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RESEARCH ARTICLE

Assessing consumers' preferences and willingness to pay for novel sliced packed fresh pears: A latent class approach

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Abstract

The North American fresh pear industry faces marketing challenges that could jeopardize its' long-term economic profitability. The production of sliced fresh pears is a promising alternative to overcome the lack of supplying consistently a product with superior quality with added convenience, potentially able to increase domestic consumption. In this paper, we used sensory evaluation and a Vickrey experimental auction to elicit consumers' preferences and willingness to pay for sliced packed fresh pears treated with SmartFresh™ (1-methylcyclopropene) and subsequently with a ripening compound (RC) in the form of glyoxylic acid at different concentration levels (1%, 2%, 3%, and control). Panelists were willing to pay a price premium equivalent to \$0.119/2 oz packet for the 2% RC sample, \$0.055/2 oz packet for the 3% RC sample, and \$0.025/2 oz packet for the 1% RC sample compared to the control sample. Results from a market segmentation analyses indicate the presence of two groups in the panelist sample. The group that liked sliced pears assigned higher importance to locally grown fruit and price, shopped at conventional retailer grocery stores, had fewer children in the household, and were younger compared to the group that disliked sliced pears. [EconLit citation: Q13].

1 | INTRODUCTION

The United States was the third largest producer of pears in the world during 1994–2014; the United States produced 831 thousand tons annually, trailing only China, with 11 million tons, and Italy, with 843 thousand tons (U.N. Food and Agriculture Organization, 2017). Despite this high-level production, per capita consumption of pears in the United States lags compared to other countries. In 2015, annual per capita consumption of fresh pears was 2.7 lb, representing 3% of annual per capita consumption of all noncitrus fruits at 88.6 lb (U.S. Department of Agriculture, 2017). By comparison, annual per capita consumption in Europe was 11.9 lb in 2009–2011 (Trentini, 2012). One factor believed to keep the consumption at low levels and a major challenge faced by the North American fresh pear industry is the need to obtain and deliver consistent fruit quality to consumers. This challenge starts at the orchard level and continues through the marketing chain. Fruit firmness varies by location within the tree, harvest date, and orchard elevation. Pears are unique in that they are harvested mature but unripe and the fruit is then conditioned to ripen; pears typically require a preripening stage in which the fruit must be exposed to cold temperatures (less than 1 °C) for a specific length of time, depending on the cultivar (Hartman, Drouet, & Morin, 1987; Sugar & Einhorn, 2011). To deter losses during handling, shippers and retailers are prone to sell pears that are not yet fully ripe, at the expense of making them less appealing to consumers who—in general—prefer ready-to-eat fruit. Unripe pears usually exhibit less than optimal flavor and textural eating quality attributes, making consumers less eager to repeat the purchase. Meanwhile, fully ripe pears are more prone to bruises when handling, leading to decay and losses (Gallardo, 2011; Gallardo, Kupferman, & Colonna, 2011).

The pear industry and allied scientists have tried different methods to improve postharvest ripening to increase pear consumption. Methods to control the ripening process of fresh pears—including ethylene treatments or conditioning—appear promising and could improve year-round marketing. Ethylene is a natural plant hormone used to control the ripening of fruits (Chen, Drake, Varga, & Puig, 1996; Sugar, Mitcham, & Kupferman, 2009). Studies evaluating consumers' response to the sensory characteristics of fresh pears conditioned with ethylene found that conditioning significantly increased consumers' willingness to pay (WTP) (Gallardo, 2011; Gallardo et al., 2011; Zhang, Gallardo, McCluskey, & Kupferman, 2010). Another alternative tried by the pear industry used an ethylene receptor–blocking compound, 1-methylcyclopropene (hereafter 1-MCP), to prolong storage and counter the superficial scald, a physiological disease consisting of a brown discoloration of the fruit skin (Yan, Xingbin, & Sugar, 2015). However, fruit treated with 1-MCP fails to ripen consistently after it has been removed from the controlled atmosphere (Argenta, Mattheis, Fan, & Amarante, 2016; Chiriboga et al., 2013; Watkins, 2006).

Consumers' perceptions of emerging food technologies or foods manufactured with these technologies are not always well understood. Despite recent upward trends showing that consumers—particularly millennials—spend more time compared to other generations, accessing information on how food is grown, harvested, processed, or distributed, the majority of consumers often ignore such details, despite their ever-increasing expectations about enhanced taste, quality consistency, convenience, and phytonutrient properties (Bruhn, 2007). Innovative food technologies can help the food industry meet consumer expectations, but the potential health effects of these technologies frequently create concern among consumers (Cardello, Schutz, & Lesher, 2007; Lusk et al., 2004).

Scientists have researched the possibility of developing a pear product that would exhibit consistently superior appearance and eating quality, in addition to being convenient, in an attempt to mirror the success of sliced apples (Dhingra, 2016; Warner, 2015). However, there are multiple challenges associated with commercializing sliced pears, including the production of an undesirable unripen product if the fruit is sliced at firmness values above 12 lbf and the potential for fast browning and reduced shelf life when sliced at firmness less than 12 lbf firmness (Warner, 2014). Recently, scientists have identified a set of plant ripening compounds (RCs) that make it possible to exploit previously unknown properties of alternative oxidase enzymes, allowing the timing of plant or plant-product maturation to be controlled (Dhingra & Hendrickson, 2017). Treatment with 1-MCP and subsequent RC appeared as a promising alternative to overcome the challenges that had prevented the production and commercialization of sliced fresh pears by producing consistently superior quality sliced fresh pears with increased shelf life in refrigeration (Dhingra & Hendrickson, 2017; Gorny, Cifuentes, Hess-Pierce, & Kader, 2000; Warner, 2015).

The motivation for this study is to contribute to find plausible alternatives to the marketing challenges of the North American fresh pear industry. A promising product is the sliced fresh pears, given the discovery of the aforementioned RC that is aimed at enabling the development and extension of the shelf life of fresh pears—cut in slices—and ultimately to increase their consumption (Dhingra & Hendrickson, 2017). The objective of this study is to estimate consumers' preferences and valuation for sliced fresh pears. Our approach combined the sensory evaluation of sliced pear samples treated with different percentages of the RC followed by a Vickrey auction in which we elicited consumers' WTP for the different sliced pear samples. We also apply a latent class model to identify the likely consumers of this novel product and better focus marketing strategies.

2 | LITERATURE REVIEW

Numerous studies have focused on the value consumers place on fruit quality traits and the price premiums consumers are willing to pay. In particular, external attributes such as color, shape, and size are important influences on product price and demand (Carew, 2000; Quagrainie, McCluskey, & Loureiro, 2003; Tronstad, Stephens Huthoefer, & Monke, 1992). These external attributes are believed to drive consumers' first impulse to buy food products (Shapiro, 1983). Internal qualities such as textural and taste attributes are determinant factors for overall enjoyment and ensuring repeated purchase, as consumers' previous experiences with the eating quality of similar products strongly affect subsequent purchasing decisions (Brennan & Kuri, 2002; Kajikawa, 1998; Shapiro, 1983). Overall, a complete assessment of consumer purchase behavior requires an integration of the purchase process, including perceptions of external appearance and the consumption process, driven by internal quality (Mueller, Osidacz, Francis, & Lockshin, 2010).

An increasing number of studies combine sensory evaluation with value elicitation (i.e., WTP) to get a more complete picture of how the organoleptic properties of foods affect consumers' perceptions and WTP. Such studies have been applied to a wide range of food products including wine (Combris, Lecocq, & Visser, 1997; Mueller et al., 2010), champagne (Lange, Martin, Chabanet, Combris, & Issanchou, 2002), dairy (Grunert, Bech-Larsen, Lahteenmaki, & Ueland, 2004; Maynard & Franklin, 2003), meats (Hobbs, Sanderson, & Haghiri, 2006; Lusk, Roosen, & Fox, 2003; Melton, Huffman, & Shogren, 1996), and fresh fruits (Jaeger, Andani, Wakeling, & MacFie, 1998; Lund, Jaeger, Amos, Brookfield, & Harker, 2006; McCluskey, Mittelhammer, Marin, & Wright, 2007; Bi, House, Gao, & Gmitter, 2011; Gallardo et al., 2011; Zhang et al., 2010; McCluskey, Horn, Durham, Mittelhammer, & Hu, 2013; Costanigro, Kroll, Thilmany, & Bunning, 2014; Seppa et al., 2015; Shi, Gao, House, & Heng, 2015; Zhang & Vickers, 2014). In general, studies using hedonic sensory evaluation scales and WTP elicitation methods confirm that overall liking scores are positively correlated with WTP. These studies also make important contributions by using a sensory evaluation component to yield more robust assessments of WTP for food compared to value elicitation studies that do not use sensory evaluation (Combris, Bazoche, Giraud-Héraud, & Issanchou, 2009).

A handful of studies focus on the sensory evaluation of fresh pears. In a seminal sensory evaluation study, Kappel, Fisher-Fleming, and Hogue (1995) found that consumers' ideal pear had a mixture of specific external and internal attributes related to fruit size, shape, color, firmness, juiciness, and sweetness. Jaeger, Lund, Lau, and Harker (2003) found that consumers identified ideal pears as sweet and juicy. Predieri, Gatti, Rapparini, Cavicchi, and Colombo (2005) found that perceived sweetness and aroma were positively correlated with overall liking of pears. Turner, Bai, Marin, and Colonna (2005) found that sweetness, texture, tartness, and juiciness were positively correlated with overall liking of pears. Manning (2009) concluded that consumer preferences were positively correlated with lightly colored blushed pears, pear flavor, sweetness, juiciness, and soft textures. Sliced fresh pears would need to be flavorful, aromatic, and sweet, yet firm, in order to be commercially viable because it is not possible to deliver a juicy, melting product in a modified atmosphere bag (Warner, 2015).

Fewer studies have used a dual approach to elicit consumers' WTP for fresh pear quality attributes. Combris, Pinto, Fragata, and Giraud-Heraud (2010) found that access to safety information reduced the premiums individuals were willing to pay for higher levels of sweetness. Zhang et al. (2010) concluded that firmness, sweetness, and juiciness induced by a conditioning treatment significantly affected WTP. Gallardo et al. (2011) found that consumers were willing to pay a price premium for increase sweetness but willing to discount for increased fruit firmness. Gallardo (2011) concluded that higher hedonic liking scores for sweetness, texture, juiciness, and firmness positively impacted WTP. Cerda, García, Tolosa, and Garcia (2015) found that the most important attributes for organic pear preferences were price, external characteristics, production type, and shape.

This paper's contribution to the existing literature is that it reports consumers' reactions in terms of preferences and values to fresh pears treated with an innovative postharvest technology, the treatment with MCP and RC. We investigate if the sliced packed pears have the quality profile deemed acceptable to consumers, and we also investigate what concentrations of the RC would lead to the quality profile most accepted by consumers.

In an experimental auction, researchers are interested in determining the monetary value people place on goods derived using a new technology, in part to estimate the cost benefit of investing in the technology (Boardman, Greenberg, Vining, & Weimer, 2005; Wertenbroch & Skiera, 2002). Experimental auctions are a popular method for assessing consumers' preferences and WTP for goods and services (Lusk & Shogren, 2007). The popularity of this method stems from the advantages it has over other types of elicitation methods: an active market environment that allows market feedback to be incorporated, incentive compatibility (meaning that participants are motivated to bid their true valuation for a good or service), a nonhypothetical nature involving real consequences to individuals' stated preferences, and using the minimum number of assumptions to represent individuals' valuation (Lusk & Shogren, 2007).

This study uses a Vickrey second-price auction format in which each participant submits a sealed bid. The highest bidder wins the auction and pays the second highest bid for the product. This format has the advantage of being demand revealing, being relatively simple to explain, and having an endogenous market-clearing price. Potential issues with the Vickrey auction include overbidding behavior and loss of interest among low-value bidding individuals after multiple bidding rounds (Colson, Huffman, & Rousu, 2011). Other mechanisms, such as random *n*th price auctions, offer alternatives that address these issues, but no conclusive evidence indicates a superior mechanism (Lusk & Shogren, 2007). We chose the Vickrey auction for its ease of implementation; using other, more complex mechanisms—such as the *n*th price auction—could induce systematically biased results due to participants' lack of prior training and understanding of the auction mechanism (Corrigan & Rousu, 2006).

3 | METHODS

All sample pears in this study were "D'Anjou" variety and experienced the same growing, harvest, and postharvest conditions. Average size was 2.75 inch diameter (100 count box) and average firmness of all pears prior to treatment was 12 lbf. Pears were treated with 150 ppb of 1-MCP. Next, the pears were sliced and treated with the antibrowning product Nature Seal® mixed with RC at 1%, 2%, and 3% concentrations. The sliced pears were sealed in 2 oz modified atmosphere bags. The processing of the fruit was performed on February 25 at Crunch Pak®, a fruit processing company in Cashmere, WA. Pears were separated into four groups. Three of the groups were treated with different concentrations of RC (1%, 2%, and 3%); a fourth group was not treated and was used as the control sample. The packed sliced pears were kept in refrigeration (4 °C) until February 29 when they were transported via ground from Cashmere, WA to Portland, OR.

The sensory evaluation and experimental auctions took place on March 1–2, 2016, at the Food Innovation Center at Oregon State University in Portland, OR. Participants were recruited through an advertisement on Craigslist that reached about 25,000 people in the Portland area. We received 15,000 applications, and 120 panelists were chosen to be representative of Portland demographics. We procured to the best of our ability the recruitment of both pear and nonpear consumers, that is individuals who consumed pears less than once a year and individuals who consumed pears more than once a week. Because 100 is the standard sample size for a central location test, we recruited 20 extra individuals to cover last-minute cancellations (Meilgaard, Carr, & Civille, 2006). Participants were told a priori that the experiment would last for 1 hr and compensated $40 in cash for their participation.

The procedure began with an introduction of the project, goals, and motivation, followed by an explanation the experiment: first the sensory tasting of four samples of packed sliced pears, followed by responses to a sensory-related questionnaire for each pear sample tasted. Researchers did not provide any insights into the treatments or technology used on the pears, as the goal of the research was not to elicit preferences for specific treatments but to obtain information on preferences for the quality attributes derived from each treatment. Participants were asked to rate overall liking as well as their enjoyment of pear flavor, sweetness, juiciness, firmness, and texture using a 9-point hedonic scale (1 = *dislike extremely* to 9 = *like extremely*). Similar questions asked participants to rate the perceived intensity of the pears' quality characteristics using the same hedonic scale.

Panelists were advised to rinse their palates between sample tastings. Next, panelists participated in a second-price experimental auction. The researcher explained the dynamics of the auction in detail. Participants were asked to write down on a ballot the amount of money they would be willing to pay for a 2 oz packet of each sample tasted. Each ballot had a random number linked to each pear sample. A practice auction using pens was conducted to familiarize participants with the experimental auction procedure. Once all panelists had written down their bids, researchers collected the ballots, ordered the bids in descending order, identified the highest and the second highest bids for each pear sample, and identified the panelist who had bid the highest amount. A total of two rounds of bids were elicited. Researchers then randomly selected one bid round and one pear sample as the binding round/sample. The panelist who bid the highest amount on the binding round and for the binding sample was the auction winner and had to buy the pear sample, paying in cash an amount equivalent to the second highest (market price) bid. Finally, participants were asked to fill out questionnaires about their fruit-purchasing habits and sociodemographic characteristics.

4 | EMPIRICAL SPECIFICATION

To explain the variation in bids for different pear samples, we used a censored regression model (Tobit) because 10% of bids submitted were zeroes. In censored models the latent unobserved variable bids y^* is depicted by y, the bid actually observed. The bids collected were to be left censored and following (Greene, 2008):

$$\begin{aligned} y_1^* &= X_i\,\beta + \varepsilon_{ij} \\ y^* &= 0 \quad \text{if } y_i^* \leq 0 \\ y^* &= y_i^* \quad \text{if } y_i^* > 0, \end{aligned} \tag{1}$$

where X_i is the matrix of explanatory variables for individual i: liking ratings for size, flesh color, aroma, firmness, juiciness, sweetness, and tartness for the pear samples; purchasing variables (e.g., shopping locally grown pears; shopping at conventional grocery stores, warehouse retailer, or food cooperative; importance of privative label or healthfulness label); sociodemographic variables (e.g., number of people in the household, age, ethnicity, and income); and indicator variables for each treatment (1 %, 2%, 3% RC); and ε_{ij} is the error term assumed with mean zero and variance σ^2. The parameter estimates are obtained by maximizing the likelihood function L, that is represented by:

$$L = \prod_{i=1}^{N} \left(\frac{1}{\sigma}\phi\left(\frac{y_i - X_i\beta}{\sigma}\right)^{UC_i} \right) \Phi\left(\frac{-X_i\beta}{\sigma}\right)^{LC_i}, \tag{2}$$

where UC_i and LC_i are indicator variables representing uncensored and left censored bids and ˘ represents the cumulative standard normal distribution (Lusk & Shogren, 2007).

Consumers often show heterogeneous preferences unrelated to their observable characteristics; therefore, a model that enables valuation for heterogeneity would more closely represent real purchase behavior (Lusk, 2003). Latent class models enable the identification of groups or segments within the sample of consumers, which are characterized using discrete observed measures. This segmentation involves empirical testing, which prevents possible unrealistic distributional assumptions (Boxall & Adamowicz, 2002; Greene & Hensher, 2003; McCutcheon, 1987).

Consider N agents facing J alternatives. In the latent class logit model, one assumes that there are C distinct classes of preference parameters. That is, consumer preferences are heterogeneous across classes but homogeneous within a class (Boxall & Adamowicz, 2002). Let P_{ij} denote a binary variable equaling 1 if individual i chooses option j and 0 otherwise. If individual i is in class c, the probability of observing her choice is given by:

$$P_i\ (\beta_c) = \prod_{j=1}^{J} \left(\frac{\exp\left(\beta_c x_{ij}\right)}{\sum_{k=1}^{K} \exp\left(\beta_k x_{ik}\right)} \right)^{y_{ij}}, \tag{3}$$

where x_{ij} is a vector of observable alternative-specific characteristics and β are the parameter estimates associated with the alternative specific characteristics. Because class membership status is unknown, we specify the sample log likelihood using the unconditional likelihood, which equals the weighted average of these products over classes. Following the standard specification of latent class model, the weight for class c, $\pi_{ic}(\theta)$, is the population share of that class and is specified as a multinomial logit model:

TABLE 1 Panelist demographics compared to Portland, OR, population

Item	Units	Panelists (*N* = 121)	2015 Portland Census
People in the household	Number	1.97	2.34
Age	Years	42.97	36.70
Female	%	66.11	50.50
Education (at least 4 years or more)	%	71.90	45.50
Household annual income	$/year	51,797	53,230
Ethnicity (Caucasian)	%	79.34	76.10

Source: U.S. Census Bureau (2015).

TABLE 2 Bids for sliced pears with different concentrations of ripening compound (RC)

	Average Bids ($/57 g Package)			
	Control	1% RC	2% RC	3% RC
Bid	$0.64[a]	$0.67[a]	$0.76[b]	$0.70[ab]
	(0.53)	(0.51)	(0.56)	(0.58)

Notes: Standard deviations are in parentheses. Superscript letters indicate statistically significant differences.

$$\pi_{ic}\ (\theta) = \frac{\exp\left(\theta_c z_i\right)}{1 + \sum_{g=1}^{C-1} \exp\left(\theta_g z_i\right)}, \tag{4}$$

where z_i is a vector of individual-specific characteristics including, indicator variable if bought from conventional grocery store, importance of locally grown, importance of price, number of children, age, and ethnicity Caucasian; and θ_c are class membership model parameters. For the purpose of identification, θ_c has been normalized to zero. The log likelihood function, in this case *LF*, can thus be obtained by summing each individual's log likelihood:

$$\log LF = \sum_{i=1}^{I} \sum_{c=1}^{C} \log\left[P_i\left(\beta_c\right) \pi_{ic}\left(\theta\right)\right]. \tag{5}$$

Data were analyzed using STATA® version 13.1.

5 | RESULTS

Compared to the population of Portland (U.S. Census Bureau, 2015), our panelists were on average older, more female, and more highly educated. Panelists' incomes were slightly lower than the general Portland city population. The majority of panelists were Caucasian (Table 1).

Tables 2 and 3 present participants' average bids and sensory attribute liking ratings for sliced fresh pears treated with different RC concentrations. The average bids for the 2% RC sample were highest, followed by 3% RC, but there were no statistically significant differences between these two concentrations (Table 2). The bids in Table 2 can be compared to prices of a similar product in the market, sliced apples. Note that it cannot be compared to sliced pears because this product does not exist currently in the market. In March 2016, sliced packed apples were sold at Portland downtown grocer stores, for an average of $0.50/2 oz packet, implying that sliced pears would sell at a premium ranging from $0.14 to $0.26/2 oz packet. Meanwhile, the 3% RC sample was ranked the highest as "most preferred" as exhibited highest average rating for overall quality attributes (Table 3) and was followed by 2% RC, 1% RC, and control The 3% RC sample received the highest ratings for external appearance and flesh color, whereas the 2% RC sample had

TABLE 3 Sensory attribute liking ratings for sliced fresh pears treated with different concentrations of a ripening compound (RC)

	Average Liking Rating (1 = *Dislike Extremely*, …, 9 = *Like Extremely*)			
Sensory Attribute	Control	1% RC	2% RC	3% RC
External appearance	6.05[a]	6.17[ab]	6.15[a]	6.45[b]
	(1.73)	(1.87)	(1.74)	(1.78)
Size	6.42[a]	6.80[b]	6.82[b]	6.64[ab]
	(1.82)	(1.65)	(1.58)	(1.80)
Flesh color	6.03[a]	6.12[a]	6.12[a]	6.53[b]
	(1.79)	(1.96)	(1.80)	(1.68)
Aroma	5.39[a]	5.43[a]	5.18[a]	5.33[a]
	(1.95)	(1.95)	(1.96)	(1.93)
Overall flavor and texture	5.12[a]	4.90[a]	5.62[b]	5.57[b]
	(1.98)	(2.24)	(2.11)	(2.01)
Firmness	5.12[a]	5.28[a]	5.72[b]	5.41[ab]
	(1.91)	(2.15)	(2.00)	(1.92)
Juiciness	4.31[a]	4.29[a]	5.45[b]	5.36[b]
	(1.93)	(2.11)	(2.21)	(3.28)
Pear flavor	4.57[a]	4.65[a]	5.31[b]	4.91[a]
	(1.85)	(2.18)	(2.16)	(2.23)
Sweetness	4.59[a]	4.60[a]	5.26[b]	4.83[a]
	(1.98)	(2.11)	(2.25)	(2.14)
Tartness	4.70[a]	4.69[a]	5.12[b]	4.83[a]
	(1.89)	(1.91)	(1.95)	(1.97)
Overall	4.68[a]	4.65[a]	5.31[b]	4.86[a]
	(2.00)	(2.25)	(2.39)	(2.23)

Notes: Standard deviations are in parentheses. Superscript letters indicate statistically significant differences.

the highest ratings for the overall flavor and texture firmness, juiciness, flavor, sweetness, tartness, and overall liking (Table 3).

The questionnaire asked about panelists' pear purchasing habits. Fifteen percent of the panelists consumed fresh pear daily, and 57% of the panelist consumed fresh pears more than once a week. If sliced pears were available in the market, 7% of panelists stated that they would consume them daily, 24% would consume them more than once a week, and 30 % would never consume them. Consuming locally grown fresh pears was "extremely important" to 42% of panelists, and 45% indicated that it was "somewhat important." The overall weighted average of the importance of locally grown (on a scale of 1–5, where 1 indicates *extremely unimportant* and 5 indicates *extremely important*) was 4.24. Sixty-one percent of panelists claimed that they buy organic fresh pears. This result corroborates a recent (Gallup, 2015) study that found that 45% of interviewed consumers actively tried to include organic foods in their diets. Portland, OR, has been identified as the American city that consumes the highest amount of organic food (Bratskeir, 2015).

When asked to rank the importance of different labels associated with fresh pears on a scale of 1–7 (1 = *extremely unimportant* and 7 = *extremely important*), panelists rated healthfulness (pesticide-free) as the most important, followed by food safety claims, regionally/locally produced, sustainable agriculture, non-GMO, organic, eco-label, and a company's private brand label. Fresh pear varieties most consumed by panelists were "Yellow Bartlett," followed by "Bosc," "Green D'Anjou," "Asian," "Red D'Anjou," "Comice," 'Seckel," "Starkrimson," and "Forelle." When asked where they bought pears, 46% of panelists indicated that they bought fresh pears at a natural grocery store (e.g., Whole Foods), followed by 43% who bought fresh pears at farmers' markets, 37% at conventional grocery stores, 18% through direct sales, 12% at food cooperatives, 4% at warehouse retailers, and 9% at other outlets.

5.1 | Empirical model results

Table 4 reports parameter estimates and marginal effects for the factors affecting bids for sliced pears depicted by model in Equation (1). We conducted three regressions: (1) the full model, including all variables: liking ratings for sensory attributes, treatment indicator variables, purchasing habits, and sociodemographic variables; (2) a model that did not include the treatment indicator variables but was otherwise identical to model 1; and (3) a model that did not including the sensory attributes but was otherwise identical to model 1. Results are consistent across the three model specifications. Higher ratings for size, aroma, firmness, juiciness, sweetness, and tartness of the sliced pear samples corresponded with higher bids.

In general, panelists preferred firm, juicy, sweet, and tart pears when making purchasing decisions. This result coincides with previous findings by Jaeger et al. (2003), Kappel et al. (1995), Predieri et al. (2005), Turner et al. (2005), and Manning (2009) on the positive impact of firmness and sweetness on the overall liking of fresh pears and with Combris et al. (2010), Gallardo et al. (2011), Zhang et al. (2010), and Gallardo (2011) that firmness and sweetness positively impact consumers' WTP for fresh pears.

The coefficient for fresh color was negative. The fact that panelists assigned similar ratings to flesh color from the control, 1% RC, and 2% RC samples might explain the negative impact for WTP. For the full model, the one including all fruit quality attributes and indicator variables for treatment, we observed no statistically significant differences across treatments (control, 1%, 2%, and 3%). When not including fruit quality characteristics, the 2% and 3% RC had a positive impact on WTP. The treatment binary variables were not statistically significant in the full model but were statistically significant when omitting the ratings for sensory attributes, implying that treatment-induced eating quality impacted WTP. When focusing on the treatments only, panelists stated a WTP premium of $0.119/2 oz packet for the 2% RC sample, $0.055/2 oz packet for the 3% RC sample, and $0.025/2 oz packet for the 1% RC sample compared to the control sample. Note that bids for the 2% RC sample were statistically significant higher, and that bids for the 3% and 0% RC samples were not statistically significant different from the control sample.

In general, panelists who bought fresh pears at conventional grocery stores and warehouse retailers offered higher bids, whereas panelists who bought fresh pears at food cooperatives offered lower bids. Panelists for whom healthfulness labels were of high importance offered lower bids. Panelists with more people at home were willing to pay higher bids. Interestingly, Caucasian and panelists with higher incomes offered lower bids for the pear samples.

5.2 | Latent class model results

Results from the Akaike Information Criterion, Consistent Akaike Information Criterion, and Bayesian Information Criterion showed that the latent model with two classes optimally distinguishes subgroups in our sample population (Table 5). We observed two groups in the panelists' sample population: those who disliked sliced pears (33% of the sample population) and those who liked sliced pears (67%; Table 6). Individuals in the group that disliked sliced pears tended to prefer pear samples with higher ratings for flesh color, aroma, and juiciness. Interestingly, they also preferred pear samples with lower sweetness and tartness ratings. The coefficient estimates for the treatment dummy variables indicated that this group showed a lower preference for pears with the 1% RC treatment; no statistically significant difference was observed between preferences for the samples with 2% RC and 3% RC treatments compared to the control sample. For the group that liked sliced pears, the coefficients of firmness, sweetness, and tartness were positive and statistically significant, indicating that these participants preferred sliced pears with higher firmness, sweetness,

TABLE 4 Coefficient estimates and marginal effects from a Tobit model to depict the factors affecting bids for sliced pears with different concentrations of ripening compound (RC)

	Coefficients Estimates					
Variable	Full Model	Marginal Effect	Without Treatment Indicator Variables	Marginal Effect	Without Rating for Sensory Variables	Marginal Effect
Size	0.034**	0.031	0.034**	0.031	–	–
	(0.014)	(0.013)	(0.014)	(0.013)		
Flesh color	–0.029**	–0.027	–0.029**	–0.027	–	–
	(0.014)	(0.013)	(0.014)	(0.013)		
Aroma	0.023*	0.022	0.023*	0.021	–	–
	(0.013)	(0.012)	(0.013)	(0.012)		
Firmness	0.061***	0.056	0.061***	0.056	–	–
	(0.014)	(0.013)	(0.014)	(0.013)		
Juiciness	0.019*	0.017	0.020*	0.018	–	–
	(0.011)	(0.010)	(0.010)	(0.010)		
Sweetness	0.027*	0.025	0.028*	0.026	–	–
	(0.015)	(0.014)	(0.015)	(0.014)		
Tartness	0.042***	0.039	0.042***	0.039	–	–
	(0.016)	(0.015)	(0.016)	(0.015)		
1% RC	0.005	0.005	–	–	0.028	0.025
	(0.061)	(0.056)			(0.068)	(0.061)
2% RC	0.033	0.030	–	–	0.133*	0.119
	(0.062)	(0.057)			(0.068)	(0.061)
3% RC	0.021	0.020	–	–	0.061	0.055
	(0.062)	(0.057)			(0.068)	(0.061)
Locally grown	–0.016	–0.015	–0.017	–0.015	–0.019	–0.017
	(0.030)	(0.028)	(0.030)	(0.028)	(0.034)	(0.031)
Conventional store	0.106**	0.098	0.105**	0.097	0.180***	0.162
	(0.050)	(0.046)	(0.050)	(0.046)	(0.054)	(0.049)
Warehouse retailer	0.403***	0.373	0.403***	0.373	0.431***	0.387
	(0.117)	(0.108)	(0.117)	(0.108)	(0.129)	(0.115)
Food cooperative	–0.236***	–0.218	–0.236***	–0.218	–0.237***	–0.212
	(0.070)	(0.065)	(0.070)	(0.065)	(0.077)	(0.069)
Private label	–0.003	–0.003	–0.003	–0.003	0.025	0.022
	(0.016)	(0.014)	(0.016)	(0.014)	(0.017)	(0.015)
Healthfulness label	–0.032**	–0.029	–0.032**	–0.029	–0.054***	–0.049
	(0.012)	(0.012)	(0.012)	(0.012)	(0.014)	(0.012)
Number of people	0.073***	0.067	0.073***	0.067	0.101***	0.090
	(0.028)	(0.026)	(0.028)	(0.0260	(0.031)	(0.028)

(Continues)

TABLE 4 (Continued)

Variable	Coefficients Estimates Full Model	Marginal Effect	Without Treatment Indicator Variables	Marginal Effect	Without Rating for Sensory Variables	Marginal Effect
Age	−0.003	−0.003	−0.003	−0.003	−0.007***	−0.006
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Caucasian	−0.168***	−0.155	−0.168***	−0.155	−0.117*	−0.105
	(0.055)	(0.051)	(0.055)	(0.051)	(0.060)	(0.054)
Income	−0.002**	−0.002	−0.002**	−0.002	−0.002*	−0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.181	–	0.189	–	1.133***	–
	(0.197)		(0.195)		(0.183)	
Number of observations	−>471	–	−>471	–	−>476	–
Pseudo-R^2	0.25	–	0.25	–	0.11	–
Log likelihood	−317.513	–	−317.686	–	−379.174	–

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels. Standard errors are in parentheses.

TABLE 5 Model selection for latent class logit model

Classes	LLF	Number of Parameters	AIC	CAIC	BIC	Posterior Prediction Accuracy
2	−106.79	27	269.23	371.71	344.71	0.93
3	−70.29	44	294.15	461.16	417.16	0.84
4	−54.92	61	309.98	541.52	480.52	0.77
5	−78.48	78	293.79	589.86	511.86	0.78

AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; CAIC, consistent Akaike Information Criterion; LLF, log likelihood function.

and tartness. However, they did not prefer larger sized pears, as the coefficient of size was negative and significant. This group exhibited a preference for the samples treated with 1% RC and 2% RC.

Results from the membership function, used to compare the sociodemographic information and purchasing habits of the two groups of panelists, are presented in Table 7. We tested the significance of the coefficients for demographic variables for the first group compared to those for the second group (controlling for other variables). The group that like sliced pears was used as a reference group and coefficient estimates were normalized to 0 and not included in Table 7. In general, the group that disliked sliced pears showed a lower preference for locally grown and price importance. No other differences were found for this group.

An Analysis of Variance (ANOVA) test was conducted to determine whether sociodemographic characteristics and purchasing habits were significantly different across the two groups. The null hypothesis was that the means of each demographic variable and purchasing habit were the same across groups (Table 8). The group that disliked sliced pears shopped less frequently at conventional retailer grocery stores, had children present in the household, and were slightly older. In general, we concluded that the group that liked sliced pears assigned higher importance to locally grown and price, shopped at conventional retailer grocery stores, had fewer children in the household, and were younger compared to the group that disliked sliced pears.

TABLE 6 Parameter estimates for latent class model to represent preference heterogeneity for sliced pears

Sensory Attribute	Dislike Sliced Pears (33%)	Like Sliced Pears (67%)
Size	2.81***	−0.67***
	(0.41)	(0.26)
Flesh color	1.33**	−0.13
	(0.53)	(0.19)
Aroma	0.69**	−0.14
	(0.33)	(0.15)
Firmness	0.50	0.46**
	(0.56)	(0.19)
Juiciness	1.59***	0.08
	(0.30)	(0.07)
Sweetness	−1.18***	1.16***
	(0.41)	(0.37)
Tartness	−1.56***	0.65***
	(0.47)	(0.23)
Sample 1	−2.84**	1.28*
	(1.32)	(0.77)
Sample 2	−0.04	1.15*
	(1.06)	(0.68)
Sample 3	1.01	0.51
	(1.47)	(0.72)

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels. Robust standard errors are in parentheses.

TABLE 7 Parameter estimates of the membership function to compare the sociodemographic information and purchasing habits of the two groups of panelists, like versus dislike pears

Variable	Dislike Sliced Pears (33%)
Conventional store	−0.51
	(0.66)
Locally grown	−1.11***
	(0.39)
Importance of price	−0.60**
	(0.27)
Number of children	0.06
	(0.69)
Age of panelist	0.01
	(0.02)
Caucasian	0.61
	(0.69)
Constant	5.52***
	(2.20)

Notes: **, and *** indicate statistical significance at the 5%, and 1% levels. Robust standard errors are in parentheses. Group 2 was used as the reference group, hence all coefficient estimates for "Like Sliced Pears" were normalized to 0 and not included in the table.

TABLE 8 ANOVA test results for consumer differences between two groups: like versus dislike sliced pears

	Dislike Sliced Pears (33%)		Like Sliced Pears (67%)		
Variable	Mean	*SD*	Mean	*SD*	ANOVA *p*-Value
Demographic variables					
Number of people	1.95	0.82	1.98	0.96	0.77
Gender	0.68	0.47	0.65	0.48	0.65
Household income ($1,000)	53.44	26.15	50.99	25.96	0.33
College	0.70	0.46	0.73	0.45	0.51
Number of children	0.25	0.58	0.28	0.77	0.62
Age	42.63	12.18	43.15	13.26	0.68
Caucasian	0.88	0.33	0.75	0.43	0.00
Purchase behavior					
Organic	0.63	0.49	0.60	0.49	0.67
Purchase Frequency	2.62	2.36	2.53	2.09	0.67
Eat frequency	4.62	1.08	4.54	1.25	0.50
Importance of price	3.48	0.95	4.04	0.76	0.00
Locally grown	3.80	0.85	4.46	0.63	0.00
Conventional store	0.30	0.46	0.41	0.49	0.02
Natural foods grocery store	0.50	0.50	0.44	0.50	0.25
Warehouse retailer	0.05	0.22	0.04	0.19	0.50
Food co-operative	0.10	0.30	0.14	0.34	0.26
Farmer's market	0.40	0.49	0.44	0.50	0.35
Direct sale	0.18	0.38	0.19	0.39	0.78
Product labels					
Company's private brand	2.23	1.22	2.69	1.59	0.00
Regional or local labels	4.08	1.54	5.30	1.62	0.00
Organic logo	3.88	1.94	4.53	1.80	0.00
Healthfulness label	4.51	2.11	5.43	1.72	0.00
Sustainable agriculture	4.38	1.50	4.81	1.65	0.00
Food safety	4.73	1.65	5.13	1.78	0.02
Non-GMO	4.03	2.06	4.73	2.13	0.00
Eco-label	3.80	1.61	4.57	1.69	0.00
Variety of fresh pears					
Asian	0.43	0.50	0.73	0.45	0.00
Bosc	0.70	0.46	0.74	0.44	0.34
Comice	0.40	0.49	0.33	0.47	0.15
Forelle	0.08	0.26	0.11	0.31	0.21
Green Anjou	0.58	0.50	0.67	0.47	0.05
Green/Yellow Bartlett	0.73	0.45	0.83	0.38	0.01
Red Anjou	0.50	0.50	0.64	0.48	0.00
Seckel	0.08	0.26	0.12	0.33	0.11
Starkrimson	0.08	0.26	0.12	0.33	0.11

6 | CONCLUSIONS

In this study we estimated consumers' preferences and WTP for a novel product, sliced packed fresh pears, treated with three different concentrations (1%, 2%, and 3%) of a RC and an untreated control sample. This research explores the application of a novel technology, the RC, with the ultimate goal of preserving the wholesomeness, appearance, and eating quality and extending the shelf life of fresh pears. One hundred and twenty consumer panelists in Portland, OR, evaluated the appearance and eating quality characteristics of sliced pears under the four treatments. Then they filled out a questionnaire including sensory-related questions. Next, a Vickrey auction was conducted. Our panelists, who were generally representative of Portland consumers, stated higher fresh pear consumption compared to the national average. Of the four treatments, panelists most preferred the 2% RC sample, followed by 3% RC, 1% RC, and the control. The bids submitted for samples with different treatments were consistent with the liking preferences. Results from the econometric model indicated that treatment-induced quality attribute levels were determinant for WTP. In general, higher liking ratings for size, firmness, juiciness, tartness, and sweetness led to higher bids. Results indicate that panelists were willing to pay a price premium equivalent to \$0.119/2 oz packet for the 2% RC sample, \$0.055/2 oz packet for the 3% RC sample, and \$0.025/2 oz packet for the 1% RC sample compared to the control sample. Results from a latent class model indicate the presence of two groups in our panelist sample, one that liked and another that disliked sliced pears. The group that liked sliced pears assigned higher importance to locally grown and price, shopped at conventional retailer grocery stores, had fewer children in the household, and were younger compared to the group that disliked sliced pears.

The use of RC to control the postharvest ripening process in 1-MCP treated fresh pears appears to be a promising way to increase demand for fresh pears. The successful introduction of sliced pears with extended shelf life has the potential to solve the problems of inconsistent quality, fresh pears that are either too firm or too soft, that increase losses during handling. Consumers seem to prefer the appearance and eating quality characteristics of sliced pears treated with the RC compared to the control sample. Additionally, results from this study can help scientists make informed decisions about the ideal concentration of RC that will yield the most desired appearance and eating quality attributes.

In our panelist sample, we did not find that consumers had an overwhelming preference for sliced pears; in fact, 33% of our panelists disliked sliced pears. This could be associated with the characteristics of the Portland population, which is familiar with pears because they are more frequent pear consumers than the average U.S. resident. Consumers in Portland are also known for their strong preferences for organic and environmentally sustainable foods as well as their partiality for superior appearance and eating quality. The fact that this population sample preferred the appearance and eating quality characteristics of treated pears compared to the sample demonstrates that this novel RC holds promise as a novel avenue for increasing pear consumption and contribute to the long-term economic profitability of the North American fresh pear industry.

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