelling requirements for these novel foods.

[1]Cisgenesis refers to a genetic mutation of a plant obtained by using genes from plants with which the original plant could sexually reproduce.

An example of such regulatory disparity is high-oleic acid soybean oil or canola oil. These oils can be obtained through three methods with different regulatory implications, although the final product has similar nutritional and health attributes. Despite this similarity, some consumers may view these oils as different and may want to see them labeled. Hence, there are cultural and societal dimensions beyond science and health (Bain et al., 2019; Sheldon, 2002; and Heumueller and Josling, 2004). Several elements condition the impact of regulations on innovation, as it was the case twenty-five years ago for earlier GMO applications in agriculture and food markets.

Several important questions arise in this context. First, will consumers treat GE-based novel foods as they treated and still treat GMO-based food items (fresh and processed), especially when considering different countries? How will consumers be informed and how will information condition their preferences? These issues could especially be salient in countries, which have opposed GMO foods in the past, such as in the European Union (EU). The resistance was both at the consumer and regulatory levels. Lusk et al. (2005), Lusk (2011), and Colson and Rousu (2013) summarize the large literature on WTP for GMO foods relative to conventional ones.

More recent papers continue to confirm this dislike or distrust of GMO food in various countries (for example, Lin et al., 2019, on GM meat; and McComas et al., 2014, on GM potatoes). Consumers tend to value and prefer labeling of goods regarding biotech-based foods. Consumers in all countries, which were studied, discount GMO based foods relative to their conventional substitutes. The discounting of GMO foods has been the highest in European countries and for meat products, and the least for vegetable oils, which often do not contain GMO material.[2] Despite this negative context, European consumers are gradually

[2] There is also a debate in the literature on how consumers behave in real purchasing environments in stores as opposed to the more contrived conditions of consumer surveys. Experiments tend to accentuate the divide between GMO and conventional food, whereas consumers in stores, may read labels less attentively (Grunert and M. Wills, 2007).

evolving in their attitudes towards biotechnology (Gaskell et al., 2011).

A very recent literature has emerged to evaluate WTP for novel foods based on GE techniques. Recent contributions underline a significant discount for GE foods compared to conventional foods, which is reminiscent of past reluctance to GMO food (Caputo et al., 2020; Edenbrandt et al., 2018; Muringai et al., 2019; Shew et al., 2018; and Yunes et al., 2019). These authors find that consumers discount GE goods relative to conventional and organic foods, but with a twist. GE foods show a small positive premium (increment in WTP) relative to GMO substitutes, even though both are discounted, relative to conventional and/or organic substitutes. These new findings on discounting innovations or food goods obtained through biotechnology appear robust across countries and food good types. Despite the potential benefits embodied in GE innovations as noted previously, consumers, on average, seem to discount these improvements in these new studies.

Our paper contributes to this GE acceptance debate by focusing on a specific new quality attribute linked to apples and by directly comparing consumers' acceptance in two different countries, in which GMOs controversies were vivid. We compare consumers' attitudes in France and the US, when considering novel apples with a tangible consumer benefit, relative to conventional ones under different technology scenarios (hybridization, GMO, GE). France serves as an illustration of European behavior. The beneficial improvement refers to inhibited browning and bruising of cut apples. We elicit WTP for these new apples, relative to conventional apples.

Consumer acceptance of cisgenic apples have been explored before, with a focus on environmental benefits and pest resistance (De Marchi et al., 2019; Hudson et al., 2015; and Rousselière and Rousselière, 2017). To the best of our knowledge, we are the first investigation of WTP for cisgenic/GE apples with new tangible consumer benefits, rather than environmental benefits, and in the more recent GE context, and with an improvement

across technologies (GE, GMO and conventional hybrids). Our investigation also contributes as the first analysis of consumer acceptance of GE apples across nations. Shew et al. (2018) compared WTP for rice across countries under different technologies, including GE. The closest investigation to ours is De Marchi et al. (2020) who investigated WTP for apples in Italy, looking at the influence of time preference, technology (conventional, cisgenic), socio-demographics, country of origin, brand, and price.

We find in our surveys, that consumers in France and the US behave qualitatively similarly, relatively to biotechnology. Consumers in both countries discount the improvement obtained through GMO and GE techniques, relative to a hybridization-based innovation. In both countries, there is a lower discount for GE relative to GMO improved apples. However, the discounting on biotech apples is heavier in France than in the US. This finding echoes similar conclusions reported in Lusk et al. (2005) and Bredahl (1999) on GMOs in European countries. This finding is in contrast to Kikulwe et al. (2011) who found that when consumers perceive personal benefits of consuming a GM food, the acceptance increases (for GM bananas in Uganda).

In addition, US consumers value the innovation positively with a net increase in WTP relative to a conventional apple, as long as the novel apple is not generated through biotechnology. In contrast, French consumers do not value the innovation at all, even when it originates from conventional hybridization methods. French consumers, respond positively to longer messages on GE and GMO, with a smaller discount on the novel apples, relative to their valuations under short messages. US consumers do not seem to be consistently influenced by the length of the message.

Importantly, consumer attitudes towards food innovations and technology acceptance deeply influence the WTP for the new apples in both countries, in such a way they can totally offset the discounting of the GE novel apples for consumers in favor of food innovations and

technology. The offsetting effect is the strongest among US consumers, relative to French consumers. In both countries however, the discount on GMO apples remains, even for consumers who are inclined towards technology and innovations. This result shows the importance of measuring acceptance of technology as part of characteristics of consumers. This finding complements results by Lin et al. (2019) who focus on six key personality traits of consumers and their impact on the acceptance of GM pork across three countries (US, China, and Italy). These authors highlight the importance of openness to experience as a key trait explaining the acceptance of GMO meat products and mitigating lower WTP for GMO meat products. Their findings corroborate our finding with our index of consumer acceptance of technology and innovation offsetting the discount of GE apples and mitigating the discount of GMO apples.

The remainder of paper is organized as follows. Section 2 focuses on the experimental design, and Section 3 presents the results. Section 4 discusses the implications for regulatory policies and concludes.

2. The experiment

This section details the respondents, the product, the experimental procedure and the information revealed.

2.1 Respondents in France and the US

We conducted the experiment in France (Dijon) and in the US Midwest (Ames, Iowa) in multiple sessions in December 2019 (for France) and early March 2020 (for the US). French consumers are used as an illustration of European consumers' behavior. In France, we selected the participants using the quota method, which uses the same proportions of sex, age and socio-economic status (occupation, income, education) criteria in the group of respondents as in the general French population. In the US, the initial selection of invited

subjects followed a similar method, although on the day of the experiment, the subjects sample had over representation of female participants, higher levels of education and income.

For France, participants were recruited through the *Chemosens PanelSens* database built by the *Centre des Sciences du Goût et de l'Alimentation,* INRAE Dijon.[3] In the US, subjects were selected by the Center for Survey Statistics and Methodology at Iowa State University,[4] with similar segmentation by gender, age, and socio economic status. Our targeted group is relatively representative of the age groups and the socio-economic status of the French and US population. Participants were first contacted by phone and informed that they would earn a participation fee of €10/USD25 for replying to questions about food for about 45 minutes. The target respondents consist of 162 (France) and 166 (US) people aged between 18 and 73 for France (resp. between 18 and 78 for the US).[5] In the experiment, we divided our respondents into four groups and randomly assigned participants to groups. The groups received the same type of information but in a different order and with different degrees of details (see below).

Table 1 presents the socio-economic characteristics (age, gender, education, income, household composition) of the participants within each sample (French and US) and the frequency of their apple consumption. The income comparison is more difficult because US median disposable income is higher than in France. In addition, French participants consume on average more apples than US participants.

<Table 1 about here>

To address differences in the two experiments (kg versus lbs, and dollar vs euro), we

[3] This recruitment database has been declared to the relevant authority (Commission Nationale Informatique et Libertés – CNIL – n°1148039). Moreover, our specific experimental study was reviewed and approved by the data protection committee of CNRS (Certificate 2-19086 \ UMR6265).
[4] CSSM is the oldest US survey research center (established in 1938). It has helped numerous federal and state agency and university researcher conducting surveys. Among other things, CSSM developed the Master Sample of Agriculture, and developed the sampling methods for the US Federal National Resource Inventory survey, which CSSM continues to support today. A brief history is here: https://www.cssm.iastate.edu/history.
[5] The exclusion of unengaged participants bidding zero at each round does not change the nature of the conclusions. Results are available upon request. The French sample includes 7 unengaged participants, while the US sample includes only 1 unengaged participant.

first normalize the WTP to a common base in both countries (basis 100), and the empirical analysis is run separately for the French and the US samples. We control for age, gender, education, income, and apple consumption to offset potential bias from sampling issues. Therefore, we are confident these differences will not bias our econometric results. By contrast, what really matters for the robustness of our analysis is the absence of significant differences between groups within each country. Tables B.1 and B.2 in Appendix B report the statistics on socio-economic characteristics and apple consumption for each country and group. Differences between the groups are tested using the Kruskal-Wallis equality-of-populations rank test.[6] A *P*-value (against the null hypothesis of no difference) of less than 5% is considered significant. The results in the last column of both tables of Appendix B strongly suggest that the four groups are not significantly different neither in France nor in the US.

2.2 Products

Our experiment focuses on apples. Three facts motivate this choice. First, apples are popular and highly consumed fruits, in both France and the US, and good for health. Many varieties (Fuji, Gala, Pink Lady, Red Delicious, etc.) are available on the market, such that any consumer can easily find a preferred variety satisfying her/his taste. Second, apples are available everywhere, all year long (in supermarkets prepacked and in bulk, in stores selling only organic products, in local fruit and vegetable stores, in neighborhood market and directly at the producer or via direct sale networks). Although some variations are observed across locations and apple varieties, the price segment for apples is not too large and relatively well known by consumers. Third, apples are subject to many innovations in order to extent their preservation, improve their vitamin content, reinforce their taste, etc.

The production and sales of apples made with GE were authorized at the time of the

[6] The Kruskal-Wallis test is a multi-sample generalization of the two-sample Wilcoxon test.

experiment in the US, but not in France. In the absence of products, we elicited hypothetical WTP. Despite the risk of hypothetical and upward biases of WTP, the lab is a practical place for eliciting WTP of well-informed consumers with a tight control of the revealed information.[7]

2.3 Experimental design and information revealed to participants

At the beginning of the experiment, some initial explanations were read, and participants signed a consent form. We insisted on the fact that all their replies were anonymous, since participants were only identified by a number. We mentioned the fact that no product will be sold or given at the end of the experiment. Pictures of products were presented (see Figure B.1 in Appendix B) and no variety reference was indicated, since apples are widespread and well-known products, sold under different brands including supermarket brands. We asked participants to indicate choices as if they were in a supermarket. We insisted on the absence of "good" or "bad" replies, but rather on the possibility to freely indicate choices reflecting their preferences.

Figure 1 describes the experiment design and the timeline. Successive rounds of information were revealed to participants, and WTPs were elicited after each message. Five rounds of WTP elicitations were organized with successive messages revealed with the notation #*R* for a round $R = \{1,2,3,4,5\}$. Round #1 took place with explanations of the weight and the mechanism linked to the multiple-price list used in the experiment. Only "conventional" apples were offered in round #1. The first round helps participants understand the mechanism and provides a baseline of their intention purchases for the conventional variety. The possibility of zero bids is carefully explained. Both varieties (conventional and new) were presented in the following rounds #2 to #5. Consequently, each round elicits

[7] Even if hypothetical WTPs are likely to be upward biased, a well-cited study downplays risks of biases for private good. By comparing hypothetical and non-hypothetical responses, Lusk and Schroeder (2004) showed that marginal WTP for a change in quality/characteristic is, in general, not statistically different across hypothetical and real payment settings.

participants' WTP for the conventional and the new varieties of apples. The price list provided to participants is revealed before the first WTP elicitation and remains fixed during the rest of the experiment. The same price list is used for both the conventional and new varieties of apples.

<Figure 1 about here>

Rounds 2-5 reveal detailed information about the browning process affecting apples, the traditional hybridization process, the gene editing techniques and GMOs. These messages are based on scientific publications, press releases and reports concerning browning process and technical innovations. The messages are simple but as close as possible to reality because some participants may have prior knowledge of the gene editing/GMOs issue.

We conduct the experiment under four treatments, varying the length and the order of information provided to each group of participants. The sequence of information revealed differs between the four groups. Groups I and III receive detailed information about GE and GMOs, while groups II and IV receive concise "short" information. Besides, groups I and II successively receive information about GE and GMOS, while Groups II and IV successively receive information about GMOS and then GE.

Finally, participants fill in an exit questionnaire on socio-economic characteristics, consumption behavior, and perceptions of label and food innovations. Interestingly, in this exit questionnaire, participants were asked about their previous knowledge (e.g. before the experiment) on food innovations and biotechnologies. 66.9% of US participants were aware of these innovations, while the percentage reaches only 46.3% in France. Furthermore, using participants' answers to questions on labels and innovations in food, we build two indexes, respectively on technology and on labeling. The indexes are centered on the "don't know" answer, and vary between -1.5 and +1.5, a higher positive value suggesting that the

participant is more in favor of innovations and label.[8] These two indexes are not significantly correlated, neither in France, nor in the US. Interestingly, these indexes show strong differences between France and the US, especially for technology. The technology index is positive in the US (mean = 0.55 and median = 0.57), while it is negative in France (mean= -0.06 and median = - 0.11). For the label index, the average value is 0.44 in the US (resp. 0.62 in France), and the median is 0.5 in both countries.

2.4 Mechanism for eliciting WTP

A multiple-price list (payment card) was used for eliciting WTP of consumers for each product (conventional and new). Such list simplifies the task for consumers when evaluating independently two products in several rounds. During each round, participants were asked to choose whether (or not) they will buy the product for prices varying from €1.60 to €3.30 for 1 kg of apples in France and from $0.70 to $2.40 for 1 pound in the US (see Table B.3 in Appendix B). More precisely for each price, consumers had to check off either "yes", "no" or "maybe" regarding their purchase intents. Prices were selected because they epitomize a representative range of prices observed in supermarkets at the time of the experiment respectively in France and in the US Midwest.

For each product and for each round of choice R with $R = \{1,\ldots,5\}$, the WTP was determined by taking the highest price linked to a choice "yes" (with the following highest price on the paper sheet implying a reply "no" or "maybe"). If one participant only replied "no" or "maybe" to each line, the selected WTP was equal to 0.[9] If one participant only replied "yes" to each line, the selected WTP was equal to €3.30 for France and $2.40 for the US. For respondents switching twice at low and high prices, the highest "Yes" was recorded

[8] The technology index takes the answers to 11 questions on attitudes towards food technologies on a scale from 1 (Not at all in favor) to 4 (completely in favor) and 5 (does not know). The label index is based on 2 questions asking the importance of food labelling, using a similar scale. These questions are shown in Appendix C. Completely in favor is mapped to 1.5; rather in favor to 0.5, does not know corresponds to 0; rather not in favor is mapped to -0.5 and not at all in favor to -1.5.

[9] The alternative configurations with a value equal to €1.50 for France and $0.60 for the US were also studied. Empirical results are not affected.

as the WTP for the analysis.

Advantages and drawbacks of multiple price lists were reviewed by Andersen et al. (2006). The main advantage of such a list is its simplicity guaranteeing a direct participants' understanding. The possibility to check off "Maybe" also captures consumers' hesitation. Conversely, one drawback is the interval response eliciting interval data rather than point estimates for WTP. With our experiment, the 10 cents interval guarantees a sufficient degree of precision for the elicited WTP. A second disadvantage mentioned by Andersen et al. (2006) is the framing effect with a psychological bias towards the middle of the multiple-price list for choices made by participants. They controlled for this effect by changing the boundaries of the multiple-price list. In this paper, we did not control this framing effect by changing the boundaries, since we focus on the impact of successive messages revelation. As all methodologies eliciting WTP, the multiple-price list has some limitations, but it is particularly tailored to a protocol insisting on the revelation of new messages.

3. Results

We now turn to results. We first provide descriptive statistics on WTP expressed by consumers and their variations across varieties and rounds of elicitation (section 3.1). We then present our econometric analysis (section 3.2).

3.1 Descriptive analysis

To allow comparisons between the French and the US samples, we transform the WTP expressed by participants in each country currency into a common metric (See Lusk, 2011). We express all individual positive WTPs into an index, which is indexed to 100 for a round 1 and the conventional variety. If participants boycott the product (WTP = 0), the index is set to 0.[10]

[10] A few consumers boycotted from Round 1, which explains why the average WTP in Round 1 is below 100.

Figure 2.a shows the average WTPs over all participants expressed in France and in the US for the conventional and the new varieties. Notable facts are as follows. First, strong variations in the WTP expressed for the new variety are observed in both countries and across rounds (min: 43.7; max: 112.4). Second, WTP reported for the new variety by US participants are always higher than the ones obtained in France (min: 43.7 in France and 82.3 in the US). Third, the WTP expressed for the new variety in rounds 2 and 3 by US participants (e.g. 109.2 for round 2 and 112.4 for round 3) are higher than those provided for the conventional variety (e.g. 96.8 for round 2 and 96.7 for round 3). The reverse is observed in France (for the new variety: 90.5 for round 2 and 93.5 for round 3; for the conventional variety: 95.2 for round 2 and 95.8 for round 3). Fourth, French participants strongly reduce their WTP for the new variety in rounds 4 and 5 (49.8 for round 4 and 43.7 for round 5); in the US, a decrease is also observed, but its magnitude is smaller (82.3 for round 4 and 83.1 for round 5). Fifth, WTPs expressed by French and US participants for the conventional variety are similar and very stable across rounds (min: 95.1; max: 99.4). In sum, US consumers value the improved attributes of the apples as long as the innovation is not based on biotechnology tools (GMO or GE). French consumers do not value the novel apple in any circumstances.

Figure 2.b goes one step further and describes the mean WTPs and their variations after information revelation expressed by each group of participants in each country for the new variety. [11] The left column presents results for France, while the column on the right reports results for the US. In addition, the upper subtitle of each sub-graph indicates the considered group. Recall that the order and length of information received by groups differed. Groups I and II received information first on GE and then on GMOs, while groups III and IV obtained information first on GMOs and then on GE. Besides, groups II and IV received

[11] Average WTPs by groups for the conventional variety are reported in Figure B.2. in the Appendix B.

short messages. By contrast, long messages are delivered to groups I and III.

<Figures 2.a and 2.b about here>

Thus, analyzed horizontally, each column of Figure 2.b highlights the average WTP for the new variety but in each country (France vs. the US) separately, which allows the reader to identify the effect of information on the new variety in each country. Analyzed vertically, each sub-graph of Figure 2.b indicates the average WTP for the new variety for different groups in a given country, which allows the reader to identify the effect of the information sequence (GE first, GMOs second, and vice versa) and length (short vs. long messages).

We test for the significance of the WTP differences linked to the information revelation with the Wilcoxon (also known as the Mann-Whitney) and the Kruskal-Wallis equality-of-populations rank tests. A *P*-value (against the null hypothesis of no difference) of less than 5% is considered significant. These tests are made as follows:

First, we investigate whether the four groups of participants in each country are initially similar, i.e., whether the WTP expressed in the first round for the conventional variety or in the second round for the new variety is statistically similar between the groups. The test result suggests no significant difference at the 5% level for the conventional as well for the new variety. This conclusion is observed both in France and in the US.

Second, we test for the impact of information revelation on WTP by examining for each country whether the WTP expressed for the new variety and a given group of participants i between rounds j and j+1 vary significantly (that is, between $WTPj_i$ and $WTPj+1_i$, represented by bars in each graph). Significant changes are observed in the following cases:[12]

- Between rounds 3 and 4 for groups II, III and IV in both France and the US;

[12] By contrast, results suggest no differences in the WTP expressed for the conventional variety between rounds whatever the group both in France and in the US.

- Between rounds 4 and 5 for groups I and II in France only.

Our analysis shows that information on GE and GMOs matters. Following the revelation of information about GE- or GMO-based apples (at rounds 4 and 5), consumers decrease significantly their WTP for the new variety. The magnitude of the decrease is stronger in France than in the US. Furthermore, GE information has a smaller negative impact compared to the one observed for GMO information, especially in France. Say differently, participants react more negatively to information on GMO than on GE. The expressed WTPs vary more between rounds 3 and 4 in terms of magnitude and significance for groups III and IV, receiving information on GMO, than for groups I and II, receiving information on GE.

In addition, participants in groups I and II decrease their WTP between rounds 4 and 5, while the WTPs expressed by groups III and IV increase between rounds 4 and 5. For groups I and II, the relative decrease in WTP for the new variety is equal respectively to 28.8% and 33.2% in France (resp. 22.5% and 25.1% in the US), following the message on GE (round 4) and 25.7% and 25.0% (resp. 10.0% and 8.9% in the US) following the message on GMO technology (round 5). For groups III and IV, the WTP for the new variety decreases by 51.0% and 61.2% in France (resp. 41.6% and 31.1% in the US) following the GMOs message (round #4), whereas it increases by 16.1% and 8.7% (resp. 11.7% and 10.0% in the US) following the GE messages.

Furthermore, our analysis suggests that the short messages have a larger negative influence than long messages, in particular in France. In France, this result is observed both for messages related to GE and GMOs. For groups I and III, the average WTP decreases respectively by 28.8% and 51.0% after the long messages respectively on gene editing and GMOs (round 4), while for groups II and IV the decreases are respectively equal to 33.2% and 61.2% after the short messages respectively on GE and GMO technology (round 4). A

similar conclusion on the differentiated impact of short/long messages is observed for round 5.

For the US, the conclusion is mixed. Short messages on GE have a stronger negative impact on WTP than long messages, but this result is not observed for messages related to GMOs. However, these US results on the length of messages are more muddled in the econometric estimation, with no clear pattern across specifications (see next section).

Moreover, our results suggest that the order of information matters, especially in France. The WTP for the new variety after the GE messages is higher for groups I (63.4%) and II (55.6%) which received this information first (round 4) than the WTP observed for groups III (58.6%) and IV (46.7%), which received this information after the one on GMO apples (round 5). Similarly, for information on GMOs, groups III (42.5%) and IV (38.0%) have higher WTP for the new variety in round 4 than groups I (37.7%) and II (30.6%) in round 5. For the US, results are again mixed. A similar conclusion to France's observation is observed for GMO apples (75.6% for group IV, 85.3% for group IV but only 74.22 for group I and 75.2% for group II). In contrast, the result is not observed for the GE variety.

Lastly, our results do not reveal any competition or substitution patterns between the conventional and the new varieties. The introduction in round 2 of the new variety does not lead to a statistically significant decrease of the WTP expressed for the conventional variety. This result is valid for all groups and both countries (Figure B.2 in the Appendix B).

Figures 2.a and 2.b and B.2 present average values, but these averages hide the strong reactions from some consumers. Our French and US samples include indifferent consumers and boycotters. Indifferent participants are participants with a similar strictly positive WTP for the new variety at the beginning and the end of the experiment, while boycotters are

participants with a WTP dropping to zero after information revelation.[13] Table 2 suggests that French participants boycott more the new variety than US participants do (42.6% vs. 19.3%). US participants are also more indifferent consumers than French participants are. This result is observed for both varieties, but the gap between France and the US is more pronounced for the new variety (13.0% of indifferent consumers in France vs. 32.5% in the US).

<Table 2 about here>

3.2 Econometric estimation

Estimated equation

We now provide more explanations regarding the results obtained in the descriptive analysis and investigate the determinants of WTP. To that end, we regress the WTP in levels (converted in basis 100) expressed by each participant for each variety and round on information and controls. We do not consider the WTP expressed in round #1 since only the conventional variety was available on the market. More formally using *C* (resp. *N*) for the conventional (resp. new) variety, our estimated equation is as follows:

$$WTP_{Ri}^{j} = \boldsymbol{\beta}' \mathbf{X}_{Ri} + \nu_i + \varepsilon_{Ri}, \qquad (1)$$

where WTP_{Ri}^{j} represents participant *i*'s WTP elicited at round *R* with *R*={2,3,4,5} for apple type *j* with *j*={*C*,*N*}. Vector $\mathbf{X}_{Ri}$ denotes the vector of explanatory variables, e.g., the information received by participant *i* at each round of the experiment. We focus on the type (browning apples process vs. traditional hybridization vs. GE vs. GMO), length (short vs. long) and order (first vs. second).

We consider each information element separately, as well as their interactions. The estimation also controls for the socio-economic characteristics of participants and their habits in terms of apples consumption as well as their perceptions about label and food technology

[13] Similar WTP between elicitation rounds are common in experiments, since participants not sensitive to a message have a WTP that is directly anchored to the previous WTP.

(using the indexes previously constructed, see section 2.3). Vector **β** is the vector of parameters to be estimated, and v_i and ε_{Ri} are the random effect and the error term. All explanatory variables are coded using dummy variables, except age, which is treated as a continuous variable.

To perform our estimations, we rely on the random effect Tobit estimator. This estimator allows us to address the issues that may affect our analysis. First, given that each participant *i* makes multiple choices, there should be some correlation across data points relating to WTP. Second, WTP cannot be negative and is left-censored at zero. As shown in the Kernel distribution reported in Figure B.3 in the Appendix B, only WTPs expressed for the new variety are in practice sorted at the lower bound of 0. Therefore, only the estimations dealing with the new variety control for the lower bound.

Results and discussion

The results are presented in Tables 3 and 4, respectively, for France and the US. Each coefficient can be interpreted as the contribution of each explanatory variable to the normalized and unitless WTP as explained before. The first four columns focus on the new variety, while the estimation results on the determinants of WTP for the conventional variety are reported in the last column.

In columns (1) to (3), we first deal with the type of information received about the new apple (about browning process, traditional hybridization, on GE, or on GMO), then with the length of the messages for GE and GMO (short vs. long), and finally the order of the information provided to participants (GE first/second vs. GMO first/second). Column (4) includes interactions between the type of information for GE and GMO, the length and the order of messages. For the estimations in column (5), we just retain the 4 types of information, which is likely to be the main driver of the WTP expressed by participants for the conventional variety.

< Tables 3 and 4 about here>

Our results confirm the influence of information on WTP highlighted in the descriptive statistics. More precisely, we observe that

- In France, the new apple is less valued than the conventional apple under the 4 messages. One can observe this by comparing the estimates in columns (1) and (5). For instance, with the information about the browning process, the coefficient is equal to 94.1 in specification (1) for the new product and to 106.2 for the conventional product, indicating the total absence of interest for new apples by French consumers (see Table 3). Further, the discounting of the new apple is clearly observed for GE and GMO messages. GE apples are less discounted than GMO apples, underlining the strong French aversion for GMO.[14] Information on traditional hybridization leads to the smallest discounting among the new apples. In the US (see Table 4), consumers value the new apples (with a premium relative to the conventional apple), as long as they are not generated using biotech technology. US consumers show a dislike of biotech apples relative to non-biotech apples. GMO apples are the most discounted, followed by the GE apple. However, the discounts are not as steep as they are for French consumers. Traditional hybridization method has the largest WTP among the 4 WTPs for new apples among US consumers.
- Short messages on biotech techniques have a stronger negative impact in France for the new apples relative to the long messages. In the US, the length of messages does not seem to consistently influence the WTP. In specification (2) in table 4, US consumers seem impatient and have lower WTP under the long message (and the difference between estimates is significant both for GE and GMO messages, $p<0.01$). However, in specification (4), when GE is first and when GMO is second, the WTPs under the long

[14] Note that the estimated parameter for the GMO dummy variable is not significantly different from zero in the French regression ($chi2(1) = 0.54$, $p>0.4$), implying a zero WTP for GMO apples. We also test for its equality with the GE fixed effects. This hypothesis is strongly rejected ($chi2(1) = 27.06$; $p<0.01$). Hence, we can confidently conclude that GMO new apples are more discounted than GE apples.

message are slightly higher (and again the difference is significant in both cases, $p<0.01$).

- The order of information (first/second) plays a significant role in both countries, especially in France. The WTP for the new variety exhibit a stronger discounting of the new apple following the second message than the first one (for both GE and GM apples). In the US, the GE apple is valued higher when the message comes after the GMO information as compared to coming first. However, for GMO, no consistent pattern emerges. For three cases, The WTP for GO is lower when elicited second, and one case (long message), the WTP actually increases when it comes second, as shown in Table 4.

Regarding socio-economic controls (not reported due to space constraints but available from the authors), none are significant for the new apples. In France, conventional apples show a small (in absolute value) negative influence of education on the WTP ($p<0.1$), and consumers with higher apple consumptions, have lower WTP ($p<0.01$).

Finally, results on technology and label indexes provide interesting insights. On the one hand, estimates on the technology index are positive and significant in both countries and for the new variety. The magnitude is such that, for consumers in favor of food innovations and technologies (e.g., with an index valued at 1 in the range [-1.5, 1.5], it totally offsets the negative effect of the GE message in both countries and through various specifications. For consumers opposed to these innovations (e.g., index at -1), their attitude greatly amplifies the negative effect of biotech messages. Furthermore, the magnitude of the effect is more than twice as large in France compared to the US effect, confirming previous results. Food innovations are a 'hot topic' in France; French consumers' perception of technology drastically drives their WTP. This result is consistent with the findings of Lin et al. (2019) on the openness character trait increasing the WTP for GMO meats. Our results on the perception of technology and innovation hold for both GMO and GE food.

On the other hand, the label index is not significant for the new or conventional

variety neither in France nor in the US. This is interesting in the sense that the EU and the US have had trade frictions with labelling requirements on GMO and GMO free products, although consumers do not seem to care about labels in our experiment.

To sum up, our experiment shows a real concern for GE/GMO varieties in both countries, but which runs deeper in France than in the US. Results are particularly strong in the French sample and for GMOs. French participants are more alarmed by short messages as well. This result and that on attitudes toward innovations suggest the importance of information policy and science education to make consumers more confident about these innovations, including biotech-based innovations.

We also ran the model in difference of WTP for the new and conventional apples (namely $WTP_{NRi} - WTP_{CRi} = \beta' \mathbf{X}_{Ri} + \nu_R + \varepsilon_{Ri}$, with notations following to the ones of equation (1)). These regressions are shown in Tables B.4 and B.5 in Appendix B with similar qualitative results, although the discounting of the new GMO apples exhibits a larger variance in the US regressions. Some information is lost by using the WTP difference rather than explaining WTP levels.

4. Conclusion

In the introduction, we asked if GE-based novel foods would be treated as GMO-based food items have been, especially in countries, in which this technology has been highly controversial. Our answer is a carefully qualified "yes". Consumers in both countries discounted the GMO and GE apples but with a steeper discount for the GMO apples. There is a stigma associated with GE, but it is smaller than for GMOs and it varies across consumers and by country. The discounting of both GE and GMO apples is weaker for US consumers compared to French consumers. The latter point is in line with the findings of Shew et al. (2018) on CRISPR and GMO rice in four countries including France and the US.

We also asked if information would condition consumer preferences. Again, the answer is a qualified "yes". French consumers reduce their dislike of both GE and GMO apples when they receive longer messages on the technologies, but not sufficiently to totally offset the discounting of the novel apple. However, US consumers do not seem to react in a systematic way to the length variation of information.

We found that in the US, the revelation of the first message on the consumer benefits of the new apple leads to a positive premium for these new apples compared to the conventional apples. Similarly, the message on new apples obtained from conventional hybridization leads to an increase in WTP. By contrast, French consumers appear skeptical and do not increase their WTP at all for the new apples in the first or second message on new apples.

Caputo et al. (2020) found that, when asked, US consumers tend to have little understanding of what GE is or does, and when provided information, they tend to be more accepting of the technology. Here, we cannot confirm this finding, although the result on the positive impact of attitude towards innovations on the WTP suggests that consumers more in tune with novel food are willing to pay more for these innovations. We also find that on average US consumers are more accepting of innovation and technology than French consumers are.

Our result on the lack of impact from the attitude towards food labels creates potential political tension. The reluctance of consumers towards GE techniques with a related discount for GE foods raises the question of a labeling system informing consumers. Interest groups in both Europe and the US have successfully pushed for mandatory labelling of GMO food. While the voluntary label is unlikely to emerge, a mandatory label system informing about the type of products (GE/GMO/traditional hybrid) could be a mix blessing, since it could deter GE innovation. Consumers in our experiment did not seem to care in terms of letting

their WTP be influenced by their attitudes towards labels. Of course, the information provided in the experiment was an informational substitute to a label. The discounts and premia observed for the new apples could also take place with a label in actual purchase situations. The question of informative labels is still an open question and can be useful in case of crisis.

The World Trade Organization (WTO) Technical Barrier to Trade (TBT) Agreement allows for labelling not related to food safety, for example either to reply to a cultural request or to avoid consumer deception. This latter argument would be a valid reason to impose a label on GE food across borders. GE apples could not be sold as conventional hybrid apples without deceiving consumers. Hence, a label could be justified, if consumers really care about these differences (Heumueller and Josling, 2004), which seems suggested by our results, at least for France (see Table 3).

The lower WTP for biotech apples reveal that a fraction of consumers are "boycotters", whereas other consumers are indifferent and do not react to the biotech messages. Hence, a potential market exists for these new apples, issued from biotech techniques, but it will be a subset of consumers consuming conventional apples, especially in Europe. We also found that in both countries, the WTP for new apples increases for consumers who exhibit positive attitudes towards innovations in foods, to the point of fully offsetting the discount on GE apples, in both France and the US. As Gaskell et al. (2011) noted about the evolving attitudes of European consumers toward more acceptance of biotechnology, there is qualified optimism regarding the acceptance of GE food with beneficial attributes by a substantial subset of consumers. Educating and providing generic knowledge about the potential of biotech for contributing to sustainable food systems will be instrumental for the future.

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Table 1. Socio-economic characteristics and apples consumption (France and the US)

Description	France	US
Age (mean)	41.8	39.8
Gender (%)		
Male	48.1	29.5
Female	51.9	70.5
Education (%)		
No diploma or high school diploma	30.3	7.2
Two years college, bachelor or graduate degree	69.8	92.8
Monthly net income of the household (%)	(€ in France)	($ in the US)
< 2000	36.3	7.0
[2000-5000]	52.5	33.5
> 50000	11.2	59.5
Children at home (%)		
No	67.9	59.0
Yes	32.1	41.0
Apples' consumption (%)		
Never or rarely	14.2	36.8
At least once a week	64.8	54.2
At least once a day	21.0	9.0
Index (mean)		
Technology	-0.06	0.55
Label	0.62	0.44

Note: for each characteristic, missing observations and answers of "don't know" are dropped. French (resp. US) sample includes 162 participants (resp. 166 participants). Technology and label indexes are centered on the 'do not know' answer and vary between [-1.5; 1.5].

Table 2. Boycotters and indifferent participants (France and the US)

	France (%)		US (%)	
	New	Conventional	New	Conventional
Boycotters				
WTP2>0 & WTP5 =0 (New)	42.6		19.3	
WTP 1>0 & WTP5=0 (Conv.)		0		0
Indifferent participants				
WTP2>0 & WTP2 = WTP5 (New)	13.0		32.5	
WTP1>0 & WTP2=WTP5 (Conv.)		49.4		59.6

Note: Indifferent participants are participants with a similar strictly positive WTP for the new/conv. variety at the beginning and the end of the experiment. Boycotters are participants with a WTP dropping to zero after information revelation.

Table 3. Determinants of French WTP

Dependent variable	WTP				
Variety	New				Conv.
	(1)	(2)	(3)	(4)	(5)
1 if info. about browning process	94.12^a	95.15^a	93.85^a	94.43^a	106.23^a
	(19.48)	(19.42)	(19.51)	(19.44)	(1.46)
1 if info. about traditional hybridization	97.99^a	99.02^a	97.71^a	98.29^a	106.74^a
	(19.47)	(19.42)	(19.51)	(19.44)	(1.46)
1 if info. about GE	45.53^b				108.40^a
	(19.55)				(1.46)
1 if info. about GMOs	14.44				109.31^a
	(19.64)				(1.45)
1 if info. about GE x short		35.76^c			
		(20.02)			
1 if info. about GE x long		56.59^a			
		(20.02)			
1 if info. about GMOs x short		5.63			
		(20.22)			
1 if info. about GMOs x long		24.57			
		(20.15)			
1 if info. about GE x first			52.47^a		
			(19.99)		
1 if info. about GMOs x first			18.51		
			(20.32)		
1 if info. about GE x second			38.29^c		
			(20.23)		
1 if info. about GMOs x second			9.53		
			(20.21)		
1 if info. about GE x first x short				45.93^b	
				(20.75)	
1 if info. about GE x first x long				59.89^a	
				(21.11)	
1 if info. about GMOs x first x short				9.82	
				(21.61)	
1 if info. about GMOs x first x long				27.79	
				(21.03)	
1 if info. about GE x second x short				24.15	
				(21.44)	
1 if info. about GE x second x long				52.14^b	
				(20.87)	
1 if info. about GMOs x second x short				-0.32	
				(21.29)	
1 if info. about GMOs x second x long				19.68	
				(21.44)	
Technology index	59.57^a	60.56^a	59.46^a	60.49^a	-0.42
	(8.85)	(8.80)	(8.87)	(8.82)	(0.66)
Label index	-1.66	-2.62	-1.491	-2.53	0.17
	(6.91)	(6.96)	(6.925)	(6.99)	(0.46)
Observations	639	639	639	639	639

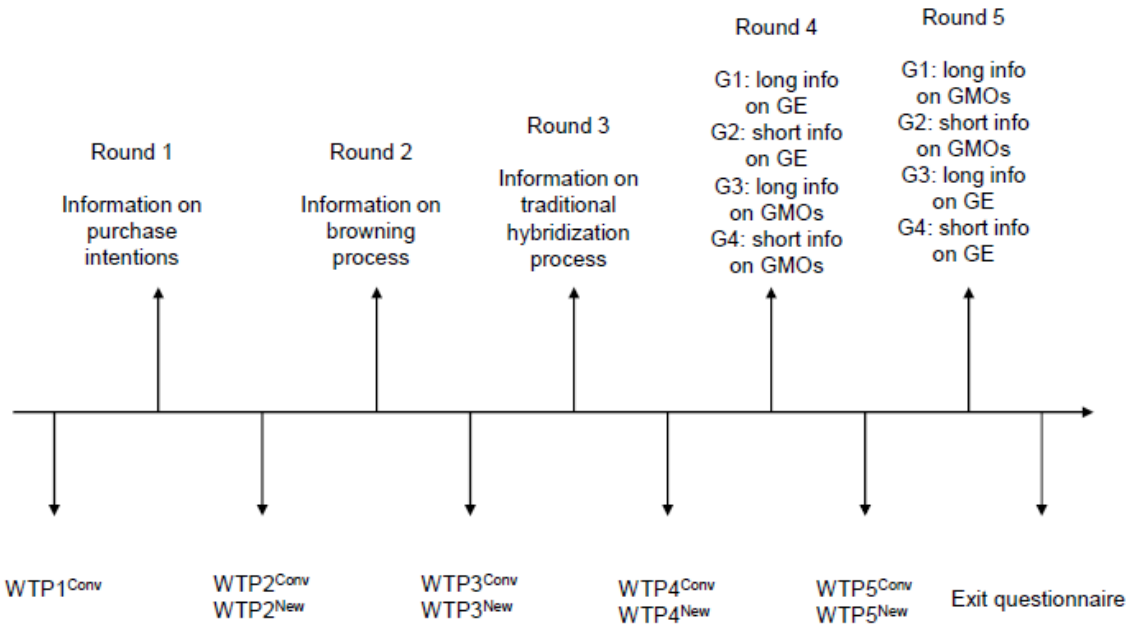
Note: The dependent variable is the WTP expressed by French participants at round R with R={2,3,4,5}. These WTP are in levels (basis 100 for round 1 and conventional variety). Estimations control for the socio-economic characteristics of participants (age, gender, presence of children, education and income) and their level of apples' consumption. These controls are not significant and not reported here (available from the authors). Significance levels are a=1%, b=5%, and c=10%.

Table 4. Determinants of US WTP

Dependent variable	WTP				
Variety	New				Conv.
	(1)	(2)	(3)	(4)	(5)
1 if info. about browning process	121.48^a	121.19^a	121.01^a	121.12^a	92.58^a
	(13.69)	(13.71)	(13.65)	(13.66)	(2.09)
1 if info. about traditional hybridization	125.22^a	124.93^a	124.75^a	124.86^a	92.64^a
	(13.69)	(13.71)	(13.65)	(13.66)	(2.09)
1 if info. about GE	96.12^a				94.09^a
	(13.70)				(2.09)
1 if info. about GMOs	84.20^a				94.59^a
	(13.70)				(2.09)
1 if info. about GE x short		97.06^a			
		(14.01)			
1 if info. about GE x long		94.67^a			
		(14.14)			
1 if info. about GMOs x short		85.61^a			
		(14.01)			
1 if info. about GMOs x long		82.29^a			
		(14.15)			
1 if info. about GE x first			92.91^a		
			(14.14)		
1 if info. about GMOs x first			85.51^a		
			(13.92)		
1 if info. about GE x second			98.23^a		
			(13.91)		
1 if info. about GMOs x second			81.85^a		
			(14.15)		
1 if info. about GE x first x short				91.44^a	
				(14.78)	
1 if info. about GE x first x long				94.47^a	
				(14.94)	
1 if info. about GMOs x first x short				89.85^a	
				(14.60)	
1 if info. about GMOs x first x long				81.46^a	
				(14.64)	
1 if info. about GE x second x short				102.01^a	
				(14.59)	
1 if info. about GE x second x long				94.76^a	
				(14.61)	
1 if info. about GMOs x second x short				80.77^a	
				(14.80)	
1 if info. about GMOs x second x long				83.06^a	
				(14.96)	
Technology index	24.76^a	24.74^a	24.83^a	24.79^a	-0.86
	(4.51)	(4.51)	(4.50)	(4.49)	(0.77)
Label index	-3.55	-3.64	-3.44	-3.42	0.14
	(4.16)	(4.17)	(4.15)	(4.15)	(0.76)
Observations	632	632	632	632	632

Note: The dependent variable is the WTP expressed by US participants at round R with R={2,3,4,5}. These WTP are in levels (basis 100 for round 1 and conventional variety). Estimations control for the socio-economic characteristics of participants (age, gender, presence of children, education and income) and their level of apples' consumption. These controls are not significant and not reported here (available from the authors). Significance level is a=1%.

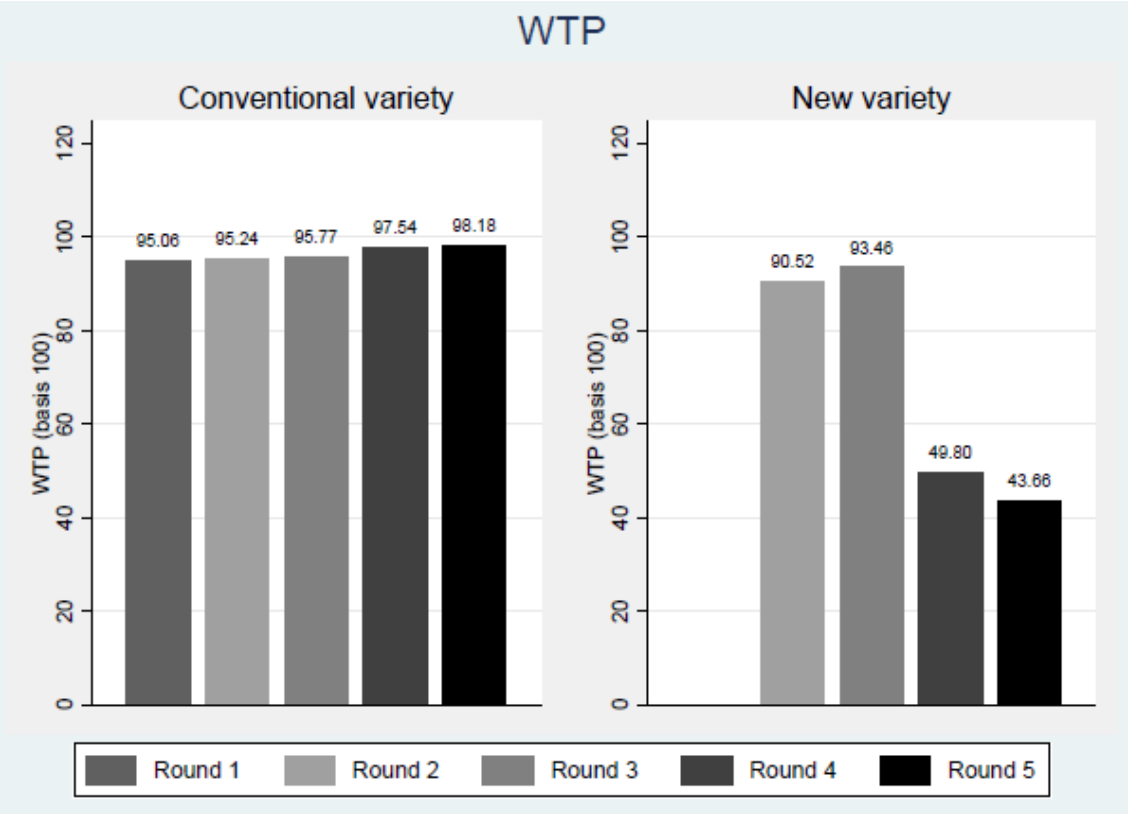
Figure 1. Experiment design and timeline



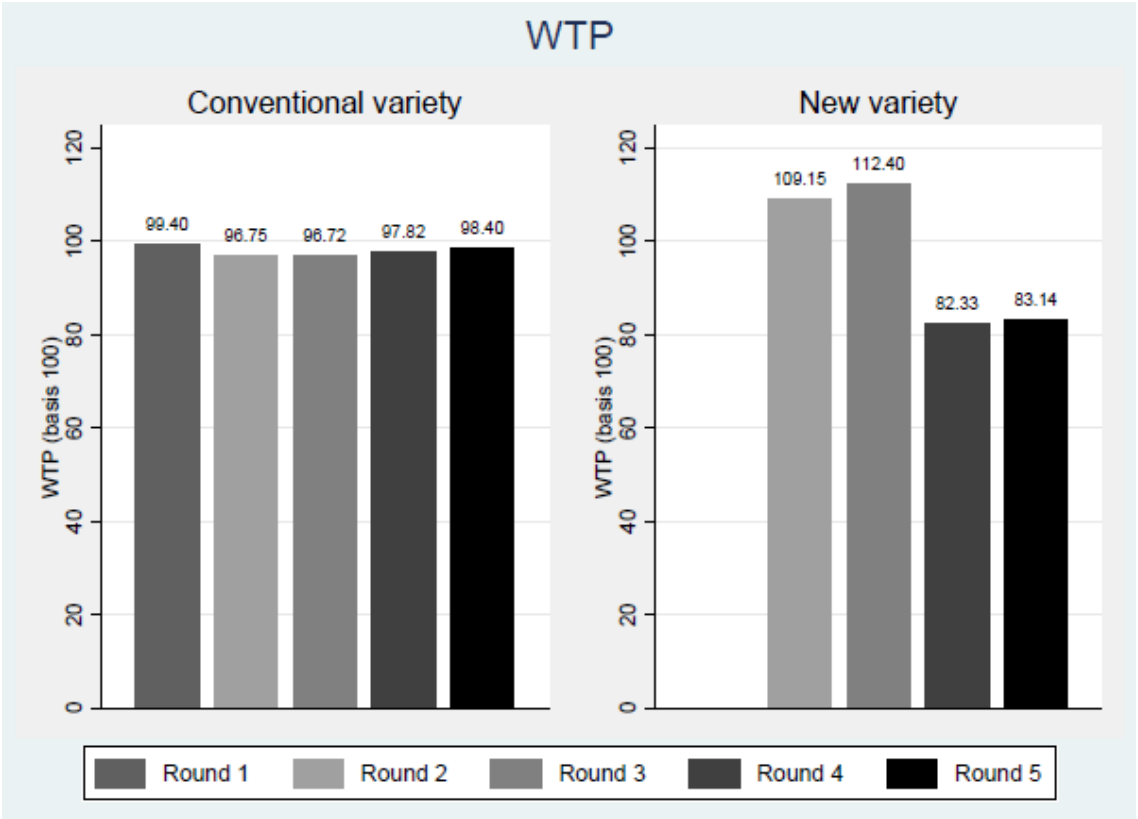
Note: GE: gene editing; GMOs: genetically modified organisms

Figure 2.a. Mean WTP and their variations after information revelation

(a) France

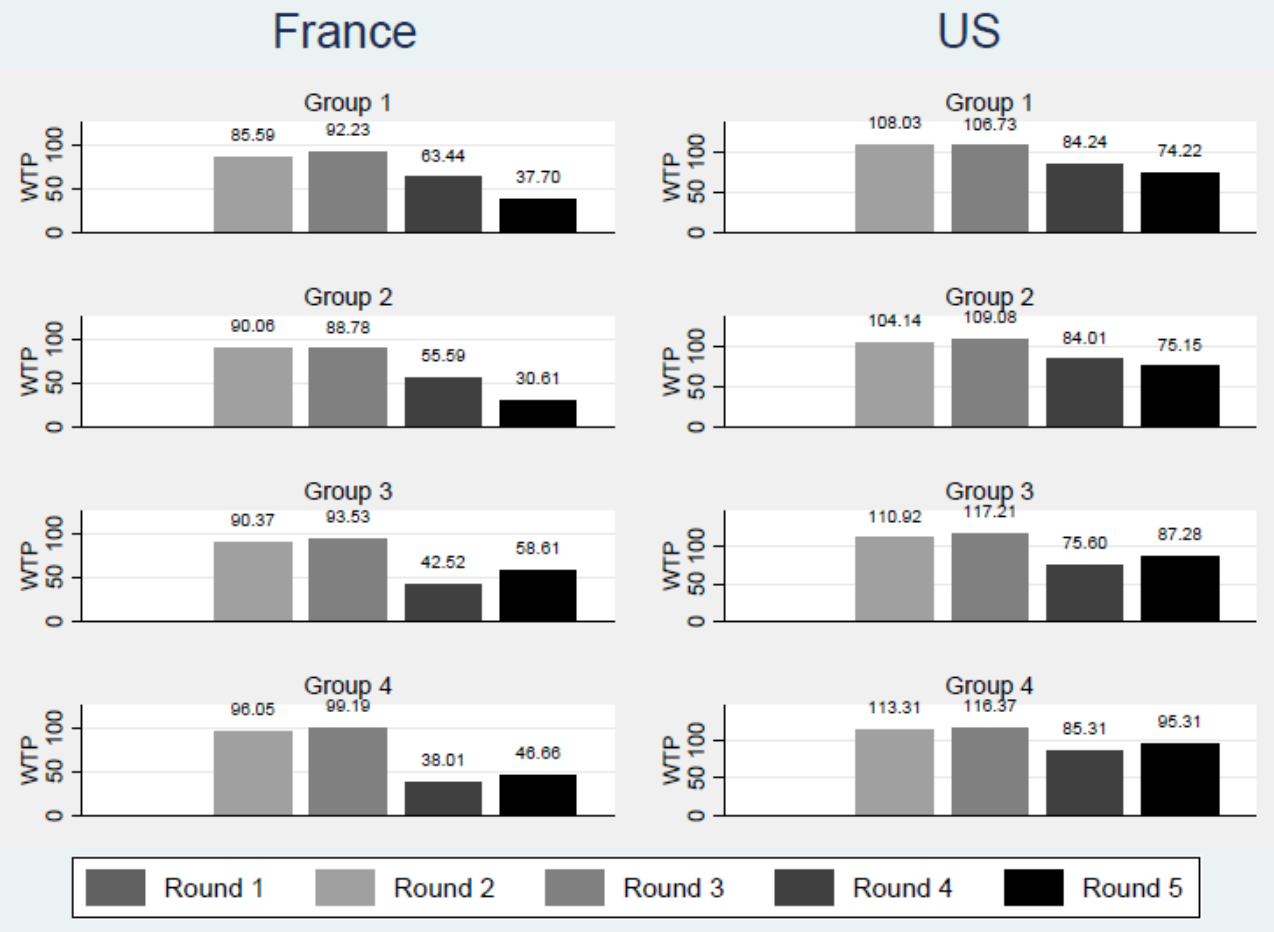


(b) The US



Note: WTP are in level (basis 100 for round 1 and conventional variety). Means are computed over all participants for each round and variety.

Figure 2.b. Mean WTP and variations after information revelation for the new variety, by group of participants



Note: WTP are in level (basis 100 for round 1 and conventional variety). Means are computed over all participants for each group and round. The variation in WTP expressed for the new variety between rounds 3 and 4 is significant for groups II, III and IV both in France and in the US. In addition for France, the variation in WTP expressed for the new variety between rounds 4 and 5 is significant for groups I and II.

Appendix A. Information revealed during the experiment

- **Information on purchase intentions (all groups, round 1)**

"We are interested in your purchasing intentions for 1 kilogram/pound of apples. These are apples from conventional farming. Regular consumption of apples is particularly recommended by various public health agencies because it is a healthy food, low in calories and a source of vitamins.
We are now asking you if you would be willing to buy 1 kilogram/pound of apples from conventional farming at different prices."

- **Information on browning process (all groups, round 2)**

"New apples will soon be on the market.
These new apples can be stored longer and they brown less quickly on contact with air (when they are peeled) compared to conventional apples. This helps reduce food waste both at the producer level, in supermarkets and at home.
Apart from the characteristics described above, these new apples are equivalent to apples from conventional farming, especially in terms of nutritional intake and value."

- **Information on traditional hybridization process (all groups, round 3)**

"These new apples which keep longer and do not turn brown were obtained through a traditional hybridization process.
This hybridization process, used for a long time in agronomy, consists in crossing two different apple varieties in order to exploit the genetic potential of each of the two varieties. The new apple variety thus created (hybrid variety) is more resistant to aging and browning.
Apart from the previous characteristics, these new apples are equivalent to apples from conventional agriculture and which have not been the subject of this hybridization process, especially in terms of nutritional benefits."

- **Information on GE**

Short message (group 2, round 4; group 4, round 5)

"These new "hybrid" apples, which keep longer and do not turn brown, can also be obtained from a technological innovation, which involves modifying the gene sequence of conventional apples, without the introduction of a foreign gene.
This innovation consists of editing the genetic sequence of the apple in order to isolate the gene responsible for browning so that it can then be neutralized or deleted.
Apart from the previous characteristics, these new apples are equivalent to apples from conventional agriculture and which have not been the subject of this innovation, especially in terms of nutritional intake and value."

Long message (group 1, round 4; group 3, round 5)

"These new hybrid apples, which keep longer and do not turn brown, can also be obtained from a technological innovation, which involves modifying the gene sequence of conventional apples, without the introduction of a foreign gene.
This innovation consists in editing the genetic sequence of the apple in order to isolate the gene responsible for browning in order to be able to neutralize or delete it. More specifically, it is a technique called CRISPR-Cas9, which has become a genetic engineering tool that makes it easier and more precise to modify DNA sequences.
Apart from these new characteristics, these new apples are equivalent to apples from conventional farming and which have not been the subject of this innovation, particularly in terms of nutritional

intake and value."

- **Information on GMO**

Short message (group 2, round 5; group 4, round 4)

"These new "hybrid" apples, which keep longer and do not turn brown, can also be obtained from a technological innovation, which introduces the gene of another species (for example from a cauliflower) into the gene sequence of the conventional apple.
This innovation consists of a genetic modification because a foreign gene is introduced into the genetic sequence of the apple in question.
Apart from the previous characteristics, these new apples are equivalent to apples from conventional farming and which have not been the subject of this innovation, particularly in terms of nutritional intake and value."

Long message (group 1, round 5; group 3, round 4)

"These new "hybrid" apples, which keep longer and do not turn brown, can also be obtained from a technological innovation, which introduces the gene of another species (for example from a cauliflower) into the gene sequence of the conventional apple.
This innovation consists of a genetic modification because a foreign gene is introduced into the genetic sequence of the apple in question. More specifically, it is a technique called cisgenesis introducing a gene from a close species so as not to express an enzyme, responsible for browning in contact with air. The insertion of this gene leads to classify the apple as GMO (Genetically Modified Organism).
Apart from the previous characteristics, these new apples are equivalent to apples from conventional farming and which have not been the subject of this innovation, particularly in terms of nutritional intake and value."

Appendix B. Additional tables and figures

Table B.1. Socio-economic characteristics and apples consumption, for France

Description	Group I	Group II	Group III	Group IV	Kruskal-Wallis test *P*-value
Age (mean)	42.6	39.6	42.5	42.3	0.793
Gender (%)					
Male	45.0	50.0	47.6	50.0	0.977
Female	55.0	50.0	52.4	50.0	
Education (%)					
No diploma or high school diploma	50.0	55.0	52.4	60.0	0.900
Two years college, bachelor or graduate degree	50.0	45.0	47.6	40.0	
Monthly net income of the household in Euros (%)					
< 2000	47.5	33.3	35.7	28.2	
[2000-5000]	37.5	53.9	57.1	61.5	0.806
> 50000	15.0	12.8	7.2	10.3	
Children at home (%)					
No	65.0	65.0	71.4	70.0	0.929
Yes	35.0	35.0	28.6	30.0	
Apples' consumption (%)					
Never or rarely	12.5	22.5	14.3	7.5	
At least once a week	65.0	62.5	66.7	65.0	0.292
At least once a day	22.5	15.0	19.0	27.5	
Index (mean)					
Technology	-0.08	-0.002	-0.13	-0.04	0.747
Label	0.63	0.51	0.77	0.54	0.129

Note: for each characteristic, missing observations and answers of "don't know" are dropped. Groups I, II, and IV include 40 participants. Group III includes 42 participants.

Table B.2. Socio-economic characteristics and apples consumption, for the US

Description	Group I	Group II	Group III	Group IV	Kruskal-Wallis test *P*-value
Age (mean)	41.6	37.8	38.9	40.7	0.464
Gender (%)					
Male	26.8	14.6	41.5	34.9	0.179
Female	73.2	85.4	58.5	65.1	
Education (%)					
No diploma or high school diploma	2.4	9.8	4.9	11.6	0.100
Two years college, bachelor or graduate degree	97.6	90.2	95.1	88.4	
Monthly net income of the household in USD (%)					
< 2000	2.5	10.8	4.9	10.0	
[2000-5000]	42.5	27.0	39.0	25.0	0.829
> 50000	55.0	62.2	56.1	65.0	
Children at home (%)					
No	53.7	61.0	61.0	60.5	0.885
Yes	46.3	39.0	39.0	39.5	
Apples' consumption (%)					
Never or rarely	31.7	41.5	34.1	39.5	
At least once a week	63.4	43.9	53.7	55.8	0.932
At least once a day	4.9	14.6	12.2	4.7	
Index (mean)					
Technology	0.56	0.61	0.53	0.52	0.940
Label	0.41	0.54	0.40	0.40	0.668

Note: for each characteristic, missing observations and answers of "don't know" are dropped. Groups I, II, and III include 41 participants. Group IV includes 43 participants.

Table B.3. Price list used in the experiment (France and the US)

France (1 kg)				US (1 pound)			
	Yes	No	Maybe		Yes	No	Maybe
1.60 Euros	□	□	□	$0.70	□	□	□
1.70 Euros	□	□	□	$0.80	□	□	□
1.80 Euros	□	□	□	$0.90	□	□	□
1.90 Euros	□	□	□	$1.00	□	□	□
2.00 Euros	□	□	□	$1.10	□	□	□
2.10 Euros	□	□	□	$1.20	□	□	□
2.20 Euros	□	□	□	$1.30	□	□	□
2.30 Euros	□	□	□	$1.40	□	□	□
2.40 Euros	□	□	□	$1.50	□	□	□
2.50 Euros	□	□	□	$1.60	□	□	□
2.60 Euros	□	□	□	$1.70	□	□	□
2.70 Euros	□	□	□	$1.80	□	□	□
2.80 Euros	□	□	□	$1.90	□	□	□
2.90 Euros	□	□	□	$2.00	□	□	□
3.00 Euros	□	□	□	$2.10	□	□	□
3.10 Euros	□	□	□	$2.20	□	□	□
3.20 Euros	□	□	□	$2.30	□	□	□
3.30 Euros	□	□	□	$2.40	□	□	□

Note: In France, the price (in Euros) is asked for one kilogram of apples. In the US, the price (in USD) is asked for one pound of apples.

Table B.4. Determinants of French WTP differences, new vs. conventional variety

Dependent variable	Differences WTP^N - WTP^C			
	(1)	(2)	(3)	(4)
1 if info. about browning process	-3.69 (12.13)	-3.12 (12.15)	-4.26 (12.15)	-4.22 (12.20)
1 if info. about traditional hybridization	-1.23 (12.13)	-0.67 (12.15)	-1.81 (12.15)	-1.77 (12.20)
1 if info. about GE	-40.14*a* (12.13)			
1 if info. about GMOs	-60.31*a* (12.13)			
1 if info. about GE x short		-45.09*a* (12.49)		
1 if info. about GE x long		-34.32*a* (12.57)		
1 if info. about GMOs x short		-62.76*a* (12.47)		
1 if info. about GMOs x long		-56.91*a* (12.57)		
1 if info. about GE x first			-33.93*a* (12.44)	
1 if info. about GMOs x first			-60.18*a* (12.61)	
1 if info. about GE x second			-47.33*a* (12.61)	
1 if info. about GMOs x second			-61.65*a* (12.43)	
1 if info. about GE x first x short				-36.82*a* (13.03)
1 if info. about GE x first x long				-31.02*b* (13.38)
1 if info. about GMOs x first x short				-63.85*a* (13.48)
1 if info. about GMOs x first x long				-56.67*a* (13.22)
1 if info. about GE x second x short				-55.56*a* (13.48)
1 if info. about GE x second x long				-39.59*a* (13.22)
1 if info. about GMOs x second x short				-63.91*a* (13.02)
1 if info. about GMOs x second x long				-59.41*a* (13.38)
Technology index	36.36*a* (5.36)	36.73*a* (5.36)	36.17*a* (5.37)	36.59*a* (5.38)
Label index	-0.70 (4.24)	-1.18 (4.26)	-0.45 (4.25)	-0.99 (4.27)
Observations	639	639	639	639

Note: The dependent variable is the difference in WTP between the new and the conventional apples of French participants at round *R* with *R*={2,3,4,5}. WTP are in levels (basis 100 for round 1 and conventional variety). Estimations use the random effect Tobit estimator and control for the socio-economic characteristics of participants as in the other runs and their level of apples' consumption. These controls are not significant and not reported here (available from the authors). Significance levels a=1% & b=5%.

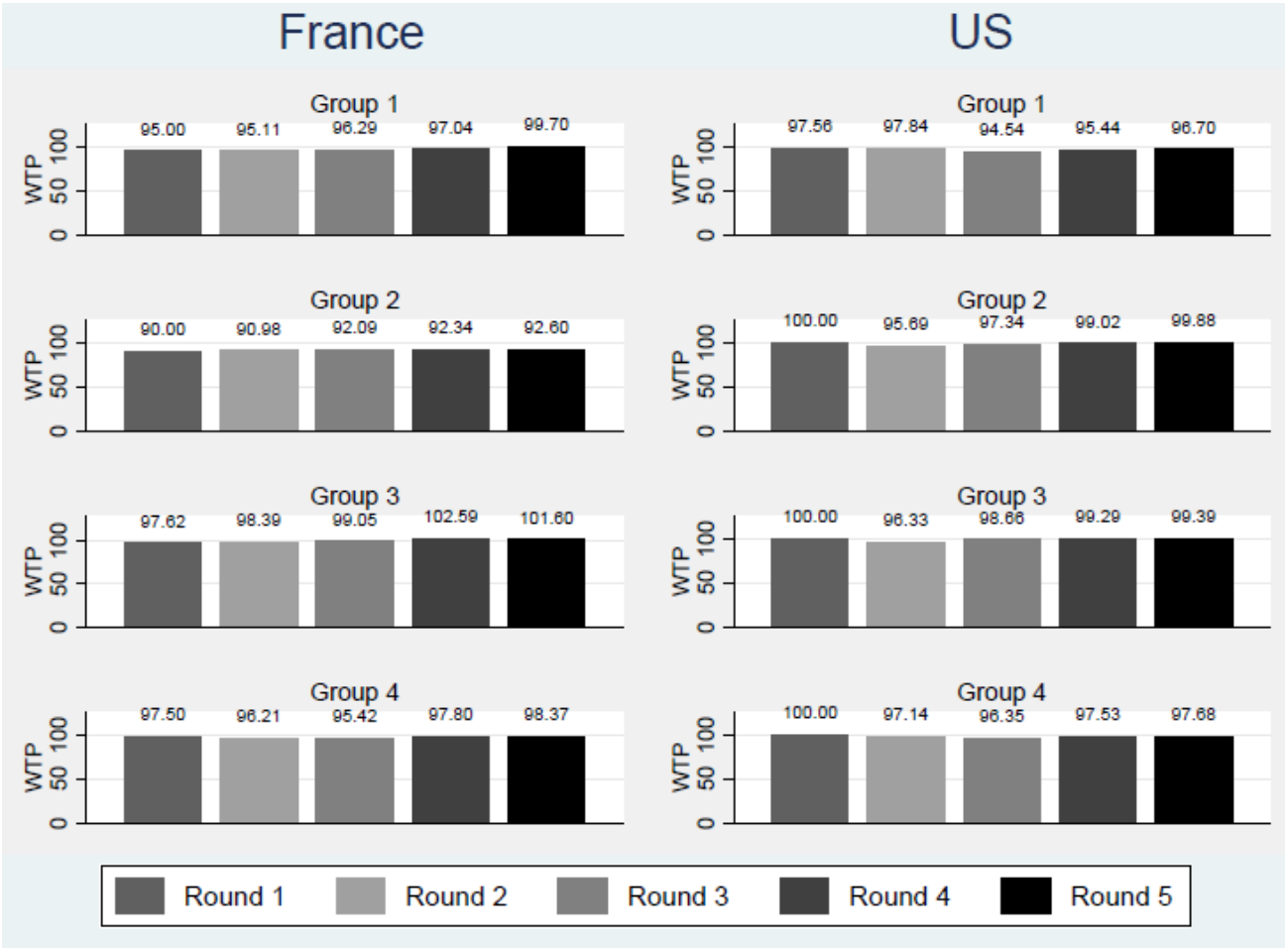
Table B.5. Determinants of US WTP differences, new vs. conventional variety

Dependent variable	Differences WTP^N - WTP^C			
	(1)	(2)	(3)	(4)
1 if info. about browning process	23.63^b (11.60)	23.49^b (11.61)	23.21^b (11.57)	23.58^b (11.55)
1 if info. about traditional hybridization	26.93^b (11.60)	26.79^b (11.61)	26.51^b (11.57)	26.88^b (11.55)
1 if info. about GE	-0.17 (11.60)			
1 if info. about GMOs	-11.22 (11.60)			
1 if info. about GE x short		0.20 (11.88)		
1 if info. about GE x long		-0.80 (12.00)		
1 if info. about GMOs x short		-10.40 (11.88)		
1 if info. about GMOs x long		-12.29 (12.00)		
1 if info. about GE x first			-2.61 (12.01)	
1 if info. about GMOs x first			-9.78 (11.80)	
1 if info. about GE x second			1.32 (11.80)	
1 if info. about GMOs x second			-13.62 (12.01)	
1 if info. about GE x first x short				-5.28 (12.56)
1 if info. about GE x first x long				0.55 (12.71)
1 if info. about GMOs x first x short				-5.21 (12.40)
1 if info. about GMOs x first x long				-13.47 (12.41)
1 if info. about GE x second x short				5.39 (12.40)
1 if info. about GE x second x long				-1.89 (12.41)
1 if info. about GMOs x second x short				-15.87 (12.56)
1 if info. about GMOs x second x long				-10.84 (12.71)
Technology index	23.23^a (3.78)	23.21^a (3.78)	23.28^a (3.77)	23.28^a (3.76)
Label index	-0.87 (3.49)	-0.92 (3.50)	-0.78 (3.48)	-0.68 (3.47)
Observations	632	632	632	632

Note: The dependent variable is the difference in WTP between the new and the conventional varieties expressed by US participants at round *R* with *R*={2,3,4,5}. These WTP are in levels (basis 100 for round 1 and conventional variety). Estimations use the random effect Tobit estimator and control for the socio-economic characteristics of participants as in previous runs and their level of apples' consumption. These controls are not significant and not reported here (available from the authors). Significance levels a=1% & b=5%.

Figure B.1. Picture of apples

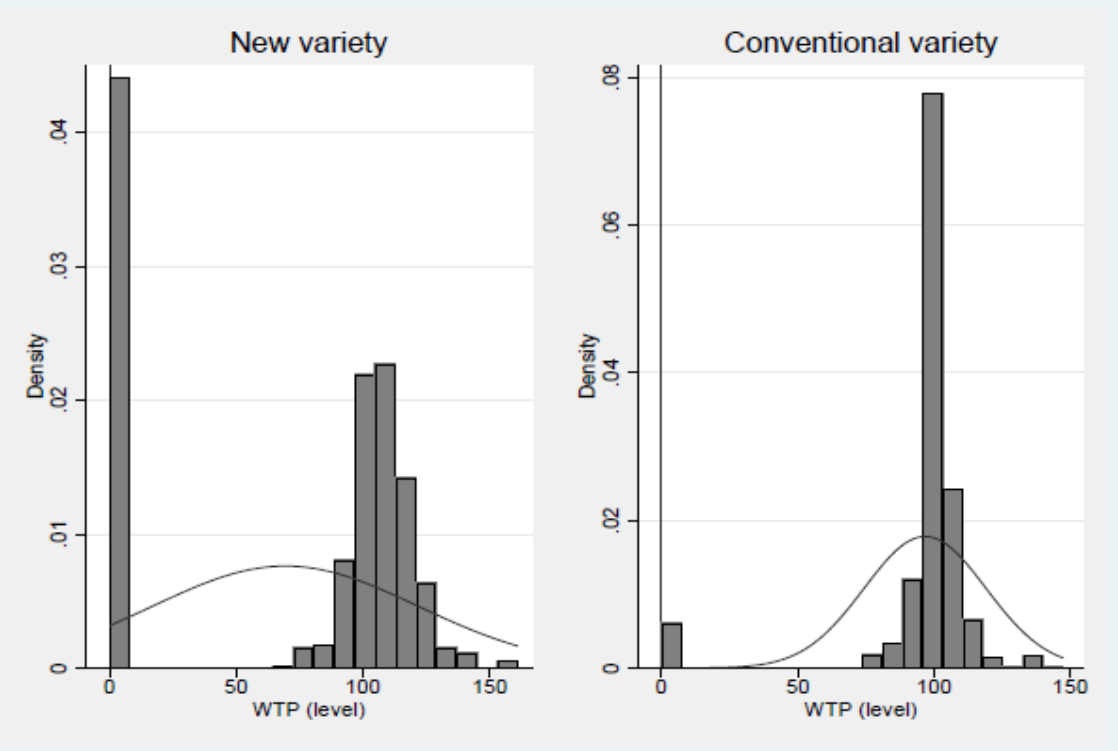
Figure B.2. Mean WTP and variations after information revelation for the conventional variety, by group of participants



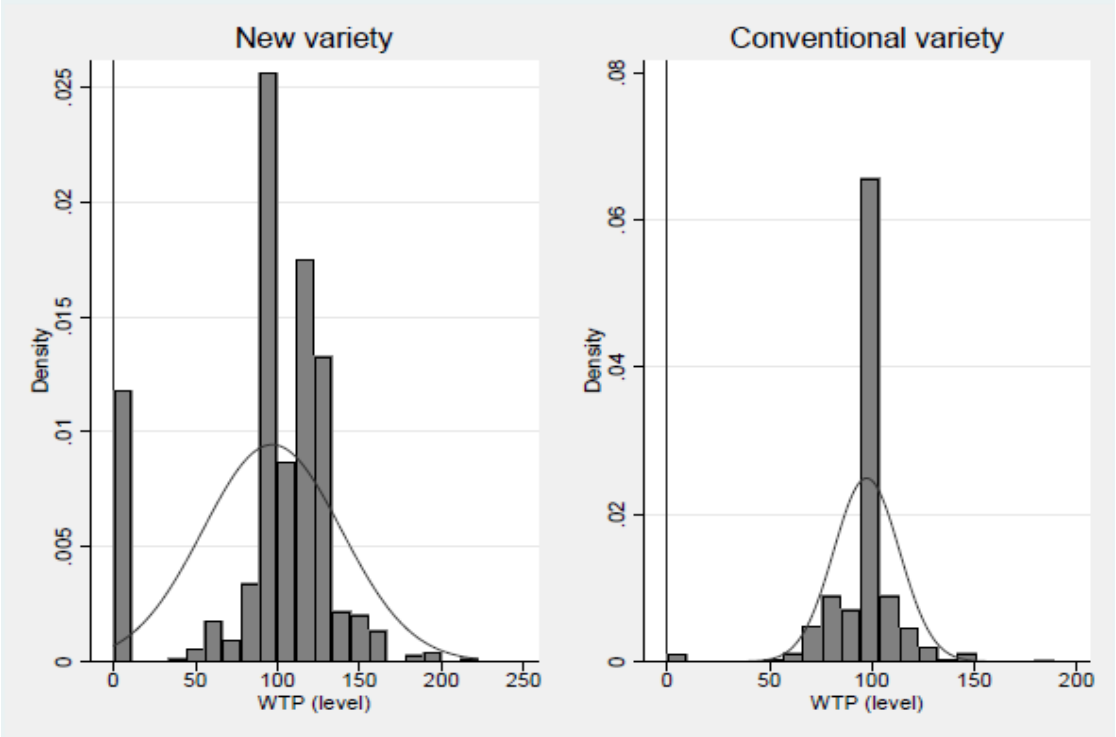
Note: WTP are in level (basis 100 for round 1 and conventional variety). Means are computed over all participants for each group and round.

Figure B.3. Distribution of WTP

(a) France



(b) The US



Note: WTP are in level (basis 100 for round 1 and conventional variety).

Appendix C. Questions used for the technology and label attitude indices

C.1. Technology and Innovation attitudes questions

The last decades have been marked by multiple innovations in food. Others will appear in the future. Are you in favor of the innovations listed below?

	Not at all in favor	Rather not in favor	Rather in favor	Completely in favor	Does not know
Using a microwave oven	1	2	3	4	5
Marketing of frozen meals	1	2	3	4	5
UHT treatment and launch of the Tetra Brik (allows you to store liquids - milk, fruit juice, soups, etc. - for several months at room temperature)	1	2	3	4	5
Packaging in a protective atmosphere (limits the proliferation of bacteria and increases the shelf life).	1	2	3	4	5
Marketing of washed, cut and ready-to-eat fruits and vegetables	1	2	3	4	5
Modification of the genome of certain products (GMOs)	1	2	3	4	5
Use of nanoparticles in the manufacture of certain products	1	2	3	4	5
Development of new products (vegetable proteins, synthetic meat)	1	2	3	4	5
Strengthening nutritional characteristics (low-fat products, salt, fiber-enriched products, omega 3, probiotics, etc.)	1	2	3	4	5
Use of new raw materials (algae, vegetable milks, Stevia, etc.)	1	2	3	4	5
Irradiation treatment of food (exposure of food to ionizing radiation to reduce the number of microorganisms it contains).	1	2	3	4	5

C.2 Label attitudes Questions

	Not at all in favor	Rather not in favor	Rather in favor	Completely in favor	Does not know
Are you in favor of the creation of the "fair trade" label	1	2	3	4	5
For you, a quality food item is a product which carries a label indicating superior quality, faire trade, etc.	1	2	3	4	5