Is the CCN-51 cacao hybrid the solution for the potential shortage of chocolate? A hedonic and willingness to pay study for different varieties of Ecuadorian chocolate

Andrés Castaño[*]
Cornell University
Department of City and Regional Planning
Cornell University

Miguel Gómez
Cornell University
Charles H. Dyson School of Applied Economics and Management
Cornell University

PRELIMINARY AND INCOMPLETE
November 2022

Abstract

Chocolate has been experiencing a significant increase in demand during the last two decades. However, the current powerful boost in demand and the expectations of an even higher one might not be accompanied by an equal increase in supply. Cacao, the main component of chocolate and the one that gives its texture and flavor, faces various threats, from climate change and fungal diseases to political instability in production regions worldwide. One potential solution to the shortage of chocolate is expanding or promoting certain hybrids that have shown good yield and disease resistance. One of the most promising solutions to the cacao shortage might be the CCN-51 cacao hybrid. We used an auction experiment to study the hedonic properties and the factors affecting the WTP for Ecuadorian chocolate produced with different cacao, including the CCN-51 cacao hybrid. We find that smell ratings favored the highest quality cacao compared to the CCN-51 hybrid; however, there were no differences in taste ratings. We also find no difference in mean WTP between the national variety and the CCN-51 cacao hybrid, even when information on the quality and nutritional value of the cacao was provided. Results suggest the expansion in the use of CCN-51 cacao in chocolate production is a plausible alternative to deal with the potential shortage of chocolate.

Keywords: Chocolate production, WTP, CCN-51 cacao hybrid

JEL codes: Q18, D44

[*] Corresponding Author. Email: ac986@cornell.edu.

Introduction

Chocolate has been experiencing a significant increase in demand during the last two decades. Chocolate confectionary retail consumption grew by 28% between 2000-2013 (Poelmans and Swinnen, 2016). The industry's growth has been driven by two factors. First, the emergent popularity of chocolate in countries with big markets and increasing income per capita, such as India, China, and Russia. Second, the recent evidence regarding the health benefits of certain types of chocolate (Moramarco and Nemi, 2016)[1]. However, the future sustainability of the industry is in jeopardy. The current powerful boost in demand and the expectations of an even higher one might not be accompanied by an equal increase in supply (Gilbert, 2016, p. 321).

Cacao, the main component of chocolate and the one that gives its texture and flavor, is facing various threats. First, climate change has led to radical decreases in land suitable for cacao crops. For instance, in Indonesia, the third highest world producer, the annual rains are becoming more intense over shorter periods, knocking the flowers off the cacao trees and avoiding pod formation (Schmitz and Shapiro, 2012, pp. 61). In Ivory Coast and Ghana (the first and second-world producers), some current cocoa areas will become unsuitable for production due to dry weather (Läderach et al., 2013). Indeed, some areas previously used for cocoa are now used for other crops (e.g., rubber).

Second, two fungal diseases have affected Latin American production: witches'

[1] For instance, dark chocolate is rich in antioxidants, which are alleged to prevent cardiac diseases. These perceived health benefits have been driving demand's growth for products with larger cocoa concentration.

broom and frosty pod rot[2]. The latter is the most recent and dangerous because it is currently in an active diffusion phase, probably due to increased human-mediated spread (Phillips-Mora and Wilkinson, 2007). Meanwhile, the former, although not too recent, have played an essential role in the fall of production in countries such as Ecuador and Brazil.

Finally, in Ivory Coast and Ghana, where 60% of the world's cocoa production is concentrated (The International Cocoa Organization, 2017), poverty and political instability are pushing the farmers out of the cocoa business. Poverty means that farmers cannot afford fertilizers, pesticides, and fungicides that boost tree productivity, and even in some cases when they can afford it, they do not have the training to use it effectively, so they opt to harvest a more profitable crop, such as rubber.

The objective of this document is to study the hedonic properties and the factors affecting the WTP for Ecuadorian chocolate produced with different varieties of cocoa. Our contribution to the literature is twofold: first and foremost, we provide estimates of the WTP for chocolate made from CCN-51 that can inform farmers and manufacturers about how the consumer value and perceive this variety. Second, we want to explore the potential of chocolate made from CCN-51 as a good substitutive for high-quality chocolate, which in turn might help to orientate the policy efforts intended by manufacturers, universities, and government agencies, as well as provide empirical evidence to consider whether the CCN-51 cacao hybrid is a

[2] Brazil has known by first-hand the effect of one these fungal diseases in the production. During the 90s the witches' broom reduced the production by an estimated of 75 percent (http://www.npr.org/templates/story/story.php?storyId=91479835)

plausible solution to deal with the potential shortage of chocolate predicted by some manufacturers and analysts.

The possibility of suffering a chocolate shortage has brought together the different stakeholders of cacao production, such as farmers, corporations, universities, and government agencies (for instance, USDA), to design and implement various methods to boost production. Selective breeding and farmer education efforts are among the alternatives. Selective breeding is used to find where in the world the cacao crops are disease resistant, more productive, and adaptable to different climate conditions. The education efforts pretend to teach farmers about novel planting, irrigation, and pest-management techniques. Despite these efforts, some analytic firms, manufacturers, and the International Cocoa Organization fear that the cacao supply will soon be insufficient to guarantee an equilibrium in the Chocolate market[3].

Another potential option for the shortage of chocolate is to promote the production of certain hybrids that have shown good yield and disease resistance. In this regard, one of the most promising solutions for the cacao shortage might be the CCN-51 cacao hybrid[4]. The CCN-51 variety was developed in Ecuador by Homero Castro in the 1970s and is now recognized worldwide as one of the most productive

[3] http://www.smithsonianmag.com/science-nature/how-save-chocolate-tree-without-sacrificing-flavor-180954148/

[4] There are three general cocoa varieties: Criollo, Forastero, and Trinitario (https://www.barry-callebaut.com/chocophilia/theobroma-cacao-food-gods). The Criollo three is originated from Central to South America, highly demanded for the finest chocolates, and represent only the 5% of the world production. The Forastero tree is the most commonly grown cocoa, it is mainly cultivated in Africa, Ecuador and Brazil, highly resistant to diseases and accounts for 80% of the world production. Finally, the Trinitario is a natural hybrid created from cross-pollination that combines the durability of the Forastero and the refined taste of the Criollo.

cocoa varieties (Boza et al., 2014). It produces around 1 to 3 tons per hectare, depending on the management practices (Amores et al., 2011). The hybrid also has several other benefits. First, it is resistant to the Witch's Broom disease. Second, CCN-51 trees start producing after two years, compared to 3-5 years for other varieties such as Trinitario. Third, CCN-51 trees are relatively short, averaging 5 meters. Finally, CCN-51 contains 54% cocoa butter and a significant number of antioxidants, which are highly demanded features in the chocolate and pharmaceutical industries.

Notwithstanding all the advantages over other cocoa varieties, using CCN-51 to make chocolate faces several challenges. On the one hand, some of the more prominent chocolate manufacturers (e.g., Hersey, Mars, and Cadbury) and experts have characterized its taste as acid and unsuitable for chocolate. Although new fermentation techniques have improved the acceptance among chocolate companies and chocolate tasters, many still think that the CCN-51 variety could affect the quality of the chocolate and consider that even the best CCN-51 is yet average in quality (Schatzker, 2014). Indeed, some countries regarded as producers of high-quality cocoa (e.g., Ecuador and Colombia) do not have the incentives to promote its cultivation because their international reputation could be affected. Therefore, it will put at risk the local producers of high-quality cocoa[5]. Finally, since the CCN-51 is genetically modified cocoa, its use in chocolate should deal with the current

[5] For instance, the Royal Tropical Institute (KIT) made a study of the fine flavor cocoa market in which the countries that mixed the fine flavor cocoa with certain varieties such as CCN-51 receive a negative assessment, thus reducing their chances of being considered high potential countries for fine flavor cocoa (van der Kooij, 2013).

political and cultural disavowal of genetically modified foods (GMF) (Greenpeace International, 2008; Rommens, 2010)[6].

Some obstacles to using and promoting the CCN-51 variety are based on the premise that if customers perceive the chocolate made with CCN-51 as low quality or associated with GMF, their willingness to pay for it will be lower compared with chocolate manufactured with higher quality cocoa. However, as far as the authors know, there is no literature about the acceptance and WTP for chocolate elaborated with CCN-51 cacao.

The paper is organized as follows: the second section presents a literature review regarding the Willingness to Pay (WTP) for Chocolate, its value chain, and some insights into the national/hybrid cacao debate. Section 3 explains the experimental design. Section 4 describes the data and the empirical strategy. Section 5 depicts the results of the econometric estimations. Section 6 concludes and discusses policy implications.

Related literature

While literature discusses chocolate's demand boos experienced during the last decade in India, China, Russia, and some African countries (Poelmans and Swinnen, 2016; Janssen and Riera, 2016; Tamru and Swinnen, 2016), the challenges that the supply side of the chocolate industry is facing to keep up with the growth of its demand (Läderach et al., 2013; Phillips-Mora and Wilkinson, 2007), and the characteristics of the cocoa value chain (Barrientos, 2013; Van der

[6] Some literature has established that consumers do not have a good understanding about the GMF (Anand et al., 2007; Curtis et al., 2004).

Kooij, 2013; Barrientos, 2016), scarce empirical attention exists on the hedonic valuation and WTP for chocolate elaborated with certain hybrids of cacao that have shown good yield and disease resistance (e.g., CCN-51), but that are considered of less quality by manufacturers.

Most of the literature on WTP for chocolate is enveloped by three groups: 1) The literature related to value-based labeling for organic and fair-trade labels; 2) The one related to the impact of reducing fat labeling on consumers' expected liking and willingness to pay, and 3) The literature associated with the acceptance of genetically modified foods (GMF). In most of these documents, chocolate bars are used as products during the experiments, but with no specific implications for the chocolate industry.

Within the first group, Tagbata and Sirieux (2008) estimate the WTP for organic and fair-trade chocolate bars in Montpellier (France) using the Becker-DeGroot-Marschak's mechanism (BDM) to elicit WTP. According to these authors, consumers' actual WTP for organic and fair-trade chocolate is higher than for traditional chocolate. For many consumers, the valuation of the organic and fair-trade labels is determined by the product's taste. Using a Discrete Choice Experiment and a larger sample size, Poelmans and Rousseau (2015) reach a similar result for Belgian consumers but with a markedly higher WTP. The respondents were willing to pay a premium of 10.60 euros per 250 gm of fair-trade chocolate compared to an identical product without a fair-trade label.

On the other hand, regarding the impact of reduced fat labeling on consumer

perception, Norton et al. (2013) for the case of Birmingham (UK) and Kahkonen et al. (1999) using university employees and students in Finland, found that despite that the expected pleasantness of chocolate bars is lower for those with a low-fat label, the actual hedonic ratings were unaffected by the labeling. Norton et al. (2013) also find that liking was positively associated with participants' buying intentions and the price they would be willing to pay.

The literature on WTP that could be more related to this document is the WTP studies for GMF. Chocolate made from CCN-51 is, by definition, a genetically modified food. This literature shows that WTP for non-GM foods is higher than WTP for GM foods. Still, the effect is conditioned on the consumers' capacity to identify GM labeling and the type of information they receive. Using an experimental auction and a random sample of the residents of Mannheim (Germany), Dannenberg et al. (2008) found that the mean bid difference between a GM chocolate bar and its non-GM version was 0.26 euros.

Kajale and Becker (2014) study the effect of information on consumers' WTP for GMF using a convenience sample of university students in Delhi (India) and applying the Vickrey second price experimental auction method to elicit WTP. The authors found that consumers were willing to pay the highest amount under a combination of positive and negative information about GMF for a soya-chocolate bar. On the other hand, only positive or negative information had no positive or negative effect on WTP for GMF. Noussair et al. (2002), using the Vickrey second price experimental auction method to elicit WTP for a representative sample of

consumers in Grenoble (France), found that labeling chocolate bars as containing GMOs do not affect consumers' WTP. Nevertheless, when the label is actually noticed, it induces a 30% decrease in WTP.

On the other hand, regarding the cocoa/chocolate value chain, cocoa is predominantly a smallholder crop, as more than 90% of world cocoa production originates from small farms (ICCO, 2013). However, the trading, processing, and manufacturing activities are dominated by a few multinationals (Fold and Neilson, 2016). There are marked differences between the places in which the cocoa is produced and the actual places in which the final chocolate product is processed and consumed. In 2010, 61% of the cocoa beans were produced in Africa (Ghana, Nigeria, and the Ivory Coast), 20% in Asia (especially Indonesia), and 12% in Latin America (primarily concentrated in Brazil and Ecuador) (FAOSTAT, 2013).

Meanwhile, the processing industry is located near the consumption centers: 52% of the cocoa beans are processed and transformed into intermediate and final chocolate in the developed world (Western Europe and North America). However, during the last 20 years, the processing industry has expanded to countries that have been previously related to only production tasks, such as Ivory Coast, Malaysia, Ghana, Brazil, and Indonesia (Kox, 2000). In 2010, these countries accounted for almost 35% of the processing industry[7]. This trend change is explained by the decomposition of the value added in the industry: only 3.3% of the consumer spending on finished chocolate products goes to cocoa farmers. Of the remaining 96.7%, 22% goes to chocolate processing, and 26% goes to wholesale and

[7] Calculations are based on Table 2.4 in Poelmans and Swinnen (2016, p. 27).

retail. So, some producing countries have started to make intermediate products and final chocolate as a form to capture a more significant share of the industry's total value added.

Chocolate consumption has also reshaped during the last 15 years. During the period 2000-2013, chocolate confectionery consumption in kg/capita declined or stagnated in wealthier countries such as EEUU, Sweden, France, and Belgium but has grown in emerging countries such as Brazil, Russia, India, and China (Poelmans and Swinnen, 2016, p. 38).

Another critical element of the chocolate value chain is the emergence of the CCN-51 variety. Homero Castro created the CCN-51 cacao in Ecuador during the 1970s, and it is now recognized worldwide as one of the most productive cocoa varieties (Boza et al., 2014). Its production has increased in other South American countries, such as Peru, Colombia, and Brazil. In some countries, the CCN-51 production is well established: in 2012, 32% of Ecuador's cocoa exports and 36% of Peru's exports were represented by this variety (Van der Kooij, 2013).

Despite scientific evidence that CCN-51 cacao is disease resistant and offers more yield (Boza et al., 2014; Amores et al., 2011), most supply countries (especially those in Latin America where weather conditions are favorable) have not made great efforts to increase its production. This could be explained by different reasons. On the one hand, some Latin American countries have been historically recognized as high-quality cocoa producers (e.g., Ecuador and Colombia), thus mixing the national variety (i.e., the highest quality one) with the CCN-51 variety might affect their

international reputation, and therefore, put in danger the local producers of high-quality cocoa.

Our contribution to the existing literature on WTP for chocolate is twofold. On the one hand, we provide empirical evidence regarding the hedonic valuation and WTP for Chocolate made with CCN-51 cacao. Our analysis might help to orientate the policy efforts intended by manufacturers, universities, and government agencies to deal with the potential shortage of chocolate predicted by some manufacturers and analysts. As of today, many of the policy efforts made by the major producers and manufacturers are related to supporting the value chain of fine-flavor cocoa, and this segment only represents between 5% to 7% of the global market. Meanwhile, the most significant part of the market (conformed by bulk and hybrid cocoa) is receiving less attention. One can argue that the appropriate handling of the supply in this segment could be the difference between a future stable market or a global shortage of chocolate.

Experiment design

We ran an experiment with students of Cornell University. The subjects were recruited through the Lab for Experimental Economics and Decision Research (LEEDR) email system. The students participating received a compensation of $10. The Becker-DeGroot-Marschak mechanism (BDM) (Becker et al., 1964) was used to elicit Willingness to Pay (WTP) for three varieties of Ecuadorian chocolate: one made with high-quality cocoa beans (National Ecuadorian Chocolate), another made from CCN-51 cocoa beans (CCN-51), and the last one made with banana and CCN-

51 cocoa beans (CCN-51 Banana). Henceforth these three varieties will be called National, CCN-51, and CCN-51 Banana. BDM is an incentive-compatible method in which subjects face a real purchase situation and has been extensively used to elicit WTP for foods (Noussair et al., 2004; Lusk and Fox, 2003; Kass and Ruprecht, 2006).

WTP for the chocolate varieties is collected from two sources of treatment. The students participating in the experiment (110 in total) were randomly assigned to one of the two group treatments, henceforth called without information group (NO INFO) and with information group (INFO). The students in the first treatment did not receive any information about the three varieties of chocolate, and they only revealed their WTP based on the smell and taste of the chocolate varieties. On the other hand, for the second treatment, the students were told attributes of the three chocolate varieties, such as the quality of the cocoa beans used in the manufacturing process and the amount of potassium and fat content, so they decided their WTP based on the hedonic properties and the information provided.

Subjects were seated randomly at individual computer terminals with privacy shields, were informed that all decisions they made would be kept strictly confidential and were paid $10 on average to participate. 24 computers were available per session, and six sessions ranging from 15 to 24 subjects were implemented. After signing a consent form, participants were given a brief introduction to the experiment, which included the amount of money they would earn and the rules. Since previous work has shown that inexperienced subjects

could submit bids that would not reflect their actual valuations (Kagel, 1995), each session started by explaining how the auction process works, and then two practice rounds were implemented to teach how the WTP auctions would be organized. During those sessions, subjects submitted bids for a dollar bill and a chocolate bar and became familiar with the bidding process used in the auctions for the chocolate.

During the chocolate auction, subjects were organized according to the previous randomized treatment design. For treatment group one (NO INFO), subjects were told to taste three different types of chocolate. Right after each tasting, the subjects answered two questions regarding the taste and smell of each variety and were told to submit a bid from $0 to $10, reflecting their maximum willingness to pay for 3.5 ounces of the chocolate just tasted. At the end of the experiment, we randomly chose just one of the auctions to be binding, so at most, the subject only purchased 3.5 ounces of chocolate. Also, we randomly drew a market price for the 3.5 ounces of chocolate in the selected auction. Only those who bid equal to or above the market price won the auction. The winners received the chocolate plus the difference (e.g., $10 minus the market price); the rest received $10. Finally, the subjects completed an exit survey regarding their demographics and chocolate consumption trends.

On the other hand, 3 additional sessions were conducted for treatment group two (INFO). The only difference between the groups was that for the latter, the subjects were told the nutritional attributes of each chocolate variety, such as the quality of the cocoa beans used during the manufacturing process and the percentage of daily potassium and total daily fat per 3.5 ounces serving before they made their bid.

Table 1 shows the information provided to the subjects regarding the three varieties of chocolate.

[Insert table 1 here]

We are interested in the differences in WTP between the National, CCN-51, and CCN-51 Banana varieties for the two treatment groups. For instance, the variety CCN-51 is the one made from the CCN-51 hybrid cocoa, so its comparison against the National variety will tell us if the consumers penalized the former for its lower quality compared to the latter, which in turn might help us to determine if the chocolate made from CCN-51 is a good substitute for the National variety (which is highly appreciated in the international markets). Also, comparisons among treatment groups will help us determine the impact of the information provided in the WTP for each variety.

Data and Empirical Model

We collected 323 observations from 112 student subjects participating in the chocolate auctions. Each subject participated in auctions for 3.5 ounces of three chocolate varieties. 57 subjects were part of treatment group 1 (NO INFO), and 53 were part of treatment group 2 (INFO)[8]. In each auction, participants submitted their bids, between $0.00 and $10.00 for 3.5 ounces of each chocolate variety. After all bids were submitted, participants completed a survey questioning demographic and purchasing habit information, including gender, age, education, income,

[8] Since the students were free to leave the room at any moment, there are some cases where the number of respondents were less than the grand total of 55 for the INFO group and 57 for the NO INFO group.

chocolate consumption, and whether the participant is the primary shopper in their family or not.

Table 2 provides descriptive statistics illustrating the WTP for the different varieties of Ecuadorian Chocolate among the two treatment groups. The table also depicts demographic and purchase habit information about the subjects. The table shows that the average bid was $2.33 per 3.5 ounces. For both treatments (NO INFO and INFO), the highest bid was for the National Chocolate (highest quality), followed by the CCN-51 and the CCN-51 banana varieties (see Figure 1). However, in the treatment group INFO (which received information about the quality of the cocoa used and some nutritional facts about the chocolate), the mean bid for the National and the CCN-51 varieties decreased compared to the treatment group NO INFO (from $2.75 to $2.7 for the National and $2.65 to $2.47 for the CCN-51).

In contrast, for the CCN-51 Banana, the mean bid increased (from $1.54 to $1.85). The bottom portion of Table 2 shows the responses to the demographic questions included in the survey. 50% of the subjects in our sample are male. The mean age of the participants is between 18 and 24 years. The mean income is between $20.000 and $29.000. The average subject rarely or sometimes checks nutritional facts and eats chocolate between once or twice a month to once per week. On average, 42% of the purchased chocolate is of the highest quality. Finally, 22% of the subjects are not primary shoppers at their homes.

[Insert table 2 here]

[Insert figure 1 here]

During the first stage of the auction process, the subjects were asked to rank the taste and the smell on a scale from 1 (worst) to 9 (best). Figure 2 shows the results of these two questions regarding the hedonic properties of the different varieties of chocolate by treatment group. The results show that the variety with the highest rate variety was the National Chocolate, followed by the CCN-51 and the CCN-51 Banana. This result holds for both treatment groups and smell and taste ratings. On the other hand, when the mean hedonic ratings between treatment groups were compared, the results did not change much for the National and CCN-51 varieties.

In contrast, for the CCN-51 Banana variety, the ratings increased in the group where information was provided. The increase was 0.47 units and 1.3 units for the smell and taste ratings, respectively. These results are in line with previous literature. When information about reduced fat content is provided, there is an increase in the acceptance of reduced-fat products (such as the CCN-51 Banana variety in our analysis) (Kahkonen et al., 1996).

[Insert figure 2 here]

Table 3 shows the results of a repeated measures ANOVA[9] for the hedonic ratings (smell and taste) and the willingness to pay variable divided by treatment. Since the ANOVA analysis only determines whether the difference among groups exists, but not which groups are different from each other, we complement the ANOVA results with Tukey Tests for pairwise comparisons between the ratings for

[9] Repeated measures ANOVA account for the fact that we are interested in differences in means between groups that are not independent.

the different chocolate varieties. The ANOVA results show differences among the three groups for the smell and taste ratings. However, the individual pairwise comparisons show that these differences follow different patterns for smell and taste ratings. On the one hand, for the smell ratings, there are differences between all groups (National vs. CCN-51; National vs. CCN-51 Banana; and CCN-51 vs. CCN-51 Banana). All the comparisons suggest that the National chocolate variety is the highest rated, followed by the CCN-51 and CCN-51 Banana varieties. The mean difference between the national and the CCN-51 varieties is 0.76 units in the treatment group with information and 0.93 units among the subjects who did not receive information.

On the other hand, taste ratings results illustrate no differences in the mean taste ratings between the national and the CCN-51 varieties. This result is highly relevant for the stakeholders of the chocolate industry because it demonstrates that the consumers do not consider that the taste of the chocolate made with CCN-51 is too far away from the national variety. Furthermore, it also suggests that the new fermentation techniques applied to the CCN-51 might improve its hedonic properties and open the door for this hybrid to play a higher regarded role in the industry.

[Insert table 3 here]

Table 3 also shows the same analysis for the willingness to pay variable (bottom part of table 3). The results suggest the existence of differences in WTP among

different varieties of Chocolate for both information treatments. However, the pairwise Tukey comparisons show that these differences are only present when we compare the National against the CCN-51 Banana variety and the CCN-51 against the CCN-51 Banana variety. There is no difference in WTP when we compare the National vs. the. CCN-51 variety. This result holds for both treatment information groups. Again, these results might suggest that despite the CCN-51 variety chocolate coming from less quality cocoa, the consumers do not perceive that those differences in hedonic properties (at least for the taste) are big enough to elicit significant differences in WTP.

The ANOVA results are an essential step in the identification process. Nonetheless, some heterogeneous preferences could emerge, and these could be guided by the demographic or purchase characteristics of the consumers. We use a Tobit specification to model the WTP. A linear model for WTP is not adequate because WTP data is censored (WTP ≥ 0) (Wooldridge, 2010). The latent value of WTP for variety j in information treatment t for individual i, denoted as WTP_{jti}^{*}, is expressed as a function of the variety V_j, the information treatment for the two new varieties I_t, and the subjects' personal characteristics of participants X_i. Because individuals submitted bids for different chocolates in the experiment, we employ a random-effects Tobit model to account for the panel nature of the data. The parameter v_i is an individual-specific disturbance for subject i, and ε_{jti} is the error term assumed to follow a normal distribution with mean zero and standard deviation σ. In Equation (1), we assume a linear functional form for the WTP

equation. However, we observe the variable WTP_{jti} that is related to WTP^*_{jti}, and the relationship between the two is shown in Equation (2).

$$(1) \qquad WTP^*_{jti} = \alpha + \beta V_j + \gamma I_t + \delta V_j I_t + \theta X_i + \nu_i + \varepsilon_{jti}$$

$$(2) \qquad WTP_{jti} = max\{0, WTP^*_{jti}\}$$

In the model specified above, α is the bid for 3.5 ounces of the CCN-51 chocolate variety when no information about the origins of the three types of chocolate is revealed, β captures the price differences that consumers are willing to pay for the National and CCN-51 Banana varieties compared to the CCN-51 variety, γ is a vector of parameters controlling for the information treatments, δ is a vector of parameters describing the interaction effects between chocolate varieties and information treatments, and these capture the price premium that consumers are willing to pay for the two new varieties under different origin information treatments, and θ is a vector of parameters for consumer characteristics.

Results and discussion

Table 4 present the results for two specifications: The Pool OLS and Random Effects Tobit Estimators. The results from the OLS model are very close to those from the Tobit model. These results are difficult to interpret, given the number of interactions and categorical variables used. Initially, for the sake of simplicity, we discuss some crucial variables to explain the WTP. On the one hand, using the results from the Tobit model, we can determine that for one unit increase in the taste ratings, the consumers are willing to pay, on average, $0.39/3.5 oz.

On the other hand, the smell does not seem to play a role in the willingness to

pay. There are differences in the willingness to pay depending on whether the subjects check nutritional facts. There was no significant difference in willingness to pay by gender. This result contrast with previous literature in which some gender differences in attitudes toward Chocolate were detected (Rozin et al., 1991).

[Insert table 4 here]

In this document, we are particularly interested in determining if there are differences in WTP between the national chocolate and the CCN-51 variety. We also want to determine if these differences are conditioned by the treatment (INFO vs. NO INFO). To simplify those comparisons, we use the Tobit model (Table 4) results to compute the average adjusted predictions (AAPs) for the WTP for each combination of chocolate variety and treatment. Then we test for the existence of differences between AAPs[10]. Table 5 reports the results of this exercise. The national variety has the highest predicted mean WTP with $2.44, followed by the CCN-51 with $2.39, and the CCN-51 Banana with $2.02. There is no significant difference in mean WTP by treatment level: $2.30 with NO INFO vs. 2.29 with INFO.

[Insert table 5 here]

[10] For instance, the AAPs for the treatment (INFO) variable are calculate as follows: first, go to the first case and treat that person as though she/he were treated (e.g. as he/she receive information), regardless of what the treatment was. Hold all other independent variable values constant. Second, compute the prediction of the WTP for this person. Third, repeat 1 and 2 for all the subjects in the sample. Finally, compute the average of all predictions.

On the other hand, the interaction between the variety and treatment variables provided interesting results.

1) When information is provided, the WTP for the national variety increased (0.14). Meanwhile, the WTP for the CCN-51 decreased (-0.18) and remained unaffected for CCN-51 Banana. However, the marginal effect of having information does not significantly impact the mean differences in predicted WTP (middle of table 5). In a nutshell, this means that information about the chocolate varieties does not significantly affect the WTP of the subjects.
2) Finally, in the bottom part of table 5, we compare the mean adjusted WTP predictions between the national and CCN-51 varieties. We believe this result might convey important information about how the subjects value the highest quality chocolate (national) compared with the one made from CCN-51. Results show that there is no difference in mean WTP between these varieties. This holds for both treatment groups. Taken at face value, this result might imply that there is an opportunity to substitute national cocoa with CCN-51 cocoa in the production of chocolate without hurting the producers. Therefore, it places CCN-51 cacao as an element to consider in dealing with the potential shortage of chocolate.

Conclusion

This paper used an auction experiment to test differences in consumers' WTP for three chocolate varieties. The study focuses on the differences between the national and the CCN-51 varieties. We included different information treatments in the experiment to assess how the information provided affects consumers' WTP for the chocolate varieties. Jointly with consumers' willingness to pay data, demographic information and purchasing habit data were collected from subjects who participated in the chocolate tasting experiment sessions. We applied a univariate analysis (ANOVA and Tukey Pairwise comparison) and a Random Effects Tobit estimator to account for the censored nature of the WTP data. We were particularly interested in the differences in WTP between the National Ecuadorian Chocolate and the variety CCN-51 Chocolate for the two treatment sources. The CCN-51 Chocolate is the one made from the CCN-51 hybrid cocoa, so its comparison against the National variety told us if the consumers penalized the former for its lower quality compared to the latter, which in turn might help us to determine if the chocolate made from CCN-51 could be a good substitute for the National variety, which is highly appreciated in the international markets. Also, comparisons among treatment groups help us determine the impact of the information provided on the WTP.

The ANOVA results show differences among the three groups for the smell and taste ratings. However, the individual pairwise comparisons show that these differences follow a different pattern. On the one hand, for the smell ratings, there

are differences between all groups (National vs. Standard; National vs. Banana; and Standard vs. Banana). All the comparisons suggest that the National chocolate variety is the highest rated, followed by the National. The mean difference between the national and the Standard is 0.76 units in the treatment group with information and 0.93 units among the subjects who do not receive information. On the other side, the results for the taste ratings illustrate that there are no differences in the mean taste ratings between the national and the standard varieties. This result is highly relevant for the stakeholders of the chocolate industry because it demonstrates that the consumers do not consider that the taste of the chocolate made with CCN-51 is too far away from the national variety. Also, it might suggest that the new fermentation techniques applied to the CCN-51 are improving its hedonic properties, opening the door for this hybrid to play a higher regarded role in the industry.

The ANOVA results also suggest the existence of differences in WTP among different varieties of Chocolate for both information treatments. However, the pairwise Tukey comparisons show that these differences are only present when we compare the National vs. the Banana variety, and the Standard vs. the Banana variety. There is no difference in WTP when we compare the National vs. the Standard variety. This result holds for both treatment information groups. Again, this result might suggest that despite the standard variety of chocolate being from a less quality cocoa (made with CCN-51 cocoa), the consumers do not perceive that differences in hedonic properties (at least for the taste) are big enough to make a

significant difference in WTP to elicit.

The average adjusted predictions (AAPs) for the WTP show that the national variety has the highest predicted mean WTP at $2.44, followed by the CCN-51 at $2.39, and finally, the banana variety with $2.02. These results also depicted that when information is provided, the WTP for the national variety increased (0.14), decreased (-0.18) for the CCN-51, and remained the same for the Banana type. However, the marginal effect of having information does not have a statistically significant impact on the mean differences in predicted WTP, this means that information about the chocolate varieties does not affect subjects' WTP.
Finally, the results show no difference in mean WTP between the national and standard varieties, no matter the information treatment. This striking result might suggest that the expansion in the use of CCN-51 cacao in chocolate production is a plausible alternative to deal with the potential shortage of chocolate.

References

Amores, F.M., Vasco, S.A., Eskes, A.B., Suarez, C., Quiroz, J.G., Loor, R.G., Jimenez, J.C., Zambrano, J., Bolaños, M.J., Reynel, V.H., Teran, M.M., & G.C. Quijano. (2011). On-farm and on-station selection of new cocoa varieties in Ecuador, p. 59–72. In: Eskes, A.B. (ed.).

Collaborative and participatory approaches to cocoa variety improvement. Final report of the CFC/ICCO/Bioversity International project on cocoa productivity and quality improvement: A participatory approach (2004–2010). Common Fund for Commodities (CFC), Amsterdam, The Netherlands; Intl. Cacao Organization (ICCO), London, UK; Bioversity Intl., Rome, Italy.

Anand, A., Mittelhammer, R.C. & McCluskey, J.J. (2007). Consumer response to information and second-generation genetically modified food in India. *Journal of Agricultural & Food*

Industrial Organization, 5(1), 1-18.

Barrientos, S. (2013). Gendered global production networks: Analysis of cocoa-chocolate sourcing. *Regional Studies*, 48(5), 791-803.

Barrientos, S. (2016). Beyond fair trade: Why are mainstream chocolate companies pursuing social and economic sustainability in cocoa sourcing? In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 213-228). Oxford: Oxford University Press.

Becker, G., DeGroot, M. & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science*, 9(3), 226-232.

Boza, E. J., Motamayor, J., Amores, F., Cedeño-Amador, S., Tondo, C., Livingstone, D., Schnell, R., & Gutiérrez, O. (2014). Genetic characterization of the cacao cultivar CCN-51: its impact and significance on global cacao improvement and production. *Journal of the American Society for Horticultural Science,* 139(2), 219-229.

Curtis, K. R., McCluskey, J.J. & Wahl, T. I. (2004). Consumer acceptance of genetically modified food products in the developing world. *The Journal of Agrobiotechnology Management and Economics*, 7, 70-75.

Dannenberg, A., Scatasta, S. & Sturm, B. (2008). Does mandatory labeling of genetically modified food grant consumers the right to know? Evidence from an economic experiment. Centre for European Economic Research, discussion paper No. 08-029.

IDH (2014), "Cocoa: strong business case creates unprecedented drive for mainstream market transformation," available at: www.idhsustainabletrade.com/cocoa (accessed July 21, 2017).

ICCO (2017). Quarterly Bulletin of Cocoa Statistics, 43(2), Cocoa year 2016/17.

FAOSTAT (Food and Agriculture Organization of the United Nations Statistics Division). (2013). *Production Statistics: Crops*. Available at: http://faostat3.fao.org/browse/Q/QC/E

Fold, N. & Neilson, J. (2016). Sustaining supplies in smallholder-dominated value chains: Corporate governance of the global cocoa sector. In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 195-212). Oxford: Oxford University Press.

Gilbert, C. (2016). The dynamics of the world cocoa price. In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 307-338). Oxford: Oxford University Press.

Greenpeace International (2008). Say no to Genetic Engineering. Retrieved from: http://www.greenpeace.org/international/campaigns/genetic-engineering, 22/04/08

Janssen, E. & Riera, O. (2016). Too hot to handle: The explosive growth of chocolate in India. In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 419-438). Oxford: Oxford University Press.

Kagel, J. (1995). Auctions: a survey of experimental research. In J. Kagel & A. Roth (Eds.), *The Handbook of Experimental Economics (pp. 501-585)*. Princeton, NJ: Princeton University Press.

Kähkonen, P., Tuorila, H. & Hannu, R. (1996). How information enhances acceptability of a low-fat spread. *Food Quality and Preference*, 7(2), 87-94.

Kähkonen, P., Hakanpää, P. & Tuorila, H. (1999). The effect of information related to fat content and taste on consumer responses to a reduced-fat frankfurter and reduced-fat chocolate bar. *Journal of Sensory Studies*, 14, 35-46.

Kajale, D. B. & Becker, T.C. (2014). Effects of information on young consumers' willingness to pay for genetically modified food: experimental auction analysis. *Ecology of Food and Nutrition*, 53, 292-311.

Kass, K.P. & Ruprecht, H. (2006). Are the Vickrey auction and the BDM mechanism really incentive compatible? – Empirical results and optimal bidding strategies in cases of uncertain willingness to pay. *Bidding Strategies*, 58, 37-55.

Kox, H. (2000). The market for cocoa powder, background paper for modelling and forecasting the market for cocoa and chocolate, prepared for the ministry of foreign affairs, the Netherlands. Amsterdam: Economic and Social Institute.

Moramarco, E. and Nemi, L. (2016). Nutritional and health effects of chocolate. In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 134-156). Oxford: Oxford University Press.

Norton, J.E., Fryer, P.J. & Parkinson, J.A. (2013). The effect of reduced-fat labeling on chocolate expectations. *Food Quality and Preference*, 28, 101-105.

Noussair, C., Robin, S. & Ruffieux, B. (2002). Do consumers no care about biotech foods or do they just not read labels?. *Economic Letters*, 75, 47-53.

Noussair, C., Robin, S. & Ruffieux, B. (2004). Do consumers really refuse to buy genetically modified food?. *The Economic Journal*, 114,102-120.

Lusk, J. and Fox, J. (2003). "Value Elicitation in Retail and Laboratory Environments." *Economics Letters,* 79, 27–34.

Läderach, P., Martinez-Valle, A., Schroth, G. & Castro, N. (2013). Predicting the future climatic suitability for cocoa farming of the world's leading producer countries, Ghana and Côte d'Ivoire. *Climate Change,* 119, 841-854.

Schatzker, M. (2014, November 14). To Save Chocolate, Scientists Develop New Breeds of Cacao. Bloomberg, Retrieved from https://www.bloomberg.com/news/articles/2014-11-14/to-save-chocolate-scientists-develop-new-breeds-of-cacao.

Poelmans, E. & Rousseau, S. (2016). How do chocolate lovers balance taste and ethical considerations?. *British Food Journal*, 118(2), 343-361.

Poelmans, E. & Swinnen, J. (2016). A brief economic history of chocolate. In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 11-42). Oxford: Oxford University Press.

Phillips-Mora, W. & J. Wilkinson. (2007). Frosty Pod of Cacao: A Disease with a Limited Geographic Range but Unlimited Potential for Damage. *Phytopathology,* 97, 1644-1647.

Rommens, C. M. (2010). Barriers and paths to market for genetically engineered crops. *Plant Biotechnology Journal,* 8, 101-111.

Rozin, P., Levine, E. & Stoess, C. (1991). Chocolate craving and liking. *Appetite*, 1991, 17, 199-212.

Schmitz, H. & Shapiro, H. (2012, February). The Future of Chocolate. Scientific American, 306(2), 60-65.

Tagbata, D. & Sirieix, L. (2008). Measuring consumer's willingness to pay for organic and Fair Trade products. *International Journal of Consumer Studies*, 32, 479-490.

Tamru, S. & Swinnen, J. (2016). Back to the roots: Growth in cocoa and chocolate in Africa. In M. Squicciarini & J. F. Swinnen (Eds.), *The economics of chocolate* (pp. 439-457). Oxford: Oxford University Press.

van der Kooij, S. (2013). Market study of fine flavor cocoa in 11 selected countries. Royal Tropical Institute. Retrieved from: http://www.cocoaconnect.org/sites/default/files/publication/Market%20study%20of%20fine%20flavour%20cocoa%20-%20revised%20version.pdf

Wooldrigde, J. M. (2010). *Econometric analysis of cross-section and panel data.* The MIT Press.

Table 1
Information provided for the three varieties of Ecuadorian chocolate

National Ecuadorian Chocolate	Standard Ecuadorian Chocolate (CCN-51)	Banana Chocolate (CCN-51 Banana)
Made with the highest quality cocoa beans	Made from commercial standard cocoa beans	Made with standard cocoa beans and banana
0% of daily potassium per 3.5-ounce serving	0% of daily potassium per 3.5-ounce serving	26% of daily potassium per 3.5-ounce serving
54% of total daily fat per 3.5-ounce serving	54% of total daily fat per 3.5-ounce serving	19.5% of total daily fat per 3.5-ounce serving

Source: Authors' elaboration

Table 2
Descriptive statistics for Willingness to Pay (WTP), demographics, and habit purchase Data.

Variable	N	Mean	Standard Deviation	Minimum	Maximum
WTP ($ per 3.5 ounces)					
Treatment 1: NO INFO	166	2.34	1.80	0.00	9.00
National	57	2.75	1.63	0.50	8.00
CCN-51	57	2.65	1.84	0.10	9.00
CCN-51 Banana	52	1.54	1.69	0.00	7.00
Treatment 2: INFO	151	2.33	1.85	0.00	10.00
National	52	2.69	2.07	0.35	10.00
CCN-51	53	2.41	1.83	0.50	10.00
CCN-51 Banana	46	1.84	1.50	0.00	5.00
Overall	317	2.33	1.82	0.00	10.00
Demographic variables					
Gender	110	0.50	0.50	0.00	1.00
Age	110	1.07	0.29	1.00	3.00
Education	110	2.31	0.89	0.00	6.00
Income	109	0.99	2.30	0.00	7.00
Consumer trends variables					
How often do you check nutritional facts?	110	1.64	1.30	0.00	4.00
How often do you eat chocolate	109	2.66	1.15	0.00	5.00
Approx. % of purchased chocolate is highest quality	106	42.54	34.10	0.00	100.00
Primary Shopper in house	109	0.22	0.41	0.00	1.00

Source: Authors' elaboration.

Table 3
Differences in hedonic ratings and WTP among chocolate varieties by treatment group

ANOVA results for hedonic ratings	Smell		Taste	
	INFO	NO INFO	INFO	NO INFO
Differences among groups	✓	✓	✓	✓
Tukey HSD tests	Mean differences			
National vs. CCN-51	0.76*	0.93*	0.42	0.53
National vs. CCN-51 Banana	1.76*	2.32*	1.53*	3.0*
CCN-51 vs. CCN-51 Banana	1.0*	1.39*	1.43*	2.47*
ANOVA results for willingness to pay	WTP			
	INFO	NO INFO		
Differences among groups	✓	✓		
Tukey HSD tests	Mean differences			
National vs. Standard	0.22	0.1		
National vs. Banana	0.84*	1.22*		
Standard vs. Banana	0.61*	1.54*		

Source: Authors' elaboration. * *Significance test statistic at 95% confidence.*

Table 4
Willingness to Pay Estimates Using Random-effects Tobit and OLS Models

Explanatory variables	(1) OLS		(2) RE TOBIT	
	Coefficient	Standard error	Coefficient	Standard error
Variety (vs.CCN-51)				
National	-0.0895	(0.3143)	-0.109	(0.2460)
CCN-51 Banana	-0.352	(0.3417)	-0.453*	(0.2733)
Treatment (vs. NO INFO)				
INFO	-0.303	(0.3156)	-0.178	(0.2535)
Interaction				
National * INFO	0.329	(0.4375)	0.323	(0.3413)
CCN-51 Banana * INFO	0.127	(0.4569)	0.176	(0.3604)
Hedonic properties				
Smell	-0.0721	(0.0617)	-0.0428	(0.0544)
Taste	0.399***	(0.0526)	0.380***	(0.0462)
Demographic				
Female	-0.210	(0.2066)	-0.201	(0.2143)
Age 25-34	1.214**	(0.4834)	0.514	(0.5628)
Income $20,000-$69,000	-0.537	(0.3718)	-0.901**	(0.3830)
Income $80,000 or more	-0.169	(0.3047)	-0.409	(0.3271)
Purchase habits				
% High-quality chocolate purchased	0.00649**	(0.0030)	0.00610*	(0.0031)
Primary shopper = yes	-0.164	(0.2594)	0.438	(0.2834)
Constant	0.528	(0.5662)	0.0943	(0.5353)
N	302		302	
AIC	1153.8		1104.4	
BIC	1231.8		1189.8	
RHO			0.395	
LR test statistic			49.81***	

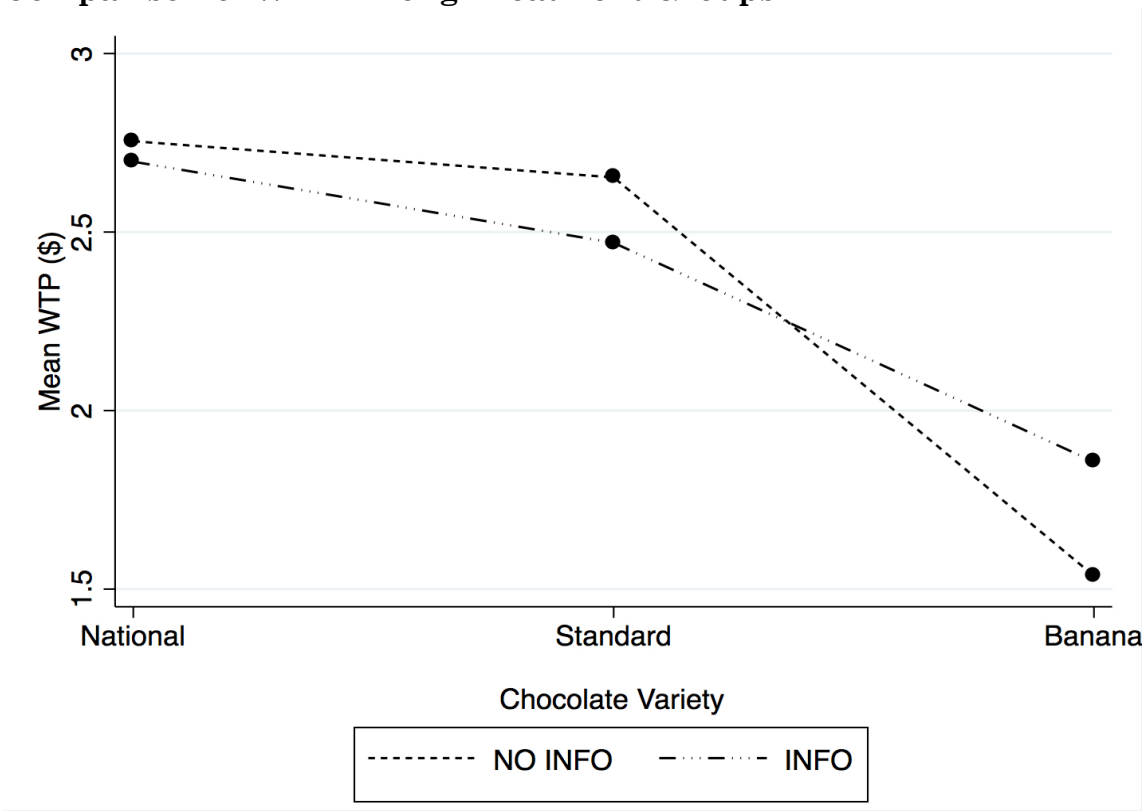
*Note: * p < 0.10; ** p < 0.05; *** p < 0.01. AIC is Akaike's information criteria. BIC is Schwarz's Bayesian information criteria. RHO is the percent contribution to the total variance of the panel-level variance component. The LR test shows the chi-square statistics for the test comparing the pooled Tobit estimator vs. the panel Tobit estimator. The results suggest that the contribution of the panel level is big enough to use the random effects Tobit model. The estimation also included controls for how often the subjects check nutritional facts and how often they eat chocolate.*

Table 5
Average Adjusted predictions (AAPs) by Chocolate Type and Treatment

Variables	Average Adjusted prediction	Standard error	95% confidence interval	
Chocolate Type			LL	UL
National	2.44	0.19	2.08	2.81
CCN-51	2.39	0.18	2.04	2.74
CCN-51 Banana	2.02	0.20	1.64	2.41
Treatment				
NO INFO	2.30	0.17	1.96	2.64
INFO	2.29	0.17	1.95	2.62
Chocolate Type ✕ Treatment				
National × NO INFO	2.37	0.23	1.92	2.81
National × INFO	2.51	0.22	2.07	2.95
CCN-51 × NO INFO	2.48	0.22	2.04	2.91
CCN-51 × INFO	2.30	0.22	1.87	2.73
CCN-51 Banana × NO INFO	2.03	0.25	1.54	2.51
CCN-51 Banana × INFO	2.02	0.23	1.56	2.48
Effect of Treatment in WTP	*Marginal effect*	Standard error	P>|Z|	
(National × NO INFO) - (National × INFO)	0.14	0.26	0.57	
(CCN-51 × NO INFO) - (CCN-51 × INFO)	-0.18	0.25	0.48	
(CCN-51 Banana × NO INFO) - (CCN-51 Banana × INFO)	0.00	0.28	0.99	
Pairwise Comparisons National vs. Standard	P>chi2			
(National × NO INFO) = (CCN-51 × NO INFO)	0.66			
(National × INFO) = (CCN-51 × INFO)	0.38			

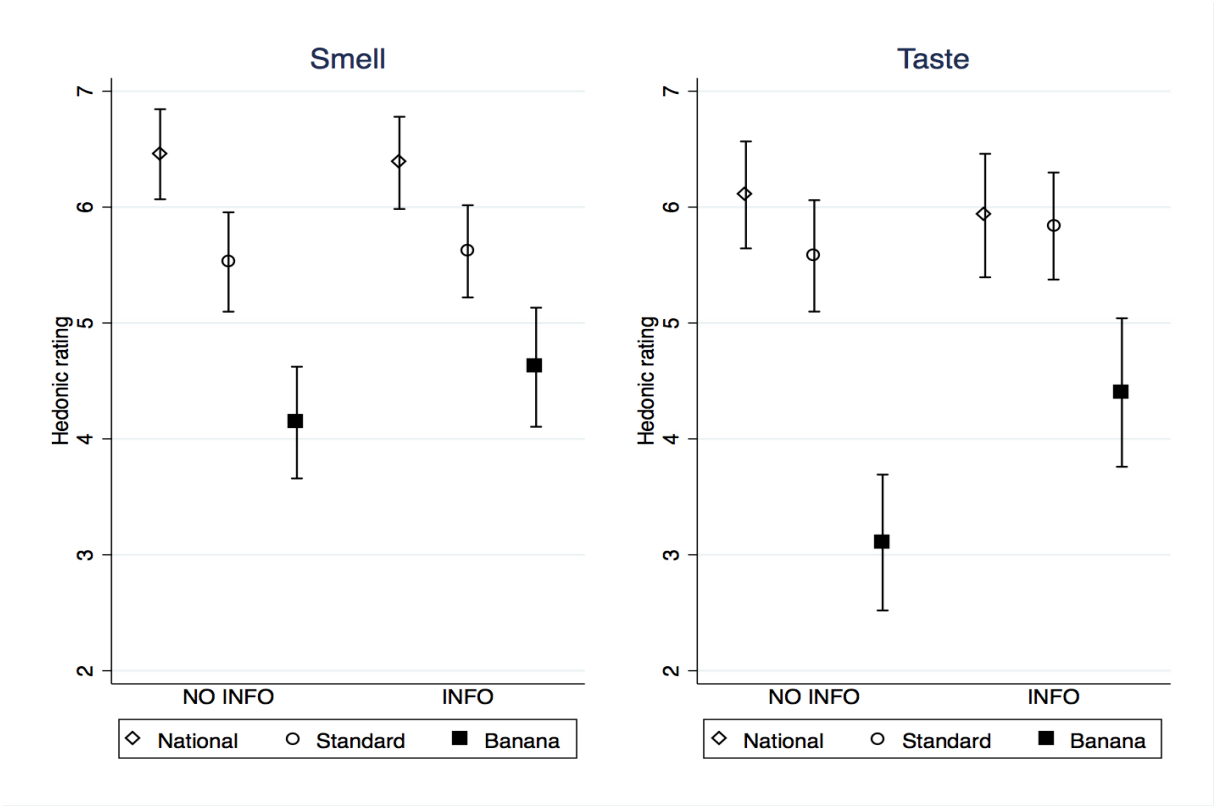
Source: Authors' elaboration

Figure 1
Comparison of WTP Among Treatment Groups



Source: Authors' elaboration

Figure 2
Hedonic properties of the different varieties of chocolate by treatment group



Source: Authors' elaboration