Consumer preferences for apple quality traits

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This study investigates the marginal values consumers place on apple quality traits as part of a larger SCRI project whose goal is to increase the long-term economic sustainability of Rosacea crops by increasing the U.S. per-capita consumption of fruits. Information on consumers' preferences and the value they place on fruit quality is important and may help breeders better establish trait priorities and make the breeding process more efficient. We conducted sensory tasting tests and experimental auctions in order to study consumer preferences for apple quality traits. We find that consumers value more some quality traits depending on the information they have to make their decision. Size and color are important when consumers have information based on appearance, and sweetness and crispness are important when consumers have information based on sensory tasting tests.

KEYWORDS: Experimental auction, Willingness to pay, Quality traits.

1. Introduction

Apple production is important for several rural areas of the U.S. as well as for the Americans diet. According to USDA data, annual per capita consumption of fresh apple has decreased by 12 percent from 2000 to 2010, with an annual per capita consumption of 15.4 pound for 2010. However, annual per capita consumption of processed apples, including canned, juice, frozen and dry apples, has increased in 17 percent during the same time period, with a per capita consumption for processed apple products of 32.2 pounds per year for 2010. Also, due to the stagnant domestic demand the U.S. industry is facing challenges that might affect long-term economic sustainability. Total apple production in the U.S. has decreased by 11 percent from 2000 to 2010, with a difference of more than 1,000 million pounds respect to the year 2000.

This study contributes to a larger project, the RosBREED project. The main goal of RosBREED is to enable the use of marker-assisted breeding in Rosacea crops (e.g., apples, pears, peaches, berries, almonds, roses, and so on) and to increase the long term economic

sustainability of them. The overall project aims to achieve this goal by enabling DNA-based technologies to inform decisions in Rosacea breeding programs. As a result, we expect an improvement in breeding efficiency and the development of break-through cultivars in shorter time periods. To achieve this, information on consumers' preferences and the value they place on fruit quality is critical. Therefore, the RosBREED goal to increase the long-term economic sustainability of Rosacea crops may be achieved by increasing the U.S. per-capita consumption of fruits.

This study investigates the marginal values consumers place on apple quality traits. Since breeders face a long list of quality traits to focus on, in their breeding programs, providing them with this information may help better establish trait priorities and make the breeding process more efficient.

Several methods have been used to estimate WTP. Hypothetical discrete choice experiments, contingent valuation and surveys have been used by many. However, in order to estimate WTP we chose to conduct an experimental auction since we can use the real good and participants get money to be used during the experiment. This gives participants the sense of being in a real market situation, therefore we might get a closer approximation to the consumer behavior. Specifically, we conducted a Second price auction. As it is an incentive compatible mechanism participants might reveal their true WTP.

This study is important for the apple industry, since it informs producers with the marginal values consumers place on apples when making their purchase decision, and identify the most important traits for consumers. As a result, the industry can use this findings to meet more closely consumers' preferences.

Some studies have explored fruit quality traits in order to provide breeders and industry, in general, with information on significant quality traits for consumers. Studies on other fruits, like pear, have examined quality traits. Gallardo et al (2011) conducted choice experiments and sensory tests to analyze the effects of experience quality attributes on willingness to pay for 'Anjou' Pears at different times of the year. They found that consumers are willing to pay less for an additional unit of firmness, while they are willing to pay more for an additional unit of soluble solid concentration. Also, Combris et al(2009) conducted a BDM auction mechanism and sensory analysis to understand how quality attributes affect WTP for different varieties of pears. They find that even food safety influences WTP, consumers are not willing to compromise taste

characteristics for food safety. Zhang et al (2010) conducted a sensory experiment and a consumer survey to estimate consumers' WTP for Anjou pears under different levels of ethylene. Using CV method, they find that consumers are willing to pay 0.25 cents/pound more for a six-day ethylene treatment pear. Additionally, they found that when increasing one unit of firmness, juiciness and sweetness, consumers are willing to pay a premium of 8.5 cents/pound, 3.7 cents/pound and 5.7 cents/pound, respectively.

Other studies have investigated apple quality attributes with different cultivars. Yue and Tong (2011) conducted choice experiments and tasting at market locations to elicit WTP for 13 apple varieties, but also to determine the liking of consumers on apple quality attributes in existing and new varieties. They find that consumers are willing to pay more for, in order, SweetTango, Zestar and Honeycrisp varieties. They also find sets of apple quality attributes for each of these varieties to be superior compared to each other variety. McCluskey et al(2013) conducted a survey and apple tasting using CV to investigate consumers WTP for internal quality characteristics for Red Delicious and Gala apples. They find that consumers are willing to pay more for firmness and sweetness for the two cultivars, with higher values for firmness in Red Delicious and for sweetness in Gala.

Furthermore, a number of studies focus their attention on other characteristics like labels. Lourerio et al (2001) conducted a survey in-store to evaluate preferences for apples with different labels. They find that organic apples are preferred over eco-label for consumers with children, and consumers that have positive attitudes to the environment and food safety. Soon after, Loureiro et al (2002) focused on consumers' mean WTP for eco-labeled apples. They find that female consumers, consumers with children at home, and consumers concerned about food safety and with positive attitudes about the environment are willing to pay a small premium for eco-labeled apples. Yue et al (2007) conducted a survey at two regional apples festivals to evaluate consumers WTP for apples They find that consumers probability of buying organic apples is great, however the greater the cosmetically damaged of apples, the less consumers are willing to pay.

This study contributes to the literature on consumer preferences for apples because it identifies the most important quality traits for consumers. This study is not based on specific apple cultivars, but aims to provide with useful information to the industry for apple quality traits in general. Additionally, consumers' information was collected from sensory tasting test and

experimental auctions before and after sensory tasting test, as well as internal quality data was collected from instrumental measures per apple. Until now, McCluskey et al (2007) used instrumental measures in their study, but they only focus on Gala apples and just measure for firmness and sweetness to analyze for destructive versus non-destructive methods. They find that non-destructive methods can be used instead of destructive to get instrumental measures, and also that instrumental measures for firmness and sweetness affect consumers' WTP along with other variables.

2. Data and experimental design

We designed an experiment with six fruit quality traits: crispness, firmness, sweetness, tartness, defects and size. The optimal experimental design has 32 different treatments, which specifies a combination of factors per treatment.

In order to be able to test for different levels of crispness we use two cultivars of apples, Honey Crisp and Gala. These two cultivars were not explicitly mentioned in any part of the experiment. We procured apples from different orchards, harvested at different times during the season, and stored under different conditions of temperature and relative humidity so we can influence, at some extent, sugar content and firmness.

Sensory tasting tests and experimental auctions were conducted during October and November 2012 at three different locations in the U.S. Sensory tasting tests and experimental auctions were conducted during October and November 2013 at Washington State University in Pullman, WA; University of Minnesota in Saint Paul, MN; and Oregon State University in Portland, OR. In each location we had a total of 128 panelists, divided into eight groups with 16 participants each. In order to take part in the experiment participants fulfilled the requirements of being fruit consumers and older than 21 years.

Before starting the session, participants were given forty dollars to participate in a one hour session. They were randomly seated and assigned an ID number during the experiment. As well, they signed a consent form and were informed about the confidentiality of the information provided.

At the beginning of the experiment we explained the Second price auction mechanism. To assure the understanding of the mechanism we had two practice rounds with chocolates. The protocol used in the practice round was similar to the protocol to be used with apples. After participants were familiar with the auction mechanism we conducted the experiment.

We had three rounds of auctions for apple samples. In the first round, participants went to the front of the room and looked at both apple samples displayed. The display contained around 10 whole apples. We requested they mimic the visual inspection of the apples, as they would usually do when purchasing apples. After the visual inspection, panelists answered questions regarding the appearance of each sample and placed their bids for one pound of each type of apple.

Following the second price auction mechanism protocol, we organized all participants' bids in ascending order. Then we wrote on the board the highest bid amount and second highest for each apple sample and the corresponding participant number.

For the second round of bids, participants got the opportunity to taste the fruit. They received a tray with two apple samples. In order to avoid cultivar association, apples were peeled and participants received half sliced apple. The remaining half of the apple was used to get instrumental measures. Participants also received three questionnaires, one questionnaire per sample and the last one with demographic and purchase habits questions. Finally, they submitted their bids for one pound of apples based on the taste of each apple sample.

For the third round, we informed participants that each sample they evaluated for appearance corresponded to the same sample tasted. Afterward they submitted their bids for one pound of each apple sample considering all the information they had, the external appearance and taste of each sample. We proceed with the bids as we did in the first and second round.

Finally, we randomly chose the binding round and the binding sample. The winner(s) paid the second highest bid and took home one pound of apples. Then, participants completed a paper survey with questions about themselves and their consumption habits.

3. Empirical model

We use censored Tobit models to analyze the data. This model is appropriate since some participants made bids equal to zero. The model specification is as follows:

$$Bid_{ij}^{*} = \beta' X_{ij} + U_{ij}$$

where Bid_{ij}^{*} is the latent variable that takes on only positive values and represents the bid of participant i in round j , $j = 1,2,3$; X_{ij} is a vector of regressors; and U_{ij} represents the error terms. In the first model, bid for external attributes is the regresand, and the vector of regressors includes external liking of quality traits evaluated by consumers (appearance, size, color). In the second model, bid for internal attributes is the regresand, and the vector of regressors includes internal liking of quality traits (aroma, crispness, firmness, juiciness, apple flavor, sweetness, tartness). The third model, bid for overall attributes is the regresand, and the vector of regressors includes both sets of liking quality traits (appearance, size, color, aroma, crispness, firmness, juiciness, apple flavor, sweetness, tartness). Due to our experimental design in data collection, models 1 and 2 do not result in the usual specification bias resulting from omitted variables. We estimate all model parameters by maximum likelihood.

4. Summary Statistics and Results

We present summary statistics for data collected during the auctions in Table 1. It shows the average bid in dollars per pound by each location as well as for the total sample. The average bid for the total sample increases from round one to round three. We expected to find this kind of behavior given that participants had more information in each subsequent round than in the preceding one. It implies that in average participants bided lower when accounting for appearance and bided higher when accounting for the overall appearance and taste of the sample. We find a similar behavior per each city except for Portland where people bided the same in the first and second rounds. We can also observe that the average bid in Pullman is lower than the average bid in Portland and St. Paul in all rounds. Also, the average bid in St. Paul is higher than the average bid in Portland and Pullman in all rounds.

Table 2 presents summary statistics for demographics. Our sample is mostly represented by women, people with college education and white people. Additionally, table 3 compares survey data to the U.S census data per city. Our sample is over represented in women and higher education in more than 10 percent depending on the city. In the case of Pullman, the sample gets close to the census data in terms of ethnicity represented by white, European American, non-Hispanic. In addition, due to the age restriction we placed to participate in the experiment, we observe that our sample per city is under represented by people from 18 to 24 years, which is more evident for Pullman. For the groups of 25 to 34 years and 65 years and more, St. Paul and Portland are close to the census data, however from 35 to 64 years both cities are over represented in more than 10 percent. However, we can say that our sample represents well income groups, since sample data is closer to the census data per city in most of the subgroups with differences below 10 percent. To highlight, greatest differences are registered in Pullman for people that make less than $25,000 per year, 18.39 percent difference above the census data, and people that make $100,000 or more per year, 21.89 below census data.

From table 4 we can state that, in average, participants eat apples among once a week and more than once a week. In average, they do grocery shopping for two and when they buy apples they buy, in average, more than four apples. Total sample and cities statistics behave in a similar way.

Three Tobit models were estimated to know which quality traits consumers value more depending on the information they have when they make their purchase decision. Additionally,

we calculated marginal effects for each model in order to find the variables that affects more WTP. We also included some interaction effects to explore the impact of location on the liking of quality traits, taking Pullman as baseline. We present results based on restricted models given that full models do not add sufficient additional explanatory power. According to results in Table 5, likeness of size is statistically significant and has a positive effect on WTP based on appearance information. Color likeness appear to be more important for participants from St. Paul and Portland, however St. Paul presents the greatest marginal effect for it.

In model 2 participants had information of apple samples based on the taste. Results for Tobit model are presented in table 6. We find that consumers are willing to pay more when they like the sweetness of the apple, they are willing to pay 0.082 cents more for an apple with an additional unit of sweetness. Participants from St. Paul and Portland are willing to pay more for a crisper apple, specifically St.Paul participants will pay 0.159 cents more for an apple that represents an extra unit of crispness likeness.

Finally, in model 3 participants had information of apple samples based on appearance and taste. Consistent with models 1 and 2, likeness of size, crispness and sweetness are the quality traits that drives consumers' WTP for apples. Consumers from St. Paul and Portland behave in a similar way, they will pay more for an apple they like the crispness more, with a greater marginal effect for St. Paul. For likeness of size, they both, are willing to pay less, in this case with a greater marginal effect from Portland.

5. Concluding Remarks

Consumers value more some quality traits depending on the information they have to make their decision. Size and color appear to have an important role when consumers have information based on appearance. On the other hand, consumers are willing to pay more when they like sweetness and crispness of apples only accounting for internal quality information based on sensory tasting tests. However, when consumers have all both pieces of information together, it seems like they are consistent with previous their preferences when having pieces of information apart, therefore size, sweetness and crispness remain being the apple quality traits that add more to WTP for apples. It is important to account for regional effects, given that marginal effects seems to be different depending on the location.

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Table 1. Summary Statistics for Auction Data

		Pullman (n=128)		St. Paul (n=128)		Portland (n=128)		Total (n=384)	
Variable	**Variable Description**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Bids									
Round 1 (External Appearance)									
Apple	Dollars / pound	1.03	0.75	2.04	1.20	1.27	0.73	1.45	1.01
Round 2 (Taste)									
Apple	Dollars / pound	1.11	0.72	2.22	1.22	1.27	0.72	1.53	1.04
Round 3 (Overall appearance and taste)									
Apple	Dollars / pound	1.21	0.71	2.32	1.17	1.35	0.70	1.63	1.02

Table 2. Summary Statistics for Survey Data (in frequency and percentage)

		Pullman (n=128)		St. Paul (n=128)		Portland (n=128)		Total (n=384)	
Variable	**Variable Description**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Demographics									
Gender	1=male; 0=female	44	34.38	34	26.56	41	32.03	119	30.99
Education	1= 4 year college degree and Advanced college degree; 0=other	98	76.56	78	60.94	86	67.19	262	68.23
Ethnicity	1=White, European American, Non-Hispanic; 0=other	101	78.91	107	83.59	109	85.16	317	82.55
Income	No data	0	0.00	3	2.34	3	2.34	6	1.56
	Median=12500	50	39.06	23	17.97	11	8.59	84	21.88
	Median=29999.5	14	10.94	8	6.25	14	10.94	36	9.38
	Median=42499.5	20	15.63	26	20.31	31	24.22	77	20.05
	Median=62499.5	13	10.16	31	24.22	20	15.63	64	16.67
	Median=87499.5	18	14.06	14	10.94	24	18.75	56	14.58
	Median=100000	13	10.16	23	17.97	25	19.53	61	15.89
Age	Median=21	27	21.09	10	7.81	5	3.91	42	10.94
	Median=29.5	38	29.69	24	18.75	27	21.09	89	23.18
	Median=39.5	36	28.13	9	7.03	23	17.97	68	17.71
	Median=49.5	12	9.38	34	26.56	28	21.88	74	19.27
	Median=59.5	12	9.38	31	24.22	29	22.66	72	18.75
	Median=65	3	2.34	20	15.63	16	12.50	39	10.16

Table 3. Survey Data compared to U.S Census Data per City (in percentage)

	Pullman		St. Paul		Portland	
Variable	**Census ***	**Survey**	**Census***	**Survey**	**Census ***	**Survey**
Gender						
Male	51.26	34.38	48.88	26.56	49.54	32.03
Education						
4 year college degree and advanced college degree	66.90	76.56	35.53	60.94	40.57	67.19
Ethnicity						
White, European American, Non-Hispanic	79.26	78.91	60.11	83.59	76.09	85.16
Income						
No data	-	0.00	-	2.34	-	2.34
Less than $25.000/yr	20.67	39.06	21.43	17.97	18.00	8.59
$25.000-$34.999/yr	5.16	10.94	11.05	6.25	8.92	10.94
$35.000-$49.999/yr	12.28	15.63	11.71	20.31	12.86	24.22
$50.000-$74.999/yr	16.13	10.16	19.02	24.22	19.36	15.63
$75.000-$99.999/yr	13.72	14.06	13.40	10.94	13.79	18.75
$100.000/yr or more	32.05	10.16	23.39	17.97	27.07	19.53
Age						
18-24	58.37	21.09	18.41	7.81	12.05	3.91
25-34	17.06	29.69	22.71	18.75	24.22	21.09
35-64	19.22	46.89	46.89	57.81	50.86	62.51
65 + Years	5.35	2.34	11.99	15.63	12.87	12.5

*Data: U.S. Department of Commerce. United States Census Bureau. Census 2010. Calculations by the author.
Note: Census' Education variable presents data for people over 25 years in four categories. Here we took Bachelor's degree or higher.

Table 4. Summary Statistics for Consumption Habits (in means)

		Pullman (n=256)		St. Paul (n=256)		Portland (n=256)		Total (n=768)	
Variable	**Variable Description**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Consumption Habits									
Children under 18 at home	Number	0.59	1.00	0.43	0.78	0.38	0.81	0.47	0.87
People you shop for groceries	Number	2.19	1.11	2.27	0.98	2.21	0.97	2.22	1.02
How often you eat apples	1=daily; 2=more than once a week; 3=once a week; 4= 2-3 times a month; 5=once a month; 6= less than once a month; 7=never	2.38	1.16	2.46	1.26	2.50	1.06	2.45	1.16
How many apples you buy	Units	4.98	1.56	4.87	1.84	4.52	1.65	4.79	1.69

Table 5. Model 1 liking of External quality variables

Variables	**BID1**		
	Estimated Coefficient	S.E.	Marginal Effects
Size like	0.065 ***	0.019	0.062 ***
Color like *St. Paul	0.158 ***	0.012	0.149 ***
Color like* Portland	0.035 ***	0.011	0.033 ***
Constant	0.599 ***	0.127	
Obs.	768		
Uncensored Obs.	751		

Table 6. Model 2 liking of Internal quality variables

Variables	BID2				
	Estimated Coefficient		S.E.	Marginal Effects	
Crispness like	-0.013		0.033	-0.013	
Sweetness like	0.086	**	0.034	0.082	**
Crispness like* St. Paul	0.167	***	0.045	0.159	***
Sweetness like* St. Paul	0.020		0.048	0.019	
Crispness like*Portland	0.086	**	0.042	0.083	**
Sweetness like*Portland	-0.041		0.044	-0.039	
Constant	0.586	***	0.131		
Obs.	768				
Uncensored Obs.	742				

Table 7. Model 3 liking of External and Internal quality variables

Variables	BID3				
	Estimated Coefficient		S.E.	Marginal Effects	
Size like	0.102	***	0.029	0.099	***
Crispness like	-0.062	*	0.034	-0.061	*
Sweetness like	0.028		0.036	0.027	
Size like* St.Paul	-0.085	**	0.038	-0.083	**
Crispness like* St. Paul	0.200	***	0.048	0.194	***
Sweetness like * St. Paul	0.059		0.049	0.057	
Size like* Portland	-0.131	***	0.037	-0.127	***
Crispness like* Portland	0.134	***	0.044	0.130	***
Sweetness like * Portland	0.029		0.047	0.028	
Constant	0.792	***	0.164		
Obs.	768				
Uncensored Obs.	745				