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Consumers' Willingness to Pay for Treatment-Induced Quality Attributes in Anjou Pears

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Ethylene treatments provide an effective method for shortening post-harvest ripening periods for winter Anjou pears and allow market availability throughout the year. However, pear quality may vary under different treatments. A sensory experiment and a consumer survey including questions that address valuation, assessments of sensory characteristics, purchasing habits, and demographics were conducted. Analyses indicate that treatment-induced quality losses significantly affect consumers' willingness to pay (WTP). Mean WTP for each treatment reveals that consumers prefer pears with a six-day ethylene treatment and are willing to pay a premium of $0.25/pound compared to the market price.

Key words: pears, sensory, willingness to pay

Introduction

The supply, demand, and quality of agricultural products are more likely to vary during the course of a year relative to nonagricultural products because of biological and weather constraints. This seasonality can be mitigated with new developments in chemicals, transportation, and shipping. For example, new technologies have made the pear market, like most other produce markets, increasingly global as imports from the southern hemisphere have increased in recent years (Winfree et al., 2004). Because fresh fruit commodities compete with one another, innovations that enable high eating quality pears to be available during a longer season should be of interest to other produce industries.

Anjou pears are one of the most popular pear varieties in the United States. Ninety-eight percent of U.S. Anjou pears are grown in the Pacific Northwest, with an average production of 9.8 million boxes (44 pounds per box) each year (Washington Growers Clearing House, 2009). However, the feasibility of marketing immediately after harvest is challenging because of Anjou pear ripening requirements. To facilitate the normal ripening capacity of Anjou pears harvested at optimal commercial maturity, the fruit needs to be conditioned at 30°F (−1°C) for a period of 60 days.[1] Pears without sufficient chilling are referred to as "under-chilled" fruit. As Anjou pears are harvested in September, consumers who purchase pears

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[1] The optimum commercial maturity for Anjou pears requires flesh firmness between 66.7N (15 lbs. force) and 57.8N (13 lbs. force) (Chen and Mellenthin, 1981).

packed prior to November typically complain that the fruit does not soften sufficiently after one week of ripening at room temperature (Kupferman, 1994). Thus, chilling requirements reduce market availability for Pacific Northwest Anjou pears with desirable eating qualities during September and October each year. However, this issue applies more broadly when one considers the marketing implications for California and imported pears from the southern hemisphere.

Scientists have developed ethylene treatments that shorten the conditioning time for Anjou pears. Chen et al. (1996) found that a three-day conditioning treatment with ethylene is sufficient to induce normal ripening capacity of under-chilled Anjou pears, thereby allowing year-round marketing. One purpose of this study is to evaluate consumers' response to fresh pears' sensory characteristics after being conditioned with ethylene. This article investigates the level of sensory qualities preferred by pear consumers and how much they are willing to pay for these qualities. Further, we examine which ethylene treatment induces sensory qualities that result in the highest levels of consumer willingness to pay (WTP).

Many previous studies have investigated the relationship between food product attributes and consumer preferences. External attributes such as size, grade, cultivars, and reputation are found to be important influences on product price and demand (Tronstad, Huthoefer, and Monke, 1992; Carew, 2000; Quagrainie, McCluskey, and Loureiro, 2003). However, internal attributes or eating quality are key drivers in determining repeat purchases (Kajikawa, 1998; Brennan and Kuri, 2002; Miller et al., 2005; McCluskey et al., 2007). Kajikawa argued that internal apple characteristics such as brix, brix/acid ratio, and juiciness have a significant effect on imported apple prices in Japan. McCluskey et al. found that firmness and soluble solids content significantly affect consumers' willingness to pay for Washington Gala apples. Miller et al. reported that consumers make apple purchase decisions based on their experiences with internal attributes such as taste and flavor. Moreover, Brennan and Kuri found that once consumers develop a preference for a product based on sensory characteristics, they are unlikely to change.

The measurements of internal attributes, especially for fresh fruit, can be obtained in multiple ways including public information, measurements with scientific instruments, and sensory analysis with either trained panels or consumers. In a hedonic price analysis of the Japanese market for imported apples, Kajikawa (1998) used publicly available varietal sample averages for growing regions by season to represent apple attributes of brix, acid, and juiciness. McCluskey et al. (2007) used scientific instruments including both destructive and non-destructive measurements to identify the objective eating quality of Washington apples, as well as sensory analysis to obtain subjective consumer assessments. Sensory analysis is a method that can be used to quantify and understand consumer responses to food products. As argued by Foster (2004), this approach helps researchers understand and manipulate formulations in a predictable fashion as an aid to developing successful products. This method has been applied to economic studies for a wide range of products such as wine, dairy, cigars, cheese, meat, citrus, and coffee (Combris, Lecocq, and Visser, 1997; Maynard and Franklin, 2003; Freccia, Jacobsen, and Kilby, 2003; Grunert et al., 2004; Hobbs, Sanderson, and Haghiri, 2006; Poole, Martinez, and Gimenez, 2007; Donnet, Weatherspoon, and Hoehn, 2008).

Sensory analysis also has been applied to pears. Predieri, Missere, and Gatti (2002) conducted a sensory analysis to evaluate different indicators of preference for two varieties: Harrow Sweet and Williams Bartlett from the Emilia-Romagna region in Italy. They found that a longer shelf life was positively correlated to perceived juiciness, sweetness, and aroma. Turner et al. (2005) performed a sensory evaluation of multiple pear products including red

and green Anjou, red and green Williams, Bosc, and Comice grown in the U.S. Pacific Northwest. Their study is a content analysis of pear appearance rankings, overall preference scores, and eating quality attributes. Red and green Anjou pears were ranked lower by study participants than the other varieties.

WTP analyses of pear quality attributes have also been performed in previous studies. Gamble, Jaeger, and Harker (2006) conducted a conjoint analysis to evaluate how consumers value appearance of pears. Using an experimental auction, Combris et al. (2007) measured the effect of information on the WTP for Rocha pears. They found that access to safety information and fruit tasting reduced the premiums individuals were willing to pay for higher concentrations of soluble solids.

Here, we utilize sensory analysis and contingent valuation (CV) to evaluate consumers' WTP for Anjou pears with different levels of ethylene treatments. The objective of this study is to estimate a model that examines the relationship between sensory attributes and consumers' WTP for Anjou pears and evaluate whether ethylene treatment level plays an essential role in determining consumers' WTP. A sensory experiment and a consumer survey were conducted to obtain consumers' assessments of pear eating quality and sociodemographic characteristics. A double-bounded, dichotomous-choice CV model is employed to estimate consumers' WTP for Anjou pears and the mean WTP for pears across three ethylene treatment periods (two days, four days, and six days) and one seven-day condition period in which ethylene was not used. This study provides information for pear producers regarding the impacts of post-harvest conditioning procedures for Anjou pears in terms of consumers' preferences and willingness to pay.

The remaining sections are organized as follows. The contingent valuation methodology is presented in the next section, followed by a description of the survey data and a discussion of results and implications. Conclusions are presented in the final section.

Methodology

The CV approach is commonly used to elicit consumer's WTP through a dichotomous-choice, market-type questioning format.[2] There are typically two types of bidding procedures used in dichotomous-choice CV approaches: the single-bounded and double-bounded dichotomous choice.[3] The single-bounded approach involves only one bid amount by asking participants one dichotomous-choice question. The binary responses of participants will be either "yes" or "no," reflecting whether they are willing to buy the product at the offered price. The double-bounded approach uses two consecutive bids in which the second bid is contingent upon the response to the first bid. Specifically, a participant is first offered an initial bid and is asked whether he or she is willing to buy the product. If the answer is "yes," the individual is willing to pay the amount of the first bid. Then, a higher price is presented to the individual as a second

[2] CV is a hypothetical method. As such, hypothetical bias (HB) is one concern. HB refers to situations in which WTP elicited from hypothetical formats diverges from WTP elicited from nonhypothetical formats. Most of the literature suggests hypothetical bias is in the form of an overstatement (e.g., List and Gallet, 2001). Familiarity with the product used (pears) and use of the prevailing market price as the initial bid likely mitigate the problem of hypothetical bias.

[3] The number of iterations to include in the bidding procedures used in the CV method (e.g., single- versus double-bounded) has been debated in the literature. Cameron and Quiggin (1994) examined the problem of anchoring/starting point bias with iterations of bids. There is some bias with the double-bounded model, primarily due to inconsistencies which may be present between the consumers' first and subsequent bids (Hanemann and Kanninen, 1999). Since we use a double-bounded model, our results may be biased toward the initial bid. However, the familiarity of our product and the use of the current market price as the initial bid mitigate concerns. The advantage to using the double-bounded model is the additional information obtained from the follow-up question.

bid. If the answer to the first bid is "no," the individual is not willing to pay the amount of the initial bid, and he or she is then presented with a lower price as the second bid. Therefore, each individual gives two responses to two successive bids. The four possible outcomes of responses in a double-bounded model will be: "no/no," "no/yes," "yes/no," and "yes/yes."

Since consumers' WTP is a latent variable that is not directly observable, the sequential questions serve to place upper and lower bounds on the true WTP such that WTP can be partitioned into four intervals based on the answers to the double-bounded bidding questions: (1) $(-\infty, B_D)$, the respondent's WTP is lower than the offered discounted price B_D when both bids are rejected ("no/no"); (2) $[B_D, B_I)$, the respondent's WTP is between the lower bid B_D and the initial bid B_I when the initial bid is rejected but the lower bid is accepted ("no/yes"); (3) $[B_I, B_P)$, the respondent's WTP is above the initial bid but lower than the higher bid B_P when the initial bid is accepted but the higher bid is rejected ("yes/no"); and (4) $[B_P, +\infty)$, the respondent's WTP is higher than the premium price when both bids are accepted ("yes/yes").

Let WTP_i denote individual i's true WTP for a pear. The discrete outcomes of the bidding process are represented by:

$$Y = \begin{cases} 1 \text{ if } WTP_i < B_D \\ 2 \text{ if } B_D \le WTP_i < B_I \\ 3 \text{ if } B_I \le WTP_i < B_P \\ 4 \text{ if } WTP_i \ge B_P \end{cases}. \tag{1}$$

The bid function for a pear for individual i is specified as:

$$Y_i = \alpha - \rho B_i + \lambda' \mathbf{z}_i + \varepsilon_i \quad \text{for } i = 1, ..., n, \tag{2}$$

where B_i is the ultimate bid faced by individual i; $\mathbf{z}_i$ is a vector of explanatory variables associated with individual i, including the assessments of eating attributes and the demographics; the error term ε_i captures possibly unobservable factors and characteristics affecting the decision; and α, ρ, and λ are the unknown parameters to be estimated. The distribution of the error term is assumed to follow a cumulative logistic distribution with mean zero and variance σ^2, i.e., $\varepsilon \sim G(0, \sigma^2)$. In the empirical implementation of the model, we define $G(\cdot)$ to have a standard logistic distribution with zero mean and standard deviation $\sigma = \pi/\sqrt{3}$.

The qualitative dependent variable in (1) can be expressed as the choice probability for individual i:

$$\Pr(Y_i = j) = \begin{cases} G(\alpha - \rho B_D + \lambda' \mathbf{z}_i) = \dfrac{e^{\alpha - \rho B_D + \lambda' \mathbf{z}_i}}{1 + e^{\alpha - \rho B_D + \lambda' \mathbf{z}_i}} \\ G(\alpha - \rho B_I + \lambda' \mathbf{z}_i) - G(\alpha - \rho B_D + \lambda' \mathbf{z}_i) \\ \quad = \dfrac{e^{\alpha - \rho B_I + \lambda' \mathbf{z}_i}}{1 + e^{\alpha - \rho B_I + \lambda' \mathbf{z}_i}} - \dfrac{e^{\alpha - \rho B_D + \lambda' \mathbf{z}_i}}{1 + e^{\alpha - \rho B_D + \lambda' \mathbf{z}_i}} \\ G(\alpha - \rho B_P + \lambda' \mathbf{z}_i) - G(\alpha - \rho B_I + \lambda' \mathbf{z}_i) \\ \quad = \dfrac{e^{\alpha - \rho B_P + \lambda' \mathbf{z}_i}}{1 + e^{\alpha - \rho B_P + \lambda' \mathbf{z}_i}} - \dfrac{e^{\alpha - \rho B_I + \lambda' \mathbf{z}_i}}{1 + e^{\alpha - \rho B_I + \lambda' \mathbf{z}_i}} \\ 1 - G(\alpha - \rho B_P + \lambda' \mathbf{z}_i) = 1 - \dfrac{e^{\alpha - \rho B_P + \lambda' \mathbf{z}_i}}{1 + e^{\alpha - \rho B_P + \lambda' \mathbf{z}_i}} \end{cases} \quad \text{for} \quad j = \begin{Bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{Bmatrix}. \tag{3}$$

The log-likelihood function is expressed as:

$$(4) \qquad L = \sum_i \begin{cases} I_{Y_i=1} \ln[G(\alpha - \rho B_D + \lambda' \mathbf{z}_i)] \\ + I_{Y_i=2} \ln[G(\alpha - \rho B_I + \lambda' \mathbf{z}_i) - G(\alpha - \rho B_D + \lambda' \mathbf{z}_i)] \\ + I_{Y_i=3} \ln[G(\alpha - \rho B_P + \lambda' \mathbf{z}_i) - G(\alpha - \rho B_I + \lambda' \mathbf{z}_i)] \\ + I_{Y_i=4} \ln[1 - G(\alpha - \rho B_P + \lambda' \mathbf{z}_i)] \end{cases},$$

where $I_{Y_i=j}$ is an indicator function for the event that individual *i* chooses the *j*th alternative. Maximum likelihood is the commonly used approach to estimate the model.

Studies such as Herriges and Shogren (1996) and Carson, Flores, and Meade (2001) question the reliability of double-bounded, dichotomous-choice CV estimates because of starting point biases. This misspecification is prevalent when individuals are confronted with unfamiliar goods with commensurately uncertain values. Misspecification also occurs when bid values are selected for survey design reasons rather than to convey information. In the current study, participants are pear consumers who are familiar with the good in question. Further, the initial bid price was based on the actual market price. Consequently, corrections for potential starting point biases are not needed. Furthermore, studies such as Bateman et al. (2008) show that CV respondents provide theoretically consistent valuation responses if they are familiar with the operating rules of the contingent valuation experiment and with the good in question.

The estimation approach for mean WTP in our experiment is based on a random utility framework in which consumers are willing to buy Anjou pears when the utility of purchasing pears is at least as great as purchasing other commodities. The empirical mean WTP was estimated as the ratio $-(\tilde{\alpha} + \bar{z}\tilde{\lambda}) / \tilde{\rho}$. This approach is used because consumers' demographic characteristics are considered to play a role in affecting their willingness to pay for Anjou pears. The marginal effect of an explanatory variable on WTP represents the impact of an incremental change in the variable on consumers' mean WTP for Anjou pears. It can be calculated as the partial derivative of the mean WTP function with respect to the *k*th explanatory variable.

Data

Pear samples were commercially 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 for two-day, four-day, and six-day ethylene treatments, and for a seven-day treatment in which ethylene was not used. Following conditioning, the pears were returned to cold storage (33°F) to simulate transit. Before being presented to consumers for evaluation, the pears were ripened at room temperature (68°F) for three days to simulate typical consumer practices.

A consumer survey and sensory experiments were conducted in Portland, OR, in October 2008. Recruitment of participants for each test consisted of sending an online *screening* questionnaire to about 5,000 consumers in the Portland metro area. Individuals were asked about their willingness to participate in the pear taste test. Of those who completed the questionnaire, a sample size of 120 consumers were recruited and offered a $25 incentive for their participation. Meilgaard, Civille, and Carr (1999) suggest a standard sample size of over 100 consumers for a central location test. An additional 20 participants were recruited for each test as a precaution against last-minute cancellations.

Table 1. Summary Statistics for Demographic Variables

Variable	Description	Frequency (%)
Age	Age group of the participants:	
	18–24	5.83
	25–34	26.67
	35–44	20.00
	45–54	23.33
	55–64	20.00
	65+	4.17
Gender	= 1 if male	21.67
	= 0 if female	78.33
Children	= 1 if there are children under 18 years of age in the household	25.00
	= 0 otherwise	75.00
Ethnicity	= 1 if white	90.83
	= 0 otherwise	9.17
Education	Education group of the participants:	
	1 = high school or technical degree	30.83
	2 = four-year college degree	40.00
	3 = advanced degree	29.17
Income	Income group of the participants:	
	1 = < $40,000/year	26.67
	2 = $40,000 to $59,999/year	26.67
	3 = $60,000 to $79,999/year	16.67
	4 = $80,000 to $119,999/year	20.83
	5 = $120,000/year or more	9.17

Participants were asked to taste each of the four treatment Anjou pear samples. Following each tasting, participants were asked to rate the attributes of tasted pears including overall desirability, flavor, sweetness, juiciness, firmness, and texture, using a nine-point Likert scale, with 1 denoting "dislike extremely," 5 denoting "neither like nor dislike," and 9 denoting "like extremely." The order of sample presentations was random by treatment, and the respondents were not informed about sample treatments.

CV questions were asked in conjunction with the taste experiment. The participants were also asked about their preferences for pears, shopping habits, and demographic information. Summary statistics of the main sociodemographic variables are reported in table 1. A comparison of the participants' demographics with the 2000 U.S. Census for Portland, OR, is presented in table 2. The majority of the survey respondents were Caucasian (91%) and female (78%). These proportions are higher than those for Portland's general population. The median participant age ranged from 35 to 44 years. The median age of Portland's population is 35.2. Only 25% of the sample had children under 18 years of age. The level of education in our sample is higher than the general population. Thirty-one percent have a two-year college or technical degree, and 69% have a bachelor's degree or higher (table 1). The median income of respondents was in the $40,000 to $59,999 range, which includes the median household income ($40,146) for the general population.

Sixty-four percent of the respondents reported they eat fresh pears every week when they are in season. The vast majority (90%) prefer "locally grown" pears. Most people consider price to be an important factor when purchasing pears, with 60% stating "somewhat important" and 20% "extremely important." Appearance (lack of blemishes) is also considered important

Table 2. Comparison of Main Demographics Between Survey Participants and the Portland, OR, 2000 U.S. Census Population

Sociodemographic Characteristic	Sample	Portland Population
Percent female	78.33%	50.60%
Median age	35–44	35.2
Percent white	90.83%	77.90%
Percent of households w/children under 18 years of age	25.00%	18.60%
Median household income	$40,000 to $59,999	$40,146

Table 3. Summary Statistics of Consumers' Ratings for Anjou Pears with Ethylene Treatment for Different Numbers of Days

	2-Day Ethylene Treatment		4-Day Ethylene Treatment		6-Day Ethylene Treatment		7 Days w/o Ethylene	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Overall Desirability	4.44 c	1.96	6.31 b	1.73	7.46 a	1.60	4.26 c	2.35
Flavor	4.74 c	1.93	6.40 b	1.72	7.43 a	1.44	4.68 c	2.11
Sweetness	3.92 c	1.92	5.69 b	1.99	7.07 a	1.92	3.63 c	2.04
Juiciness	3.13 c	1.94	5.79 b	2.06	7.94 a	1.42	2.42 d	1.58
Firmness	4.90 b	2.04	6.36 a	1.94	6.92 a	1.79	4.22 c	2.45
Texture	4.11 c	2.06	5.99 b	2.01	7.22 a	1.59	4.04 c	2.28

Notes: Values are ranked on a 1–9 Likert scale, with 9 denoting most preferred. Lower-case letters (a, b, c, d) should be read by row for each variable. Differing letters denote statistically significant differences; identical letters denote no statistically significant differences.

by many consumers (69%). Twenty-four percent of the respondents answered that it is "extremely important" for pears to be organic, and 46% reported being organic is "somewhat important." About 48% stated they usually buy organic pears. Thus, a considerable proportion of respondents consider organic production an important characteristic of pear quality. This result is consistent with the findings of a national survey that Portland, OR, is the top ranked U.S. city for consumer understanding of and preferences for organic products (D'Ambrogi, 2006).

Table 3 presents summary statistics of consumers' ratings for the sensory characteristics of the sample pears across different ethylene treatments. Results indicate no statistically significant differences associated with overall desirability, flavor, sweetness, and texture between two-day ethylene treatment and seven-day conditioning in the absence of ethylene. The ratings for these variables were higher for the six-day ethylene treatment relative to the four-day ethylene treatment. The ratings for juiciness across treatments were statistically different. There were no differences in firmness between six- and four-day ethylene treatments, but the two-day treatment samples were rated firmer than the seven-day no-ethylene treatment.

After tasting each pear sample, respondents were asked if they would be willing to purchase pears at an initial price of $1.49/lb. This initial price was selected based on the average pear prices in Portland grocery stores during the first week of October 2008. A follow-up CV question was asked contingent on the participant's response to the initial price. If the initial

Table 4. Percentage of Respondents in Each WTP Category by Treatment Level

WTP Category	Response	2-Day Ethylene Treatment (%)	4-Day Ethylene Treatment (%)	6-Day Ethylene Treatment (%)	7 Days w/o Ethylene (%)
$(-\infty, B_D)$	"no / no"	48.70	24.79	6.90	57.89
$[B_D, B_I)$	"no / yes"	30.43	22.22	17.24	19.30
$[B_I, B_P)$	"yes / no"	14.78	25.64	29.31	12.28
$[B_P, +\infty)$	"yes / yes"	6.09	27.35	46.55	10.53

response was "no," the discounted price was then randomly set at one of the following levels: \$1.39/lb., \$1.29/lb., \$1.19/lb., \$1.09/lb., or \$0.99/lb. Similarly, if the initial response was "yes," the premium price was randomly set at one of the following levels: \$1.59/lb., \$1.69/lb., \$1.79/lb., \$1.89/lb., or \$1.99/lb. The distribution of responses to the discount and premium bid offers is presented in table 4.

Most respondents indicated they preferred pears with a six-day ethylene treatment, followed by a four-day treatment, and then the two-day treatment. They least liked the pears that did not receive an ethylene treatment. On a scale of 1–9, the average overall desirability rating was 7.46 for six-day treatment pears and only 4.26 for pears without an ethylene treatment (table 3). The ratings reveal that flavor, sweetness, juiciness, and texture improved significantly by increasing the number of ethylene treatment days. Correspondingly, a majority of the respondents (76%) were willing to pay the initial bid for the six-day treatment pears, about one-half (46%) were willing to pay the initial price of \$1.49/lb. for the four-day treatment pears, and 27% were willing to pay the premium bid offered. For the two-day treatment and no-treatment samples, most of the respondents (79% and 77%, respectively) indicated they would not buy pears at the initial price, and over one-half (49% and 58%, respectively) would not buy pears at the discounted price.

Model Specification

Because of multicollinearity among pear characteristics, sweetness, juiciness, and firmness are chosen as the representative tasting factors in the empirical model based on previous studies of fresh fruit attributes (Kajikawa, 1998; McCluskey et al., 2007). Consumer demographic variables (i.e., age, gender, children, ethnicity, and income) are also included. We estimate three versions of the following model:[4]

$$
\begin{aligned}
(5) \qquad Y_{ij} = {} & \alpha_j - \rho_j Bid_{ij} + \lambda_{j1} Sweetness_{ij} + \lambda_{j2} Juiciness_{ij} + \lambda_{j3} Firmness_{ij} \\
& + \lambda_{j4} Children_{ij} + \lambda_{j5} Age_{ij} + \lambda_{j6} Gender_{ij} + \lambda_{j7} Ethnicity_{ij} \\
& + \lambda_{j8} Income_{ij} + \lambda_9 D_2 + \lambda_{10} D_4 + \lambda_{11} D_6 + \varepsilon_i ,
\end{aligned}
$$

where $i = 1, \ldots, n$ denotes the ith individual; $j = 1, 2, 3, 4$ represents the jth sample; Bid_i is the final bid offered to individual i; *Sweetness, Juiciness*, and *Firmness* are individual i's ratings

[4]Alternative models were also estimated, including models which grouped the data by treatment and a model with pooled data that utilized interaction of the treatment and attribute variables. The reason for considering alternative model specifications was to identify whether there exists a treatment effect or interactions in addition to the treatment-induced pear attributes, and whether the effects of the pear attributes on consumers' WTP differ across samples. The estimation results are similar across the models and thus are not presented here. Interested readers can obtain the results from the authors upon request.

for the pear attributes; *Children* indicates the presence of children under 18 years of age in the household; *Age* represents the respondent's age group; *Gender* indicates whether the respondent is male; *Ethnicity* indicates the individual is Caucasian; *Income* is the income level of the household; D_2, D_4, and D_6 are variables indicating the tasted sample received two-day, four-day, and six-day ethylene treatments, respectively; and α, ρ, and λs are unknown parameters to be estimated.

First, we estimate the full model in (5). Second, we estimate the model in (5) with sensory effects while omitting the treatment variables. Third, we estimate the model in (5) with treatment effects while omitting the sensory variables. The first model evaluates treatment effects independent of treatment indicator variables. The second model isolates the effects of sensory variables. The third model estimates the "unconditional" effects of the treatment dummies on WTP.

Results and Implications

Three specifications of model (5) were estimated using maximum likelihood with the GAUSS statistical package. The parameter estimates for all three specifications are reported in table 5. The coefficient for *Bid* is negative and statistically significant in all of the model specifications. The sign of the *Bid* coefficient is expected because consumers are more likely to indicate they will buy the product if it is offered at a lower price. In the full version of the model, the three sensory variables *Sweetness*, *Juiciness*, and *Firmness* are all positive and statistically significant. At the same time, the three treatment indicator variables are all insignificant, suggesting it is the treatment-induced eating qualities that affect consumers' willingness to pay. The estimation results are similar across the two models with and without the treatment indicator variables. The significance of these variables confirms these sensory attributes are important for consumers' purchase decisions. The demographic variables are insignificant except for the *Children* variable, which has a positive and significant relationship with WTP. In the model without the sensory variables, the four-day treatment and six-day treatment coefficients are positive and significant, indicating these treatments induce the desired qualities that affect WTP.

The marginal effects associated with explanatory variables are presented in table 6. *Firmness* has the largest marginal effect among the sensory variables, suggesting it is a key factor affecting consumers' willingness to pay. Based on the pooled model without treatment indicators, consumers are willing to pay 5.7¢, 3.7¢, and 8.5¢ per pound more, respectively, as the ratings of *Sweetness*, *Juiciness*, and *Firmness* increase by one. The respondents with children under 18 years of age are willing to pay 9.6¢ per pound more to buy Anjou pears than those without children.

We now examine consumers' mean WTP for pears with different levels of ethylene treatments. The estimated means of WTP for Anjou pears with different levels of ethylene treatment are reported in table 7. On average, consumers are willing to pay \$1.19/lb., \$1.53/lb., and \$1.74/lb. for the two-day, four-day, and six-day ethylene treatments, respectively, and \$1.09/lb. for the seven days *without* ethylene treatment. These results indicate that the six-day ethylene treatment is most desirable among the four scenarios to induce the "target" eating quality most preferred by consumers. Compared to the average market price of \$1.49/lb., consumers were willing to pay a premium of \$0.25/lb. and \$0.04/lb. for the pears with six-day and four-day ethylene treatments, respectively.

Table 5. WTP Estimation Results for Anjou Pears

	Full Model		Without Treatment Indicator Variables		Without Sensory Variables	
Variable	Parameter	*p*-Value	Parameter	*p*-Value	Parameter	*p*-Value
Intercept	3.068***	0.000	2.884***	0.000	4.195***	0.000
Bid	−5.330***	0.000	−5.305***	0.000	−3.797***	0.000
Sweetness	0.307***	0.000	0.304***	0.000	—	—
Juiciness	0.158**	0.022	0.197***	0.000	—	—
Firmness	0.457***	0.000	0.453***	0.000	—	—
Children	0.512**	0.033	0.510**	0.033	0.407*	0.066
Age	−0.025	0.746	−0.023	0.766	0.031	0.665
Gender	−0.142	0.546	−0.142	0.545	−0.162	0.454
Ethnicity	−0.165	0.611	−0.176	0.589	−0.106	0.736
Income	−0.101	0.206	−0.102	0.199	−0.023	0.758
D_2	−0.244	0.396	—	—	0.252	0.329
D_4	0.054	0.866	—	—	1.607***	0.000
D_6	0.213	0.596	—	—	2.518***	0.000

Note: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Marginal Effects of Explanatory Variables

	Full Model		Without Treatment Indicator Variables		Without Sensory Variables	
Variable	Parameter	*p*-Value	Parameter	*p*-Value	Parameter	*p*-Value
Sweetness	0.058***	0.000	0.057***	0.000	—	—
Juiciness	0.030**	0.022	0.037***	0.000	—	—
Firmness	0.086***	0.000	0.085***	0.000	—	—
Children	0.096**	0.032	0.096**	0.033	0.107*	0.065
Age	−0.005	0.746	−0.004	0.766	0.008	0.665
Gender	−0.027	0.546	−0.027	0.545	−0.042	0.454
Ethnicity	−0.031	0.612	−0.033	0.590	−0.028	0.736
Income	−0.019	0.205	−0.019	0.199	−0.006	0.758
D_2	−0.046	0.395	—	—	0.066	0.329
D_4	0.010	0.866	—	—	0.423***	0.000
D_6	0.040	0.596	—	—	0.663***	0.000

Note: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

While the current analysis is not focused on costs, producers who are considering ethylene treatment should examine the potential costs of the conditioning treatments. Costs are highly variable and dependent on the size of operations. Nonetheless, costs for conditioning fruit include a storage room (or trailer rental), an ethylene dispenser and ethylene concentrate, and energy. Additionally, extra caution must be taken in transportation to avoid potential damage to fruit with lower firmness. Based on discussions with industry participants, we estimate the cost of ethylene treatment to be $0.004/lb. (see the appendix for the cost calculations). According to this estimate, the premiums that can be obtained from six-day and four-day

Table 7. Mean WTP for Anjou Pears with Different Levels of Ethylene Treatment

	2-Day Ethylene Treatment				4-Day Ethylene Treatment		
Variable	Parameter	Standard Deviation	95% Confidence Interval for Mean WTP		Parameter	Standard Deviation	95% Confidence Interval for Mean WTP
WTP	1.19***	0.036	(1.12, 1.26)		1.53***	0.033	(1.46, 1.59)
	6-Day Ethylene Treatment				**7 Days w/o Ethylene**		
Variable	Parameter	Standard Deviation	95% Confidence Interval for Mean WTP		Parameter	Standard Deviation	95% Confidence Interval for Mean WTP
WTP	1.74***	0.034	(1.67, 1.81)		1.09***	0.053	(0.98, 1.19)

Note: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

treatments are greater than this cost.[5] More precise cost estimates should be the topic of future investigations.

Conclusions

Supplying Anjou pears with optimal sensory characteristics can be difficult because of the way the product ripens. Ethylene treatments may reduce this problem by shortening the conditioning time of Anjou pears. However, the eating quality of pears may vary as treatment time differs. It is important for pear producers to understand how ethylene treatment conditioning affects eating quality attributes and consumers' willingness to pay.

This article uses contingent valuation to evaluate consumers' WTP for pears with different levels of ethylene treatments. A taste evaluation and a consumer survey were conducted to collect data on consumers' WTP and their assessments of pear characteristics across different ethylene treatments. Treatment-induced sensory characteristics are found to significantly affect WTP. The sensory variables *Firmness*, *Sweetness*, and *Juiciness* are significant factors explaining consumers' WTP. Respondents with children under 18 years of age have a higher WTP. The means of WTP for pears with the four types of treatments are \$1.19/lb., \$1.53/lb., \$1.74/lb., and \$1.09/lb. for two-day, four-day, and six-day ethylene treatments, and seven days *without* ethylene treatment, respectively, compared to the benchmark average price of \$1.49/lb. in Portland-area grocery stores at the time of the experiment.

Based on our findings, consumers are willing to pay a premium of \$0.25/lb. for pears that receive the six-day treatment compared to the market price. Pears without ethylene treatment have the least desirable eating qualities. The estimated premiums that can be obtained with the four-day and six-day treatments are greater than the estimated costs of treatment, which are less than one cent per pound. The six-day treatment is longer than that used in current industry practices, perhaps reflecting other tradeoffs that the pear industry faces. However, as consumer expectations for quality continue to increase, one would expect pears with the most preferred eating quality to be provided and marketed as a premium product. This study underscores the importance of eating quality attributes and the ultimate value to consumers, which leads to the realized value of ethylene conditioning treatments to producers.

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[5] Of course, there are many other factors to consider, including both supply and demand factors.

References

Bateman, I. J., D. Burgess, W. G. Hutchinson, and D. I. Matthews. "Learning Design Contingent Valuation (LDCV): NOAA Guidelines, Preference Learning, and Coherent Arbitrariness." *J. Environ. Econ. and Mgmt.* 55(2008):127–141.

Brennan, C. S., and V. Kuri. "Relationship Between Sensory Attributes, Hidden Attributes, and Price in Influencing Consumer Perception of Organic Foods." In *UK Organic Research 2002: Proceedings of the COR Conference*, eds., J. Powell, G. Davies, S. Fowler, M. Hovi, N. Lampkin, M. Lennartsson, and S. Padel, pp. 65–68. Aberystwyth, UK, March 2002.

Cameron, T., and J. Quiggin. "Estimation Using Contingent Valuation Data from a 'Dichotomous Choice with Follow Up' Questionnaire." *J. Environ. Econ. and Mgmt.* 27(1994):218–234.

Carew, R. "A Hedonic Analysis of Apple Prices and Product Quality Characteristics in British Columbia." *Can. J. Agr. Econ.* 48(November 2000):241–257.

Carson, R. T., N. E. Flores, and N. F. Meade. "Contingent Valuation: Controversies and Evidence." *Environ. and Resour. Econ.* 19(2001):173–210.

Chen, P. M., S. R. Drake, D. M. Varga, and L. Puig. "Precondition of D'Anjou Pears for Early Marketing by Ethylene Treatment." *Food Quality* 19(1996):375–390.

Chen, P. M., and W. M. Mellenthin. "Effects of Harvest Date on Ripening Capacity and Postharvest Life of D'Anjou Pears." *J. Amer. Society of Horticul. Sci.* 106(1981):38–42.

Combris, P., S. Lecocq, and M. Visser. "Estimation of a Hedonic Price Equation for Bordeaux Wine: Does Quality Matter?" *Econ. J.* 107, no. 441 (March 1997):390–402.

Combris, P. A., S. Pinto, A. Fragata, and E. Giraud-Heraud. "Does Taste Beat Food Safety? Evidence from the 'Pera Rocha' Case in Portugal." Paper presented at the European Association of Agricultural Economists (EAAE) seminar, Bologna, Italy, 8–10 March 2007.

D'Ambrogi, K. "Organic IQ: Who Has a Clue and Who Needs to Study Up?" Seeds of Change Foods, 2006. Online. Available at http://www.seedsofchangefoods.com/whats_new/news_2006_09.aspx. [Accessed July 17, 2009.]

Donnet, M. L., D. D. Weatherspoon, and J. P. Hoehn. "Price Determinants in Top-Quality E-Auctioned Specialty Coffees." *Agr. Econ.* 38(2008):267–276.

Foster, P. "Sensory Research." 2004. Online. Available at http://www.fabresearch.com/docs/sensory.pdf.

Freccia, D. M., J. P. Jacobsen, and P. Kilby. "Exploring the Relationship Between Price and Quality for the Case of Hand-Rolled Cigars." *Quart. Rev. Econ. and Fin.* 43(2003):169–189.

Gamble, J., S. R. Jaeger, and F. R. Harker. "Preferences in Pear Appearance and Response to Novelty Among Australian and New Zealand Consumers." *Postharvest Biology and Technology* 41(2006):38–47.

Grunert, K. G., L. Lahteenmaki, O. Ueland, and A. Astrom. "Attitudes Towards the Use of GMOs in Food Production and Their Impact on Buying Intention: The Role of Positive Sensory Experience." *Agribus.: An Internat. J.* 20,1(2004):95–107.

Hanemann, W. M., and B. Kanninen. "The Statistical Analysis of Discrete-Response CV Data." In *Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the U.S., EU, and Developing Countries*, eds., I. J. Bateman and K. G. Willis, pp. 302–442. London: Oxford University Press, 1999.

Herriges, J. A., and J. F. Shogren. "Starting Point Bias in Dichotomous Choice Valuation with Follow-up Questioning." *J. Environ. Econ. and Mgmt.* 30(1996):112–131.

Hobbs, J. E., K. Sanderson, and M. Haghiri. "Evaluating Willingness-to-Pay for Bison Attributes: An Experimental Auction Approach." *Can. J. Agr. Econ.* 54,2(2006):269–287.

Kajikawa, C. "Quality Level and Price in the Japanese Apple Market." *Agribus.: An Internat. J.* 14,3(1998): 227–234.

Kupferman, E. M. "Anjou Pear Quality." *Tree Fruit Postharvest J.* 5,1(1994):3–16.

List, J. A., and C. A. Gallet. "What Experimental Protocols Influence Disparities Between Actual and Hypothetical Stated Values?" *Environ. and Resour. Econ.* 20(2001):241–254.

Maynard, L. J., and S. T. Franklin. "Functional Foods as a Value-Added Strategy: The Commercial Potential of 'Cancer-Fighting' Dairy Products." *Rev. Agr. Econ.* 25,2(Fall/Winter 2003):316–331.

McCluskey, J. J., R. C. Mittelhammer, A. B. Marin, and K. S. Wright. "Effect of Eating-Quality Characteristics on Consumers' Willingness to Pay for Gala Apples." *Can. J. Agr. and Resour. Econ.* 55(2007): 217–231.

Meilgaard, M., G. V. Civille, and B. T. Carr. *Sensory Evaluation Techniques*, 3rd ed. Boca Raton, FL: CRC Press, 1999.

Miller, S., C. Hampson, R. McNew, L. Berkett, S. Brown, J. Clements, R. Crassweller, E. Garcia, D. Greene, and G. Greene. "Performance of Apple Cultivars in the 1995 NE-183 Regional Project Planting: III. Fruit Sensory Characteristics." *J. Amer. Pomological Society* 59,1(2005):28–43.

Poole, N. D., L. M.-C. Martinez, and F. V. Gimenez. "Quality Perceptions Under Evolving Information Conditions: Implications for Diet, Health, and Consumer Satisfaction." *Food Policy* 32,2(April 2007): 175–188.

Prederi, S., D. Missere, and E. Gatti. "Studies on Sensory Evaluation and Quality of Pear Fruits in Emilia-Romagna." *Acta Horticulturae* 596(2002):817–820.

Quagrainie, K. K., J. J. McCluskey, and M. L. Loureiro. "A Latent Structure Approach to Measuring Reputation." *S. Econ. J.* 67,4(April 2003):966–977.

Tronstad, R., L. S. Huthoefer, and E. Monke. "Market Windows and Hedonic Price Analyses: An Application to the Apple Industry." *J. Agr. and Resour. Econ.*17,2(December 1992):314–322.

Turner, J., J. Bai, A. Marin, and A. Colonna. "Consumer Sensory Evaluation of Pear Cultivars in the Pacific Northwest." *Acta Horticulturae* 671(2005):355–360.

Washington Growers Clearing House. "Five-Year Northwest Pear Production." Online. Available at http://www.waclearinghouse.org/. [Accessed July 17, 2009.]

Winfree, J. A., J. J. McCluskey, R. C. Mittelhammer, and P. Gutman. "Seasonal Market Power in the U.S. D'Anjou Pear Industry." *J. Food Distrib. Res.* 35,2(2004):56–65.

Appendix: Cost Calculations

Table A1. Estimated Conditioning Cost Under the Assumption of Renting a Trailer

Item	Total Cost	No. of Hours	Cost per Hour	No. of Hours for Ethylene Treatment	Cost for a 48-Hour Ethylene Treatment for 1,000 Euro Boxes	Cost per Box	Cost per Pound
Cost of renting a trailer per month	$1,500	720	$2.08	48	$100	$0.10	
Cost of diesel per gallon per hour	$11.25	48	$0.23		$11.25	$0.01	
Cost of ethylene + ethylene dispenser	$456		$0.13		$6.24	$0.01	
Total						**$0.12**	**$0.004**

Notes: The cost of diesel per gallon per hour assumes a rate of 3.75 gallons/hour and the cost of diesel is $3/gallon. The cost of ethylene is $76/box, and one box contains 12 quarts of ethylene. When purchasing at least six boxes of ethylene, the supplier loans the ethylene dispenser for free. Hence, total cost for these items is $456. We assume that one quart of ethylene is needed for 1,000 euro boxes for 48 hours of conditioning. Estimated costs in this table do not include labor costs for loading and unloading trucks.