International Food and Agribusiness Management Review
Volume 14, Issue 3, 2011

Choice Experiments' Findings: A Tool for Fruit Agribusiness Managers' Decision Making

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Abstract

Choice experiment studies eliciting values for quality attributes provide relevant information to fruit agribusiness managers in various ways. First, it helps orchard managers to know if novel cultivars possess the attributes most valued by consumers. Second, it benefits warehouse and retail store managers to apply appropriate techniques to enhance fruit quality characteristics most appealing to consumers. Third, it is valuable for marketing managers to base their strategies on research-based information on consumers' preferences. Results from a choice experiment showed that consumers were willing to pay $0.19, $0.16, $0.16, and $0.06 for a one unit increase in Anjou pears' sweetness, texture, juiciness, and firmness liking scores, respectively.

Keywords: Anjou pears' quality, sensory test, choice experiment

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Introduction

To ensure the economic sustainability of the U.S. fruit industry, it is important to provide a consistent supply of fruit with optimal quality. This task needs to be carried out on multiple fronts, including improved genetics, postharvest handling, and marketing. In this context, choice experiments eliciting values for optimal quality attributes provide relevant information to agribusiness managers. First, these studies help reduce the uncertainties about commercial success of new varieties. Second, they guide warehouse and retail store managers on what postharvest methods to apply in order to maintain and enhance quality characteristics most preferred by consumers. Third, they guide marketing managers in formulating strategies based on research-based information on consumers' preferences.

This manuscript presents an empirical application on the relevance of choice experiment findings to the Anjou pear industry. Agribusiness managers understand that innovation is important for the long term viability of an enterprise. In the case of the pear industry, at the orchard level, innovation implies removing and replanting existing orchards with new systems that could be a different variety, training system, or some combination of these. Orchard managers need to take into consideration numerous risks including uncertainty if new variety would be commercially successful, ability to manage new horticultural systems, loss of cash income until new planting reaches mature yields, among others (White 2002, 2). Consequently, information on the potential commercial viability of new varieties alleviates some of the uncertainties managers face. That is, managers would faces less uncertainty if they know that the breeding program originating the new variety used a consumer feedback routine on preference and value. This adds to the concept of market driven horticulture, a strategy in which managerial decisions are based on information elicited from consumers rather than from the inside business only (Jaeger and Harker 2005, 2520).

Moreover, choice experiment studies can provide warehouse and retailer store managers, with information on the gains they could realize if postharvest methods aimed to enhance and maintain pear quality characteristics are applied appropriately. Typically, warehouse managers select fruit according to its quality condition when arriving at their facilities. The idea is to pack and store, in controlled or regular atmosphere, pears with optimal characteristics that are believed to preserve its quality attributes throughout the marketing season. However, pears do not always meet such requirements in a uniform fashion, and quality consistency of the fruit being packed is often jeopardized. To avoid losses when handling and guarantee an extended shelf-life, retailers are increasingly demanding pears immediately after harvest despite the fact that this fruit is not fully ripe. Unripe fruit does not possess the characteristics more appealing to consumers. One alternative is to treat pears with ethylene, a natural occurring hormone. Ethylene application or conditioning permits some control over ripening, making possible the supply of fruit with consistent quality.

The Pear Bureau Northwest reports that conditioning is becoming a popular practice across warehouses and retailers in the U.S. Indeed, about 38 percent of Anjou pears and 15 percent of Bartlett pears produced in the U.S. Pacific Northwest are being conditioned. Moreover, there is evidence indicating increased sales of about 25 to 50 percent for retailers starting a conditioning program in the first year (Moffitt 2011). Consequently, warehouse and retail store managers face the decision whether or not to implement conditioning at their facilities. For warehouse managers, a piece of information to take into consideration is the estimated cost of conditioning. Zhang et al. (2004, 117) report that conditioning at the warehouse using a rented trailer costs about $0.004/lb. The benefit of conditioning pears at the warehouse is that process' parameters (temperature and time) are customized for pears only. Yet, there are some limitations, like less control when handling the fruit in transit. Nonetheless, anecdotal evidence suggests that benefits are greater than losses (or shrink) as pear damage at the retailer shelf is decreased because consumers do not over manipulate the fruit when checking for ripeness (the guess work). Also, selling ripe fruit implies an increase in the velocity of sales (Morgan, 2011, 62). Conditioning can also happen at the retailers' warehouses. Here, there is more control on handling fruit. However, typically, these warehouses ripe other fruits (e.g., bananas, tomatoes, avocados), and process' equipment and parameters are not necessarily tailored for pears (Moffitt, 2011). In sum, to minimize shrink when handling ripe fruit retailers shall find the right length of time to keep the fruit on display. This means balancing between selling the fruit too early when taste is not at its premium or too late when fruit is starting to soften and spoil. Retailers shall also find ways to increase consumers' awareness of ripe fruit (Morgan, 2011, 60).

Choice experiment studies are useful for fruit marketing managers, who are in constant search of consumers' feedback to guide their promotion and selling strategies. Relevant to marketing, choice experiment is one of the most popular marketing research tools, used in thousands of applications in both academia and business. Lusk and Schroeder (2004, 467) observe that such popularity is based on three factors. First, it allows the simultaneous valuation of numerous attributes. Second, it is consistent with consumer demand theory indicating that consumers derive utility from consuming a good from its attributes rather than from the good itself. Third, choice experiment frames questions in a way closely resembling a true purchase situation. However, the validity of choice experiment studies has recently been under scrutiny. Most concerns revolve around hypothetical biases or inconsistencies with situations involving experimental settings instead of actual settings and lack of monetary commitments instead of real money in line (List and Gallet 2001, 41, Lusk et al. 2008, 487, and Chang et al. 2009, 518). Carlsson and Martinsson (2001, 188) and Lusk and Schroeder (2004, 480) indicate no major differences in willingness-to-pay across hypothetical and non-hypothetical settings. Also supportive is Yue and Tong (2009, 370) who argue that the use of real products in a value elicitation experiment helps reduce hypothetical biases. Furthermore, McCluskey et al. (2007, 229) support the view that consumers' subjective evaluation of quality based on taste has a higher predictive ability than objective tests from instrumental measurements.

The purpose of this study is to enhance the understanding of how choice experiment studies' findings can be useful to fruit agribusiness managers. This manuscript is focused on WTP for Anjou pears targeted quality characteristics. Specific objectives include: (1) Eliciting consumers' WTP for Anjou pears' sweetness, juiciness, firmness, texture and ripeness (days to wait until fully ripe). (2) Estimate the potential effects of using different postharvest treatments (conditioning protocols) on Anjou pears' market share. It is hoped that these findings will induce industry actors and researchers in related disciplines to focus their efforts in enhancing sensory characteristics likely to increase Anjou pears' commercial viability.

A few WTP studies have been conducted to elicit values for pear quality characteristics (Gamble et al., 2006, 38; Combris et al., 2007, 465; Zhang et al. 2010, 105; and Gallardo et al. 2011, 452). Gamble et al. (2006, 38) conducted a conjoint analysis to evaluate consumers values for appearance of novel pears in Australia and New Zealand. Combris et al. (2007, 465) conducted an experimental auction to measure the effect of sanitary information, labels, and taste on the willingness-to-pay for Rocha pears in Portugal. They found that consumers were willing to pay 0.35 Euros/kg more for pears with 14 °Brix compared to pears with 11 °Brix; despite the fact that pears with 14 °Brix displayed no food safety guarantee. The present study is similar to Zhang et al. (2010, 105) who estimated WTP for ethylene-induced quality in Anjou pears. They found that consumers were willing to pay $0.25/lb more for pears with higher liking scores resulting from ethylene treatment applied to pears at the beginning of the marketing season. This study differs from Zhang et al. in the primary objective and the methodology used. In this study, the goal is to measure the WTP for each quality attribute, regardless of the postharvest treatments applied. In relation to the methodology, here a choice experiment approach is used instead of contingent valuation. Another similar study is Gallardo et al. (2011, 452). They also investigated the effects of ethylene treatments on consumers' WTP for Anjou pears. Here, treatments were applied to pears at the mid and end of the marketing season, hence the experimental design was different to the one used in this manuscript. Gallardo et al. found that consumers were willing to pay in between $0.20-$0.24/kg for a one unit increase in °Brix and willing to discount in between $0.15-$0.37/kg for a one unit increase in firmness measured in N. Again, this study differs on the experimental design and the primary objective (here we want to elicit values for quality characteristics regardless of the postharvest treatments applied).

Regarding the importance of studying Anjou pears, note that they are a popular pear variety grown in the U.S. Pacific Northwest. Between 2003 and 2008, Anjou pears represented, on average, 23 percent of all pears produced in the U.S. The average production is approximately 2.2 million metric tons per year with an estimated value of USD $185 million (Washington Growers Clearing House 2010 and United States Department of Agriculture National Agriculture Statistics Service 2010).

Methodology

Data

This study utilized data from a choice experiment questionnaire conducted during a sensory test at the Food Innovation Center in Portland, Oregon in October 2008. Recruitment of participants for each test consisted of sending an online screening questionnaire to about 5,000 consumers in the Portland metropolitan area. Individuals were asked about their willingness to participate in the pear taste test. Of those who completed the screening questionnaire, a sample of 120 consumers were recruited and offered a $25 incentive for their participation.

Prior to the sensory test, researchers provided individuals with a brief set of instructions on how to complete the test and questionnaire. Each participant was asked to taste four pear samples under different conditioning protocols. Pear samples used in the sensory test were harvested from a single orchard in mid-September 2008 and placed at room temperature (72°F) for 24 hours prior to cold storage (33°F). Then they were moved to a conditioning room and held at 65°F to 74°F, and one of conditioning treatments was applied to each test group: two, four, or six days with ethylene or no ethylene exposure. Following the treatment, fruit was kept in cold storage (33°F) to simulate transit. Before the taste test, one half of each sample was tested for firmness by using a Fruit Texture Analyzer penetrometer and soluble solids concentration (a proxy measurement for sweetness) using a refractometer. After tasting each sample, participants were asked to respond a questionnaire. Questions included ratings for the pear samples tasted, respondents' demographics, fruit shopping habits, and the choice experiment questions. Out of the 120 completed questionnaires, 4 were ineligible yielding 116 usable questionnaires.

Compared with the demographics of Portland's population, the sample in this study over-represented individuals aged 45-64, female, white, and with 4-year and advanced college degrees (United States Census Bureau 2000) (Table 1). This sample population is reasonably representative of the pear consumer profile described by the Pear Bureau Northwest: 75% to 80% female, white, 35-65 years of age, and post-secondary education (Moffitt, 2002).

Table 1. Comparison between Portland Population and Respondents Demographics - Summary Statistics

Demographics	**October 2008 N=120 %**	**US Census Portland Pop=529,121 %**
Age		
Under 24	6.0	31.4
25-34	27.2	18.3
35-44	19.5	16.4
45-54	23.8	14.8
55-64	19.3	7.6
Older than 65	4.3	11.5
Gender		
Male	22.1	49.4
Female	77.9	50.6
Ethnicity		
American Indian, Alaska Native	0.9	1.1
Asian, Asian American	3.4	6.3
Black, African American	0	6.6
Hispanic, Latin American	2.6	6.8
White	90.6	77.9
Other	0.9	1.3
Decline to respond	1.7	
Education		
High school graduate	0	22.2
2 year college or technical degree	31.3	30.8
4 year college	40.0	21.3
Advance college degree	28.7	11.4

Choice Experiment Design

The choice experiment included eight hypothetical purchasing scenarios, each mimicked a situation in which an individual would choose to buy one pound of Anjou pears from a set of two options (A and B) each with a different combination of given ratings for sweetness, juiciness, firmness, texture, ripeness, and price. If neither of the options was of interest, respondents were given a third option to choose none of the alternatives presented. The experimental design for the questionnaire included three given rating levels: 2, 5, and 8 (based on a 9-point hedonic scale)[1] for the attributes sweetness, juiciness, firmness, and texture. Ripeness levels were categorized as one of three time periods needed to wait until fully ripe: ready to eat, wait 2-4 days to eat, or wait 7-10 days to eat. Each attribute combination was matched with two levels of prices ($1.09 /lb and $1.99 /lb). These prices were consistent with Portland grocery store prices for the first week of October 2008 (Figure 1).

Question #1

	Option A	Option B	Option C
Sweetness	Rate 2 Using a 1-9 Scale where 1= not sweet, 9=ideally sweet	Rated 8 Using a 1-9 Scale where 1= not sweet, 9=ideally sweet	Neither of them
Juiciness	Rate 2 Using a 1-9 Scale where 1= not juicy, 9=ideally juicy	Rated 2 Using a 1-9 Scale where 1= not juicy, 9=ideally juicy	
Firmness	Rate 2 Using a 1-9 Scale where 1= hard, 9=soft	Rated 8 Using a 1-9 Scale where 1= hard, 9=soft	
Texture	Rate 8 Using a 1-9 Scale where 1= mealy, 9=buttery	Rate 5 Using a 1-9 Scale where 1= mealy, 9=buttery	
Ripeness	Will take 1 to 2 days to become fully ripe	Ready to eat	
Price per pound ($/lb)	$1.09/lb	$1.99/lb	
I would BUY ✓ Check only one			

*If you chose Option C, please tell us why:*____

Figure 1. Example of Choice Experiment Question

A factorial design was considered to create random combinations of given attributes, levels, and prices. This design is commonly used because it guarantees equal frequency of rating levels, no correlation between ratings and prices, minimization of invariant rating levels within a scenario, and balance in the probability of choosing an alternative within a scenario (Louviere et al. 2001, 85). There were five attributes each varied at three levels, and a price attribute varied at two

[1] Note that for sweetness we used the scale 1=not sweet, 9=ideally sweet, similar for juiciness. Our intention by using this scale was to get a "definition" of the ideal pear characteristics in terms of sweetness and juiciness, and later compare these values with refractometer measurements. However, comparisons were not to assess how well consumers predicted sweetness levels, rather, our intention was to observe what levels of SSC were considered as ideal. We noted that if we used an intensity scale (1=not sweet, 9=extremely sweet) and a like scale (1=extremely dislike, 9=extremely like) we could get a better correlation with the refractometer and a good idea of what consumers actually consider as ideally sweet or juicy. We acknowledge that the scale we used is not common in sensory analysis. Later in the manuscript, when we discuss the lack of correlation between refractometer measurement and sensory ratings, we hypothesize that the use of this scale could partially explain this lack of correlation.

levels. This means that there were 3^5 x 2= 486 possible descriptors that could be created, for individuals to respond. Obviously, this is not a reasonable option, thus a main effects fractional factorial design was used. The latter design yielded 32 scenarios. Yet, it was felt that 32 was too lengthy for respondents, so 4 questionnaire versions were created, each with 8 scenarios randomly assigned to participants.

Statistical Model

Choice experiments are based on the random utility theory stating that the utility derived from consuming a good has two components: a systematic component given by the good's attributes and a random component given by all factors not directly measurable. The random utility for individual *i* choosing alternative *j* is defined by,

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

where V_{ij} and ε_{ij} are the deterministic and random components, respectively. Moreover, ε_{ij} is distributed independently extreme value with variance $(\theta_j \pi)^2 / 6$. In this study, V_{ij} is represented by,

$$(2) \quad \begin{aligned} V_{ij} = {} & ASC_j + \alpha_1 Sweetness_{ij} + \alpha_2 Juiciness_{ij} + \alpha_3 Firmness_{ij} \\ & + \alpha_4 Firmness_{ij}^2 + \alpha_5 Texture_{ij} + \alpha_6 Ripeness_{ij} + \beta \Pr ice_{ij} \end{aligned}$$

where ASC_j is the alternative specific constant representing the utility provided by option *j* not explained by rating variations (*j*=option A, option B); α_1 to α_6 represent the marginal utility of the ratings for sweetness, juiciness, firmness, firmness^2, texture, and ripeness, respectively; $Sweetness_{ij}$, $Juiciness_{ij}$, $Firmness_{ij}$, $Firmness^2_{ij}$, $Texture_{ij}$, $Ripeness_{ij}$, represent the ratings for sweetness, juiciness, firmness, firmness^2, texture, and ripeness as presented in option *j* to individual *i*; β is the marginal utility of price; and $Price_{ij}$ is the price presented in option *j* to individual *i*.

About the model specification, different from the other quality attributes, firmness is not treated as linear but as quadratic. This means that respondents' utility will not increase linearly as pears become softer. This specification is aligned with the rating setting in the choice experiment (i.e., firmness ratings were set at "one" if pear was found hard and "nine" if soft). In relation to ripeness, note that choice experiments allow an evaluation of both production and demand side effects. From a production perspective, quality attributes included in this specification are correlated with ripeness. In fact, ripe fruit is likely to be sweeter, softer, and have a more buttery texture when compared to unripe fruit. However, this experiment aims to measure a demand side effect. That is, investigate what consumers want. A consumer may want to have a ripe fruit that is not soft or not sweet, although theoretically impossible from a production perspective. An extreme example to illustrate this issue is when researchers investigate consumers' choices for high quality products offered at low prices. Typically, prices are higher when the quality is higher. However, it is always possible to evaluate consumers' choices in a situation where quality is high and the price is low, or vice versa.

To estimate the model coefficients, this study used the heteroskedastic extreme value (HEV) model. Typically, practitioners use the conditional logit model, because of its simplicity. Yet, it exhibits two main restrictive assumptions. First, it assumes independence of irrelevant alternatives (IIA), meaning that no matter what options are presented to the respondent his/her choice will remain invariant. The other restrictive assumption is that variance of unobserved factors are assumed to be constant across alternatives. Results from a Hausman specification test to check for IIA show that, in fact, this assumption holds for this particular setting (χ^2=12.18 and p=0.143). However, a test for homoscedasticity shows that variance error terms differ across alternatives (χ^2=11.83 and p=0.002). Hence, the HEV model was used. In this application, the variance of one alternative is normalized to 1, so that the variances for the other alternatives are estimated relative to the normalized one. Bhat (1995, 474) shows that the probability that individual *i* chooses option *j* is given by,

$$(3) \qquad P_{ij} = \int \left[\prod_{j \neq k} \exp\left(-\exp\left(-V_{ij} - V_{ik} + \theta_i w\right) / \theta_j\right) f\left(\varepsilon_{ij}\right) dw \right]$$

where $w = \varepsilon_j / \theta_j$, and θ_j is a scale parameter for the *jth* alternative. Coefficients are calculated in SAS® software using quadrature methods.

Results and Discussion

This section presents and discusses model estimates, WTP, market share and results' validation. About model estimates, the negative sign of the alternative specific constants[2] (option A and option B), indicates respondents' unwillingness to choose a pear purchase scenario unless it possesses certain quality characteristics. The marginal utility of price is statistically significant and negative, indicating that as price increases, an individual's utility decreases. Also, the marginal utility for the sweetness, juiciness, and texture ratings are all statistically significant and positive, meaning that individuals prefer sweet, juicy, and buttery pears. Firmness increases at a decreasing rate. Indeed, after reaching a maximum rating of 5.81 (in the 1-9 scale, 1=hard, 9=soft), preference for firmness decreases. Ripeness was not significant, indicating that individuals do not show great concern for the amount of time needed to wait for fully ripe pears as long as expectations for other quality characteristics included in this experiment are fulfilled. Not surprisingly coefficient estimates for the scale parameters for options A and B are statistically significant, indicating that error variances across alternatives are not constant.

[2] We included in the model ASCs for each option rather than one ASC for the "none" option. By doing this, the model provides more information about preferences for each option. Note that probability of choice for Option B is slightly larger than Option A. Although our fractional factorial experimental design aimed to keep the probabilities of choosing alternatives as similar as possible, we found differences across option A and option B. Results from a T-test show that Option B had statistically significant larger mean values for sweetness, firmness, and prices. Although having larger values for the latter two attributes will imply a lower probability of choice, respondents seem to prefer the option with higher values for sweetness.

Table 2. Parameter Estimates for Anjou Pear Quality Attributes – HEV Model

Variable	Parameter Estimate	Standard Error
ASC A[a]	-2.432*[b]	0.329
ASC B	-2.043*	0.355
Price	-0.990*	0.176
Sweetness	0.190*	0.024
Firmness	0.418*	0.111
Firmness squared	-0.036*	0.010
Juiciness	0.162*	0.028
Texture	0.157*	0.034
Ripeness	0.036	0.044
Scale parameter B	1.511*	0.280
Scale parameter C	2.081*	0.660

Number of Observations: 928, Log likelihood: -780.04, Akaike Information Criterion: 1582
[a] ASC means alternative specific constant
[b]* Significance at the 5% level

Validation of Results

We investigated the reliability of the choice experiment estimates by using a holdout sample test, following the methodology used by Haener et al. (2001, 636). First, the dataset was randomly divided into an estimation sample and a holdout sample. Parameters were estimated for the estimation sample. To assure reliability, the prediction test was repeated for the remaining models and holdout samples generated from 116 random draws from the dataset, or by deleting observations for one individual for each replication (there were 116 usable responses).

The percentage of correctly predicted choices was calculated by comparing each repetition outcome with actual respondents' choice. Results indicate that the model predicted correctly respondents' choice 56.8% of the time. Note that with the three options provided, to select A, B and none, a model of pure chance would correctly predict outcomes only 33% of the times. The holdout sample test thus reveals that our model results are reasonably robust.

Willingness-to-Pay

Willingness-to-pay (WTP) depicts the amount of money the individual would have to give up to be indifferent towards a one-unit increase in the quality attribute. This statistic is obtained by:

$$(4) \quad \text{WTP} = -\frac{\text{Attribute}_m}{\text{Price}}$$

where "Attribute" is the parameter estimate for the rating of attribute *m*, *m*=sweetness, juiciness, texture, firmness and ripeness, and "Price" is the parameter estimate for price.

WTP can also be calculated as the amount of money an individual would have to give up to be indifferent between two attribute levels, for example between rating 2 and rating 5. This time, the estimation follows:

$$(5) \quad WTP = -\frac{Attribute_m(Level_2 - Level_1)}{Price}$$

Table 3 lists results for WTP under three formats. First, there is the WTP for a one unit increase in the attribute rating, then the WTP for improving from attribute rating two to rating five, and from rating five to eight (in the 1-9 scale). Ripeness was evaluated differently, a one unit increase means one extra day to wait until fully ripe, going from rating two to five and from rating five to eight mean wait three more days to wait until fully ripe. Results imply that consumers are willing to pay more for a one unit increase in sweetness, juiciness, and texture when compared to firmness and ripeness or days to wait until fully ripe. Moreover, consumers seem to prefer softer pears, but this preference seems to decrease once reached a maximum point. Indeed, consumers express a willingness to pay 52 cents/lb when firmness varies from rating 2 to rating 5, however they are willing to discount 13 cents/lb if pears' firmness varies from a rating 5 to a rating 8 (i.e., softness increases). This information is particularly useful to agribusiness managers who are considering new orchard plantings, to select a cultivar with the highest scores for sweetness, texture, and juiciness, compared to other cultivars. Also, calls the attention to warehouses and retailers in that ripeness inducement shall be closely controlled for firmness. Having "too soft" pears might pose a challenge in handling and might not be aligned to consumers' preferences. Table 3 also exhibits the 95% confidence intervals estimated for WTP, via parametric bootstrapping (Krinsky and Robb, 1986, 715).

Table 3. Willingness-to-Pay (WTP) and Relative Importance Estimates for Anjou Pears Quality Attributes

Quality Attributes	WTP ($/lb) For a 1 unit increase in the attribute rating	For going from attribute rating 2 to rating 5	For going from attribute rating 5 to rating 8	Relative importance of attributes
Sweetness	0.19 (0.15-0.26)	0.58 (0.45-0.79)	0.58 (0.45-0.79)	32.46%
Firmness	0.06 (0.03-0.09)	0.52 (0.32-0.72)	-0.13 (-0.31-0.02)	6.87%
Juiciness	0.16 (0.13-0.21)	0.49 (0.38-0.62)	0.49 (0.38-0.62)	27.68%
Texture	0.16 (0.11-0.21)	0.48 (0.34-0.64)	0.48 (0.34-0.64)	26.85%
Ripeness[a]	0.04 (-0.03-0.12)	0.11 (-0.09-0.35)	0.11 (-0.09-0.35)	6.14%

[a] One unit increase in the rating of ripeness means one day extra to wait until fully ripe. Going from rating two to five and going from rating five to eight means wait three days extra to fully ripe.

Relative Importance of Quality Attributes

An important piece of information for agribusiness new product development or breeding programs is the relative importance of quality attributes to consumers. This information will help set priorities when selecting attributes for a new cultivar. Relative importance is the change in an individual's utility relative to a change in the level of the attribute rating, which is calculated by,

$$\text{(6)} \quad \text{Relative importance} = \frac{\alpha_{ij}(\text{highest level} - \text{lowest level})}{\sum_{m=1}^{5} \alpha_{ij}(\text{highest level} - \text{lowest level})}$$

Results, reported in Table 3, indicate that sweetness, juiciness, and texture are the most important quality attributes for pear consumers, with a score of 32.46%, 27.68%, and 26.85%, respectively. Far behind is firmness and ripeness with scores of 6.87% and 6.14%, respectively.

Market Share Estimation

A useful feature of choice experiments is that it allows for the estimation of potential market share of the goods being analyzed. To illustrate the application of this statistic, we used the average rating scores from the sensory test of the pear samples under the four conditioning protocols described in the Methodology section and presented in Table 4. Market share is calculated by,

$$\text{(7)} \quad \text{Market share} = \frac{\exp(\overline{V_s})}{\sum_{s=1}^{S} \exp(\overline{V_s})}$$

where $\overline{V_s}$ represents the utility as depicted in expression (2), with the difference of having the average ratings for each attribute and treatment *s* multiplied by the parameter estimate for each attribute, and *S* represents the set of all pears that can be described with similar attribute ratings to those presented in this study. We assume that the samples, under the four treatments, represent all pears available in the market, and that price is the same across pears ($1.49 /lb). Market share estimates suggest that pears with sweetness rated as 7.11, firmness 6.97, juiciness 7.95, texture 7.26 and a no wait for full ripeness (pear sample 4, 6-day conditioning) will display a 54.68% share relative to pears with sensory characteristics as described in Table 4.

Table 4 also exhibits instrumental measurements for sweetness, expressed as soluble solids concentration, and firmness, expressed as lbf. About the lack of correlation between ratings for the ideal sweetness and refractometer measurements, note that the purpose of listing instrumental measurements was not to validate how well consumers predicted such values, but to have a close description of what level of sweetness is considered as ideal by consumers. This is the reason why we use the scale 1=not sweet and 9=ideally sweet. It is true that the use of this scale could introduce noise when comparing refractometer measurements and ratings for the ideal pear. However, to make direct comparisons between both measures was not the intention of the experiment. Moreover, it is relevant to consider that, often, the correlation between the perception of sweetness and soluble solids measured with a refractometer could be low, as explained by Kader (2008, 1864). Individuals' perception of sweetness is heavily influenced by fruit aromatic components that are mostly developed as fruit ripens. Thus, one observes higher scores for ideal sweetness in pears with more days of conditioning (pear samples 4 and 3). For firmness we used a different scale (1=hard, 9=soft) and not surprisingly there was a high correlation (-0.95) between the instrumental measurement (the higher the resistance in lbf, the firmer the pear) and individual's sensory ratings (scale 1-9, 1=hard, 9=soft).

These results have interesting implications for the industry. First, soluble solids as measured by a refractometer might not be as precise in measuring sweetness as it cannot measure other aromatic components more influential in consumers' perceptions. This underscores the importance of having consumer panels' feedback when evaluating quality characteristics. Second, ethylene treatments applied to pears within days of harvest seems to be a promising alternative to trigger ripening and enhance the quality attributes more valuable for consumers. Also, these results coincide with previous studies in that conditioning Anjou pears appears promising to positively affect consumers' preferences and WTP premiums (Zhang et al. 2010, 105; Gallardo et al. 2011, 452).

Table 4. Consumer Liking Scores, Instrumental Measurement for Soluble Solids and Firmness, and Market Share Estimates for Pears under Four Conditioning Protocols.

Quality Attributes	Pear 1 No conditioning	Pear 2 2-day conditioning	Pear 3 4-day conditioning	Pear 4 6-day conditioning
		Consumer Liking Scores		
Overall liking	4.33c	4.49c	6.33b	7.48a
(1=dislike extremely, 9=like extremely)	(2.37)	(1.95)	(1.73)	(1.58)
Sweetness	3.73c	3.93c	5.71b	7.11a
(1=not sweet, 9=ideally sweet)	(2.10)	(1.91)	(1.99)	(1.90)
Firmness	4.24c	4.96b	6.38a	6.97a
(1=hard, 9=soft)	(2.44)	(2.03)	(1.93)	(1.78)
Juiciness	2.47d	3.17c	5.82b	7.95a
(1=not juicy, 9=ideally juicy)	(1.59)	(1.97)	(2.07)	(1.41)
Texture	4.08c	4.13c	6.03b	7.26a
(1=mealy, 9=buttery)	(2.30)	(2.03)	(1.99)	(1.59)
Ripeness	6.00	4.00	2.00	0.00
(number of days to wait until fully ripe)				
		Instrumental Measurement		
Soluble solids (°Brix)	14.94a	14.61b	14.57b	14.52b
	(1.03)	(1.04)	(1.04)	(1.07)
Firmness (lbf)	11.13a	6.11b	3.47c	2.23d
	(1.75)	(1.14)	(0.68)	(0.45)
		Market Share (%)		
	8.40	9.80	27.13	54.68
	(4.93-14.15)	(6.56-14.26)	(24.77-28.19)	(43.48-63.77)

Lower case letters (a, b, c, and d) should be read by row for each attribute. Differing letters denote statistically significant differences; same letter denote no statistically significant differences.

Conclusions

Findings from this study demonstrate that choice experiments provide useful information for fruit agribusiness managers' decision making. This manuscript presents an empirical application of using a choice experiment to elicit WTP for targeted quality attributes of Anjou pears. There is evidence that pear consumers in the Portland metropolitan area are willing to pay $0.19, $0.16, $0.16, and $0.06 for a one unit increase in pears' sweetness, texture, juiciness, and firmness liking scores, respectively. This information is useful to pear orchard managers who are planning to diversify their operations with new plantings and planning to select pear cultivars that emphasize sweetness, buttery texture, and juiciness. Second, for new product developers in fruit agribusinesses, fruit breeders, it helps in setting priorities when selecting for quality attributes. As such, the relative importance for pear quality attributes is 32.46% for sweetness, 27.68% for juiciness, 26.85% for texture, and 6.87% for firmness. Third, it benefits fruit marketing managers. Marketing strategies seeking to increase pear consumption should emphasize the dessert qualities highlighted by consumers' in this study.

Moreover, findings from this study suggest the potential benefits of conditioning pears or applying ethylene to trigger ripening. This is an important piece of information for warehouse and retail store managers who are contemplating whether or not to invest in conditioning pears. We found that pears two weeks after harvest and under a 6-day conditioning treatment developed an ideal sweetness score of 7.11 (soluble solid concentration 14.52%)[3], firmness 6.97 (2.23 lbf), juiciness 7.95, and texture 7.26. A pear with such characteristics will absorb a 54.68% market share when compared with pears receiving different conditioning treatments or no treatments. These results add to the anecdotal evidence suggesting that benefits could be greater than losses as pear shrink at retailer shelf could be decreased if fruit is conditioned. In sum, findings from this study underscore the potential benefits of conditioning to supply pears with optimal and consistent quality.

Finally, findings in this paper provide research-based information for agribusiness managers seeking to diversify their output with new cultivars and/or looking for methods to enhance the fruit attributes most preferred by consumers. Considering that preferences might not be consistent across time or individuals (consumers versus non-consumers), further research into the valuation of quality attributes across different population clusters is required to provide pear agribusiness managers with a more precise tool to forecast novel cultivars acceptance and the potential benefits of alternative postharvest methodologies.

Acknowledgments

This project was funded by the Pear Bureau Northwest. The author acknowledges the contribution of Eugene Kupferman, project leader and Emeritus Professor in the Department of Horticulture and Landscape Architecture at Washington State University Tree Fruit Research and Extension Center, Wenatchee, Washington and Ann Colona, Sensory Manager at the Oregon State University-Food Innovation Center, Portland, Oregon. The author is also grateful to Jayson Lusk, Ron Mittelhammer, the IFAMR Managing Editor, and the anonymous reviewers for their recommendations to improve this manuscript.

[3] Note that the use of the scale 1=not sweet, 9=ideally sweet could have influenced this lack of correlation. It would have enhanced our understanding of the interactions between consumers' ratings and instrumental measurements, if we used two scales, one that measure likeness (1=extremely dislike, 9=extremely like) and another that measures intensity (1=not sweet, 9=extremely sweet).

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