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Consumers' Preferences for Novel and Traditional Pear Cultivars: Evidence from Sensory Evaluation and Willingness-to-pay Elicitation

R. Karina Gallardo
School of Economic Sciences and Puyallup Research and Extension Center, Washington State University, 2606 W. Pioneer Avenue, Puyallup, WA 98371, USA

Xueying Ma
School of Economic Sciences, Washington State University, Hulbert Hall 103K, P.O. Box 646210, Pullman, WA 98164, USA

Ann Colonna
Food Innovation Center, Oregon State University, 1207 NW Naito Pkwy 154, Portland, OR 97209, USA

Maria Laura Montero
School of Food Science, Washington State University, P.O. Box 646376, Pullman, WA 99164, USA; and National Center for Food Science and Technology, University of Costa Rica, WXR2+3GR, San José, Mercedes, 11501-2060, Costa Rica

Carolyn Ross
School of Food Science, Washington State University, P.O. Box 646376, Pullman, WA 99165, USA

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Abstract. **A significant challenge faced by the US Pacific Northwest pear industry is the limited availability of diverse pear cultivars beyond conventional selections. This scant availability of new pear options that align with consumers' consistent quality preferences falls short of their expectations and jeopardizes potential demand growth, which poses a threat to the industry's long-term economic viability. We use a combined approach of sensory evaluation and contingent valuation to uncover preferences and willingness to pay (WTP) for specific pear cultivars, encompassing both novel and traditional types. The outcomes reveal that the key determinants driving WTP are taste and texture attributes. Particularly for early-season pears, a greater liking score for flavor, firmness, and juiciness corresponds to an elevated WTP. For late-season pears, the range of quality attributes expands to encompass overall appearance and sweetness, in addition to the aforementioned factors. Participants who use social media to access information about pears exhibit a heightened WTP. These findings provide valuable insights for the industry to consider revitalizing existing pear orchards through the incorporation of alternatives to conventional pear cultivars.**

The focal point of the pear industry in the United States is the Pacific Northwest (PNW), encompassing the states of Washington and Oregon. As of 2022, 75% of US fresh-pear production was concentrated in the PNW. The total value of this production was estimated at $353 million, as reported by the US Department of Agriculture, National Agricultural Statistics Service (2023). The PNW pear industry is currently dealing with several significant challenges. One of these challenges is the lack of diverse options in pear cultivars beyond the traditional ones. This difficulty is compounded by the struggle to provide high-quality fruit consistently (Dhingra 2013; Prengaman and Courtney 2022). Not offering new pear cultivars that meet consistent quality standards leads to a shortfall in meeting consumer expectations. This, in turn, hinders potential increases in demand and puts the long-term economic sustainability of the industry at risk (Gamble et al. 2006).

The described situation underscores the importance of boosting pear consumption in the United States. This urgency is further highlighted by the lack of growth in per-capita consumption, which has remained stagnant at 1.27 kg/person for the past two decades (2001–21), as reported by the US Department of Agriculture, Economic Research Service (2023). Globally, the United States trails significantly behind China (17,442,000 t) and the European Union (1,888,040 t) in terms of fresh-pear consumption, according to data from Index Mundi (2022). These figures accentuate the critical need to formulate strategies aimed at revitalizing and increasing pear consumption.

In the United States, two types of pear cultivars are commercialized. The most significant volume is represented by the European cultivars (*Pyrus communis*), which include D'Anjou, Bartlett, and Bosc. These three cultivars represent 97% of the volume produced in the PNW (Washington State Tree Fruit Association 2022). Other cultivars grown in the PNW are the Asian cultivars (*Pyrus pyrifolia*), which are less dominant than the European cultivars (Agricultural Marketing Resource Center 2023).

The literature is conclusive that the fruit produced must meet consumers' evolving demands to maintain the industry's economic sustainability (Colonna et al. 2023; Gamble et al. 2006; Jaeger et al. 2003). However, there is scant updated knowledge of how consumers would react toward these new cultivars, especially if these cultivars are less familiar to them and exhibit a different sensory profile from the traditional D'Anjou, Bartlett, and Bosc cultivars.

The objective of this study was to estimate the willingness to pay (WTP) from two samples of consumers: one sample (n = 107) evaluating early-season pears and the other (n = 112) evaluating late-season pears. In both groups, the study included traditional and novel cultivars, with varying levels of sensory attributes. We investigated how the sensory qualities of the pears, along with the sociodemographic profiles and purchasing behaviors of the participants, influence their WTP. This information is valuable for producers who are considering the substitution of their current pear trees with innovative cultivars.

Many of the existing studies that have focused on consumers' sensory evaluation of pears are outdated and centered primarily around traditional pear cultivars (Elkins et al. 2008; Gamble et al. 2006; Kappel et al. 1995; Konopacka et al. 2015; Manning 2009; Turner et al. 2005). In contrast, our study places its focus on a more recent selection of cultivars. In addition, the chosen pear set showcases distinct sensory characteristics by including both winter and summer pears grown in the PNW. To address consumer preferences comprehensively, our study uses a combination of sensory evaluation and WTP assessment using contingent valuation (CV).

The literature agrees that flavor and textural quality are the main drivers for consumers' acceptance and WTP price premiums for fresh pears (Combris et al. 2009; Gallardo et al. 2011; Zhang et al. 2010). In general, flavor in fresh fruit and vegetables is dictated by sensory-perceived traits, including the balance of sweetness and acidity, low/no astringency,

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R.K.G. is the corresponding author. E-mail: karina_gallardo@wsu.edu.

and aroma given by the concentration of odor-active volatile compounds (Kader 2008). Fruit genotypes are responsible for most taste and aroma traits. Hence, different pear cultivars have distinct sensory characteristics that ultimately define the cultivar profile (Kader 2008).

In a seminal study, Kappel et al. (1995) concluded that consumers' ideal pear exhibited a mixture of external qualities such as size, shape, and color; and internal qualities such as firmness, juiciness, and sweetness. When looking at specific flavor-related traits in European pears, the intensity of the pear flavor—related to aromatic components—and the taste traits of sweetness and juiciness are associated with increased consumer liking scores. When looking at textural traits, not juicy, gritty texture, or a too-firm or too-soft pear is often related to low liking scores (Escribano et al. 2016; Gallardo et al. 2011; Gamble et al. 2006; Jaeger et al. 2003; Makkumrai et al. 2014; Manning 2009; Predieri and Gatti 2009; Turner et al. 2005; Zhang et al. 2010).

Studies seeking to identify the cultivars with optimal quality sensory attributes have been conducted in different parts of the world. In the United States, Elkins et al. (2008) conducted consumer sensory evaluations of European pear that were commercially available, along with pear selections from breeding programs. These cultivars included Williams, Sunrise, Abate Fetel, Cinnamon, Concorde, Rosemarie, Taylors Gold, and Blake's Pride. Lack of flavor and gritty texture were crucial factors in discerning why a cultivar was disliked. Importantly, consumers indicated a relatively poor familiarity with cultivars different from Williams and Bosc, influencing their final purchase intent.

Also, in the United States, Turner et al. (2005) evaluated four cultivars compatible with the production environment of the PNW: Concorde, Williams, USDA047, USDA014, Blake's Pride, Madeira, and Taylor's Gold. Consumers preferred the yellow-blush pears over green/ripe and russet cultivars. Regarding taste, 'Concorde' was rated the highest in taste ratings.

Gamble et al. (2006) conducted evaluations among consumers in New Zealand of pear images showcasing varying shapes and external colors. Their findings indicated that individuals who consume pears regularly tend to prefer those with a familiar and recognizable appearance. However, the researchers acknowledged the potential for establishing novel appearance categories to appeal to the perceptions of pear consumers.

Konopacka et al. (2015) evaluated the sensory quality of nine Polish pear cultivars: Alfa, Radana, Hortensia, Dicolor, Concorde, Uta, Xenia, Erika, and Verde. They compared them with 'Clapp's Favorite' and 'Conference', and concluded that potential consumers' liking is related directly to fruit aroma, texture (juiciness and buttery flesh), and taste attributes (sweetness). Predieri et al. (2005) evaluated the acceptance of the Abate Fetel cultivar, showing that consistency in quality attributes, juiciness, sweetness, and aroma correlated positively with higher liking ratings. Manning (2009) conducted a series of consumer sensory taste tests in South Africa and found that appearance and taste were essential factors for consumers' liking of pears. Consumers preferred brighter yellow/green colors with a light-pink or red blush over dark or dull skin colors with low chroma values. Taste, flavor, juiciness, sweetness, and melt character drove internal quality preference.

An increasing body of literature merges sensory evaluation with WTP elicitation, aiming to achieve a more comprehensive understanding of how the sensory attributes of food influence consumers' perceptions and WTP. Such investigations have been applied across a diverse spectrum of food products, including wine (Combris et al. 1997; Mueller et al. 2010), champagne (Lange et al. 2002), dairy products (Grunert et al. 2004; Maynard and Franklin 2003), meat (Hobbs et al. 2006; Lusk et al. 2003; Melton et al. 1996), and fresh fruit (Costanigro et al. 2014; Gallardo et al. 2011; Jaeger et al. 1998; Lund et al. 2006; McCluskey 2013; Seppa et al. 2015; Shi et al. 2015; Zhang and Vickers 2014; Zhang et al. 2010). A common finding of these studies is the positive correlation between likability scores of taste and textural attributes with WTP. More specifically to fresh pears, a greater WTP is associated with higher liking scores for flavor, sweetness, and juiciness. These investigations offer more robust evaluations of preference for food attributes, in comparison with value elicitation studies that omit sensory evaluation (Combris et al. 2009).

Our study extends the groundwork laid by earlier research, which combines sensory evaluation and WTP elicitation, focusing on novel pear selections suitable for the PNW region. Our goal is to gain insights into the influence of both product-related (e.g., sensory attributes) and consumer-related (e.g., sociodemographics, buying behavior) characteristics on the WTP for new pear cultivars.

Materials and Methods

Preparation of the samples. Twelve pear cultivars, six early-season (summer) and six late-season (winter), representing a variety of sensory attributes found in pears, were selected for consumer sensory evaluations. Early-season pears are harvested in early August, whereas late-season pears are harvested in late August and September (Washington State University Tree Fruit 2019). The early-season pear cultivars included Bartlett, Seckel, and proprietary cultivars 417, 642, 573, and 720. Cultivar 417 is an Asian/European cross that is bright red, crisp, and juicy; has a low acidity; and is slightly sweet. Cultivar 642 is a red-blush hybrid Asian pear that tastes like apple, is juicy, and has a crispy texture. Cultivar 573 is of 'Bartlett' heritage that is yellow and green with some blush, has a dense texture, and is sweet. Last, cultivar 720 is also of 'Bartlett' heritage; it is large and yellowish with a red blush (Colonna et al. 2023). The late-season pear cultivars tested were the D'Anjou, Bosc, Comice, Concorde, Gem, and Paragon. A thorough description of the sensory profile of each cultivar is presented in Table 1.

The pears were procured from commercial growers, packinghouses, university research centers, and grocery stores in the PNW. The fruit was ripened in commercial ripening rooms [18 °C for 24 h with ethylene, only if the firmness was > 5.89 kg (13 lb)]. The fruit with firmness between 4.99 and 5.89 kg (11–13 lb) were held at ambient temperatures for 3 to 4 d to condition the fruit to ripen. No synthetic compound (such as 1-methylcyclopropene) was used. Ripening pear cultivars with different sensory quality profiles simultaneously to be at their optimum is challenging. Nonetheless, all pears were at their optimum, with one exception. Pear cultivar 720 was less ripe than the other early-season pears tested. Also noted that the Gem pear cultivar was served not ripened. We followed the recommendation of researchers at the Agricultural Research Service's Appalachian Fruit Research Station in Kearneysville, WV, USA, who described the Gem as having a crisp, juicy texture that can be served immediately after harvest without conditioning (Durham 2015).

One day before the consumer sensory evaluation, most pears were transported from the packing house in Wenatchee, WA, USA, to the Oregon State University (OSU) Food Innovation in Portland, OR, USA. The pears were held in a warm room for the consumer trials to be served at a room temperature of 68 °F. A subsample of pears of each cultivar was left with the OSU Mid-Columbia Agricultural Research and Extension Center for instrumental analysis. The results from the instrumental analyses are presented in Table 2. The details on the devices and measurements of physical and chemical fruit quality are presented in Montero et al. (unpublished).

The sensory taste test took place in October (early season) and December (late season) of 2021. Before serving to the consumers, the pear samples were washed and cut into eight equal slices. Each consumer received the whole pear for the appearance evaluation and two slices of each sampled cultivar for the sensory evaluation. The pear samples were blind-coded with three-digit codes and served on ceramic plates. A glass of spring water and some unsalted crackers were provided for palate cleansing. Three-digit codes are used in place of single letters or numbers so that consumers do not orient their thinking for or against samples based on the order associated with a label such as A, B, C or 1, 2, 3. This method of using three-digit codes is the standard in sensory science. These codes are kept consistent throughout the project and are used to label each pear. The sample serving order is randomized in a Williams Latin square design so that there are no serving order effects, and each of six samples is served an equal number of times in each serving position throughout the experiment.

Compusense® Cloud Software (v21.0.25; Academic Consortium, Compusense Cloud, Compusense Inc., Guelph, ON, Canada) was used to set the sample presentation and to

Table 1. Description of the pear cultivars used in the study.

Cultivar[i]	Description		
	Origin	Appearance	Aroma, flavor, taste, and texture
Early season			
Bartlett	European	Green to yellow when ripe; true pear shape; smooth, firm, and thick skin	Aromatic flesh, melting flesh type, soft and juicy
720	Cross of Bartlett × US56112-146	Larger blocky shape, yellowish green skin with red blush	White flesh, fine texture, grit free, strong pear flavor
Seckel	European	Small size, tear-drop shape, smooth external surface, medium intensity, green, ivory flesh	Sweet, creamy flesh; juicy
573	Bartlett heritage	Midsize yellow-and-green pear with some blush	Sweet and juicy
417	Asian/European hybrid	Small size, squat pear shape with orangish red color	Crisp, juicy, low acidity, slightly sweet flavor
642	Asian/European hybrid	Small size, apple shaped, red skin, yellow flesh	Apple-like in taste, juicy and crisp texture
Late season			
D'Anjou	European	Medium size, short and squat, bright-green and yellow skin, smooth, covered in lenticels	White flesh, dense, buttery, slight gritty texture, juicy with soft texture when ripe, sweet with citrus flavor
Paragon	Cross between a Red Bartlett and Comice	Small size, green to yellow skin when ripe, thin skin	Melting flesh type, buttery, sweet, juicy
Concorde	European heritage	Medium size; large, round base; long, pointed neck; smooth, green-yellow skin; golden-brown russeting; white/ivory dense flesh	Aromatic, very juicy, sweet, floral and vanilla aroma
Comice	European	Small to large size, squat shape, yellow-green skin with large lenticels, red blush on some, tougher skin texture	Fragile, off-white flesh, melting texture, very juicy, highly aromatic, very sweet, earthy flavor
Bosc	European	Medium to large size, oblong, thick tan to brown skin with russeting and mottling	Ivory, dense flesh; firm, crisp; intense honey aroma; juicy, crunchy, and very sweet when ripe
Gem	European heritage	Medium size, light-green skin with red blush, yellow skin when ripe	Moderately fine texture, moderate juiciness, firm and crisp, lightly sweet with mild aroma

[i] Cultivar sources: Bartlett = USA Pears, https://usapears.org/bartlett/; 720 = Hunter et al. (2009); Seckel = USA Pears, https://usapears.org/seckel/; 573 = Colonna et al. (2023); 417 = Colonna et al. (2023); 642 = Colonna et al. (2023); D'Anjou = USA Pears, https://usapears.org/green-anjou/; Paragon = http://www.applegater.org/pdf/2014/v07n03/v07n03p12.pdf; Concorde = USA Pears, https://usapears.org/concorde1/; Comice = https://usapears.org/comice/; Bosc = USA Pears, https://usapears.org/bosc/; Gem = Bell et al. (2014).

ensure that samples were served an equal number of times in each position. Consumers were seated in individual sensory booths with white lighting and were equipped with touchscreen computers. This study was approved by OSU Institutional Review Board No. 2021-1217.

Participant recruitment. Participants were recruited from an online database of 40,000 consumers, of whom 1940 individuals responded. They were 18 years or older and lived in the greater Portland, OR, USA, metro area. Of the 1940 potential participants, 107 were selected to evaluate the six early-season pears in Oct 2021, and 112 different participants evaluated the six late-season pears in Dec 2021. Individuals were offered $40 in cash as an incentive for participating in the study.

Data collection questionnaire. Sensory test participants responded to a questionnaire that included questions that asked them to rate their liking on a 9-point hedonic scale (1 = dislike extremely to 9 = like extremely) for each pear cultivar's overall appearance, aroma, color of the skin, overall liking, pear flavor, sweetness, tartness/acidity, aftertaste, overall texture, firmness, juiciness, and crispness/crunchiness), following Meilgaard et al. (2006). The questionnaire included CV questions to elicit their WTP for each pear cultivar. The prices included in the CV were obtained from grocery stores in downtown Portland, OR, USA, during 14 and 15 Oct 2021. The prices ranged from $2.39 to $2.99/lb. The questionnaire also included open-ended questions to measure the participants' knowledge of how to ripen a pear, and other questions and concerns about pears. Last, the questionnaire also addressed purchasing habits related to fresh fruit, and, pears in particular, and sociodemographic information.

Table 2. Instrumental measures of pears used in consumer trials.

Cultivar	Firmness (kg ± *SD*)[i]	Total soluble solids (°Brix ± *SD*)	Titratable acidity (% malic acid ± *SD*)	Wt (g ± *SD*)
Early-season pears, Oct 2021				
Bartlett	1.14 ± 0.4	12.9 ± 0.1	0.35 ± 0.01	195 ± 14.7
Seckel	2.6 ± 0.8	15.4 ± 0.4	0.26 ± 0.01	125 ± 4.3
417[ii]	3.7 ± 0.4	10.8 ± 0.1	0.15 ± 0.01	128 ± 18.9
642[iii]	4.1 ± 0.6	15.7 ± 0.1	0.19 ± 0.01	173 ± 21.1
573[iv]	4.4 ± 0.4	14.3 ± 0.1	0.40 ± 0.02	200 ± 8.0
720[v]	5.4 ± 2.3	13.6 ± 0.7	0.44 ± 0.00	231 ± 38.7
Late-season pears, Dec 2021				
Comice	0.9 ± 0.2	15.1 ± 0.2	0.26 ± 0.02	234 ± 8.3
Concorde	1.4 ± 0.4	13.7 ± 0.2	0.10 ± 0.01	170 ± 17.9
D'Anjou	1.6 ± 0.5	13.6 ± 0.3	0.24 ± 0.01	234 ± 15.8
Paragon	2.2 ± 0.3	20.5 ± 0.2	0.26 ± 0.00	160 ± 17.7
Gem[vi]	4.6 ± 0.4	14.1 ± 0.3	0.33 ± 0.05	207 ± 10.6
Bosc	7.0 ± 0.4	14.6 ± 0.6	0.19 ± 0.00	192 ± 16.7

[i] *SD* = standard deviation.
[ii] This proprietary pear cultivar is an Asian/European cross that is bright red, crisp, and juicy, with a low acidity and slightly sweet flavor.
[iii] This red-blush hybrid nashi-type pear is apple-like in taste, and is juicy with a crisp texture.
[iv] This 'Bartlett' heritage pear is yellow-green with some blush, a denser texture, and is sweet.
[v] This 'Bartlett' heritage pear is a numbered US selection cross with large fruit and yellowish skin with a red blush. The pear samples from this cultivar were less ripe than the other early-season pears tested.
[vi] These pear samples were not ripened.

Empirical model. The CV is a widely used approach among stated preference techniques for eliciting WTP if prices do not exist (e.g., example for products that are not yet on the market) (Hoyos and Mariel 2010). Our study used the double-bounded choice task that asked two consecutive questions that elicited two consecutive bids (t^1 and t^2), where the second bid was contingent upon the response to the first bid. Specifically, participants are asked to offer an initial bid and then are asked whether they were willing to buy the product at the initial price. If the answer was yes, participants would pay the equivalent of the first bid. Next, a higher price, or a second bid, was presented to participants. If the answer to the first bid was no, participants were unwilling to pay the initial bid amount, and they were then presented with

a price less than the second bid. In the end, participants submit two responses to two successive offerings. The four possible outcomes in a double-bounded model are: no/no, no/yes, yes/no, and yes/yes (Hanemann et al. 1991). This dichotomous format has gained considerable acceptance because it has incentive compatibility—meaning, it induces respondents to reveal their true preferences. Also this method simplifies the cognitive task faced by respondents compared with other preference elicitation methods (Hoyos and Mariel 2010).

In our study we followed the work of Lopez-Feldman (2012) to estimate the double-bounded model parameters using

$$\mathrm{Bid}_i = \sigma_i + \beta z_i + u_i, \qquad [1]$$

where σ_i is a constant term, z_i is a vector of explanatory variables, β is a vector of parameters reflecting the marginal values of each explanatory variable, and u_i is the error term that follows a standard normal distribution, $u_i \sim N(0, \sigma^2)$. Lopez-Feldman (2012) defined y_i^1 and y_i^2 as the dichotomous variables capturing the response to the first and second questions. The four possible responses/outcomes of the double-bounded model are represented by

$$y_i^1 = 1 \text{ and } y_i^2 = 0 : \Pr(y,n) = \begin{cases} \Pr\left(t^1 \le z_i\beta + u_i < t^2\right) \\ \Pr\left(\dfrac{t^1 - z_i\beta}{\sigma} \le \dfrac{u_i}{\sigma} < \dfrac{t^2 - z_i\beta}{\sigma}\right) \\ \Phi\left(\dfrac{t^2 - z_i\beta}{\sigma}\right) - \Phi\left(\dfrac{t^1 - z_i\beta}{\sigma}\right) \end{cases},$$

$$y_i^1 = 1 \text{ and } y_i^2 = 1 : \Pr(y,y) = \begin{cases} \Pr\left(z_i\beta + u_i > t^1; z_i\beta + u_i \ge t^2\right) \\ \Pr\left(\dfrac{u_i}{\sigma} \ge \dfrac{t^2 - z_i\beta}{\sigma}\right) \\ 1 - \Phi\left(\dfrac{t^2 - z_i\beta}{\sigma}\right) \end{cases},$$

$$y_i^1 = 0 \text{ and } y_i^2 = 1 : \Pr(n,y) = \begin{cases} \Pr\left(t^2 \le z_i\beta + u_i < t^1\right) \\ \Pr\left(\dfrac{t^2 - z_i\beta}{\sigma} \le \dfrac{u_i}{\sigma} < \dfrac{t^1 - z_i\beta}{\sigma}\right) \\ \Phi\left(\dfrac{t^1 - z_i\beta}{\sigma}\right) - \Phi\left(\dfrac{t^2 - z_i\beta}{\sigma}\right) \end{cases}$$

and

$$y_i^1 = 0 \text{ and } y_i^2 = 0 : Pr(n,n) = \begin{cases} \Pr\left(z_i\beta + u_i < t^1; z_i\beta + u_i < t^2\right) \\ \Pr\left(\dfrac{z_i\beta + u_i}{\sigma} < \dfrac{t^2}{\sigma}\right) \\ \Phi\left(\dfrac{t^2 - z_i\beta}{\sigma}\right) \end{cases}. \qquad [2]$$

All four models are estimated using maximum likelihood,

$$\sum_{i=1}^{N}\left[d_i^{yn}\ln\left(\Phi\left(z_i\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \Phi\left(z_i\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right) + d_i^{yy}\ln\left(\Phi\left(z_i\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right) + d_i^{ny}\ln\left(\Phi\left(z_i\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) - \Phi\left(z_i\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right)\right) + d_i^{nn}\ln\left(1 - \Phi\left(z_i\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right)\right], \qquad [3]$$

where d_i^{yn}, d_i^{yy}, d_i^{ny}, and d_i^{nn} are indicator variables that equal one or zero depending on the outcome: yes/no, yes/yes, no/yes, and no/no.

We present three regressions based on including different sets of variables in z. The variables included in the models are 1) indicators for each of the pear cultivars evaluated, 2) representative sensory quality characteristics of appearance and tasting factors (i.e., flavor, sweetness, firmness, and juiciness), and 3) participants' demographics and purchasing habits. These variables were selected according to an iterative process of regression analysis. We prioritized those variables that contributed to achieving the models with the best goodness of fit. In addition, our selection of variables followed prior research (Escribano et al. 2016; Gallardo et al. 2011; Gamble et al. 2006; Jaeger et al. 2003; Makkumrai et al. 2014; Manning 2009; Predieri and Gatti 2009; Turner et al. 2005; Zhang et al. 2010). We conducted three versions of the following regression:

$$\begin{aligned} \mathrm{Bid}_{ij} = {} & \alpha_i + \sum_{j=1}^{6}\beta_{1j}\mathrm{Cultivar}_{ij} + \beta_2\mathrm{Overall\_appearance}_i \\ & + \beta_3\mathrm{Flavor}_i + \beta_4\mathrm{Sweetness}_i + \beta_5\mathrm{Firmness}_i \\ & + \beta_6\mathrm{Juiciness}_i + \beta_7\mathrm{Age}_i + \beta_8\mathrm{Female}_i \\ & + \beta_9\mathrm{College}_i + \beta_{10}\mathrm{Family\_size}_i + \beta_{11}\mathrm{Income}_i \\ & + \beta_{12}\mathrm{Healthy}_i + \beta_{13}\mathrm{Consume\_often}_i \\ & + \beta_{14}\mathrm{Use\_social\_media}_i + \beta_{15}\mathrm{Supermarket}_i \\ & + \beta_{16}\mathrm{Direct\ marketing}_i + \sigma_i. \end{aligned} \qquad [4]$$

The parameter estimates (α, β, and σ) were computed using STATASE ver. 13 (StataCorp, College Station, TX, USA) and the doubleb command. To estimate the WTP, we used a linear combination of the parameter estimates for the cultivar (β_1) and the constant (α). The WTP was computed using STATASE ver. 13 (StataCorp) using the nlcom command.

Results and Discussion

Participants' demographic data. A description of the participants' sociodemographics for both sensory evaluations is presented in Table 3. Comparing sociodemographic data, those who participated in the early-season pears sensory taste test exhibited a more significant proportion of individuals older than 35, were female, had at least a 4-year college degree, and self-reported as healthy compared with the late-season pears testing cadre. Conversely, those who participated in the early-season pear testing had a more significant proportion of individuals with a household income equal to at least $60,000/year and household size with more than two members compared with those participating in the late-season pear testing. Compared with the census of Portland, OR, USA, our pooled sample of participants exhibited a more significant proportion of individuals who were older than 35 years, were female, were white, and had at least a 4-year college degree, but had a smaller proportion of individuals from households with an income equivalent to at

Table 3. Participants' sociodemographic characteristics

Characteristic	Early-season pears Participants, n (%) (N = 107)	Late-season pears Participants, n (%) (N = 112)	Pooled sample Participants, n (%) (N = 219)	Portland, OR, census (%)[i]
Age, > 35 years	70 (65)	67 (60)	137 (63)	56.3
Female	74 (69)	61 (54)	135 (62)	50.3
White ethnicity	90 (84)	95 (85)	185 (84)	73.8
≥ 4-Year college degree	74 (69)	72 (64)	146 (67)	54.3
Household income, ≥ $60,000/year[ii]	55 (51)	65 (58)	120 (55)	61.2
Household size, > 2[iii]	23 (21)	26 (23)	49 (22)	—
Households with children, < 18 years[iv]	107 (100)	112 (100)	219 (100)	—
Self-reported healthy	72 (67)	73 (65)	145 (66)	—

[i] US Census Bureau (2023).
[ii] The mean value for income was $55,000/year.
[iii] The mean value for the number of members in the family was two.
[iv] The mean value for the number of children in the family was one.

Table 4. Responses to participants' fresh-pear purchase habits.

Factor	Questionnaire responses, n (%)	
	Early-season pears	Late-season pears
Consume fresh pears often, once a mo. or more frequently	79 (74)	83 (74)
Time usually taken to ripen fresh pears at home		
None	4 (4)	2 (2)
1–2 d	29 (27)	24 (21)
3–4 d	55 (51)	58 (52)
5–6 d	12 (11)	12 (11)
> 7 d	7 (7)	16 (14)
Place where fresh pears are bought		
Supermarket	44 (41)	44 (39)
Discount store	13 (12)	13 (12)
Organic/natural/specialty stores	24 (22)	24 (21)
Farmers' market, pick-your-own farms or farm stand	20 (19)	20 (18)
Importance of fresh-pear quality attributes when purchasing		
Taste and texture: crispness, firmness, juiciness, flavor, aroma, tartness, sweetness, and sugar/acid balance	90 (84)	86 (77)
Shelf life: freshness and ripeness	71 (66)	70 (63)
Appearance: uniform external color, size, free of defects, uniform shape	32 (30)	40 (36)
Phytonutrient content	14 (13)	14 (13)
Use social media to learn about pears	75 (70)	78 (70)

least $60,000/year (US Census Bureau 2023).

Participants' average results from both sensory evaluation tests. Table 4 presents participants' fresh-pear purchasing habits. Seventy-four percent of the participants consumed pears once a month or more frequently. Approximately half of the participants indicated they usually ripened their fresh pears at home for 3 to 4 d, and ≈40% of participants indicated they bought fresh pears at a supermarket. When asked about the importance of the fresh-pear quality attributes at purchase, 80% of participants said the most important attributes were taste and texture quality (i.e., crispness, firmness, juiciness, flavor, aroma, tartness, sweetness, and sugar/acid balance). Sixty-four percent indicated the most important attributes were shelf life related (i.e., freshness and ripeness), 33% indicated the most important attributes were appearance related (i.e., uniform external color and shape, size, and free of defects), and 13% stated nutrient content was the most important attribute. That most Participants' replies indicating the importance of taste and texture quality are consistent with previous studies (Escribano et al. 2016; Gallardo et al. 2011; Gamble et al. 2006; Jaeger et al. 2003; Makkumrai et al. 2014; Manning 2009; Predieri and Gatti 2009; Turner et al. 2005; Zhang et al. 2010). Last, 70% of the participants indicated they used social media to learn about pears. This percentage appears high and could be linked to the participants in our study consuming fresh pears more frequently than the national average. This heightened consumption might have fostered a greater inclination toward seeking information through these channels.

Figure 1 illustrates the average liking ratings attributed to key sensory quality attributes assessed in both early- and late-season pears. These ratings were derived from a one-way analysis of variance and Tukey's honestly significant difference test for multiple comparison of means. The scale used for liking ratings ranged from 1 to 9 points, with 1 point indicating "extremely disliked" and 9 points denoting "extremely liked." It is important to acknowledge that the range of sensory quality attributes under evaluation is more extensive. However, to ensure clarity in presentation, we focused deliberately on including only those sensory quality attributes that were incorporated into the WTP models.

Regarding late-season pears, with respect to overall appearance, there were no notable differences in ratings when compared with

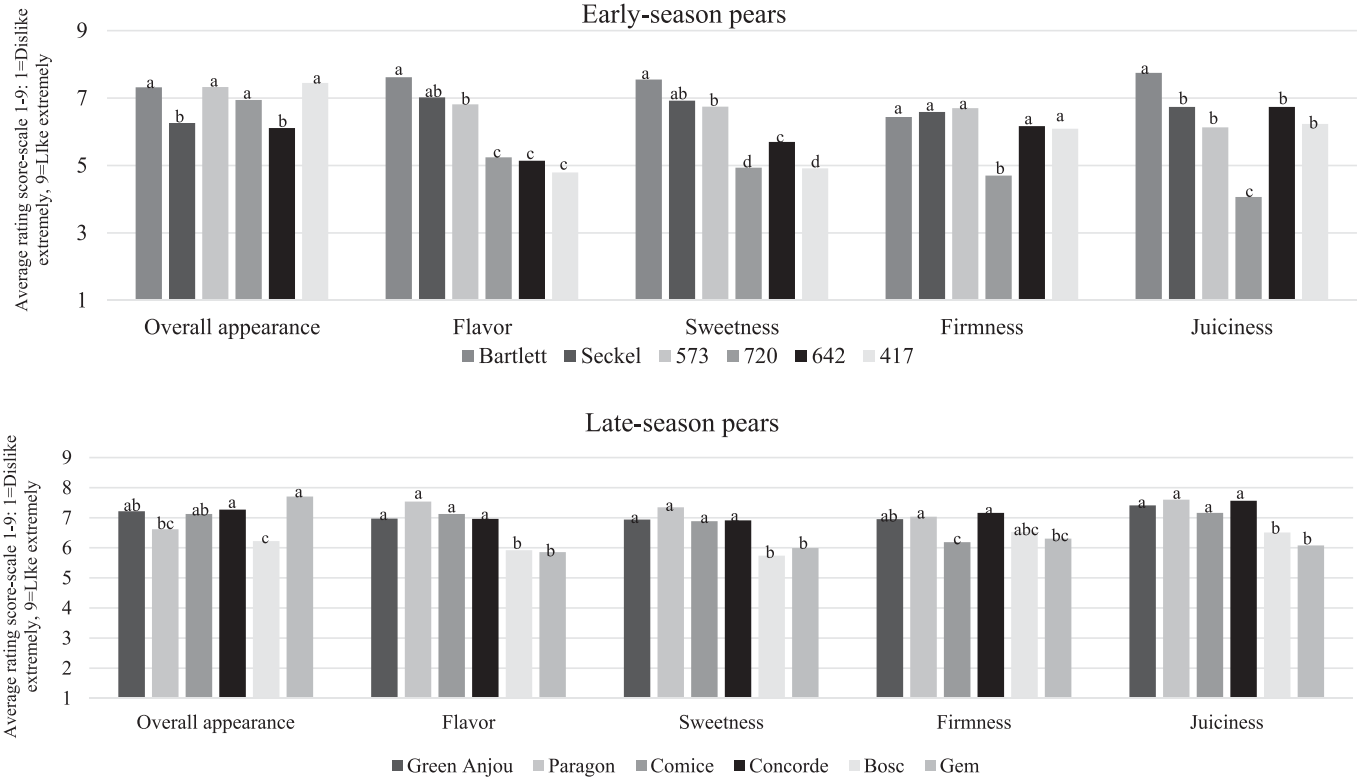

Fig. 1. Average ratings for selected sensory quality attributes for early- (top) and late-season (bottom) pears. Different letters indicate that the mean value was different among the pear cultivars ($P < 0.05$) using Tukey's honestly significant difference test. 417 = a proprietary pear cultivar, an Asian/European cross that is bright-red, crisp, and juicy with a low acidity and slightly sweet flavor; 573 = 'Bartlett' heritage yellow-green pear with some blush, denser texture, and sweetness; 642 = a red-blush hybrid nashi-type pear that is apple-like in taste, juicy, and has a crisp texture; 720 = 'Bartlett' heritage, numbered US selection cross with large fruit and yellowish skin with a red blush.

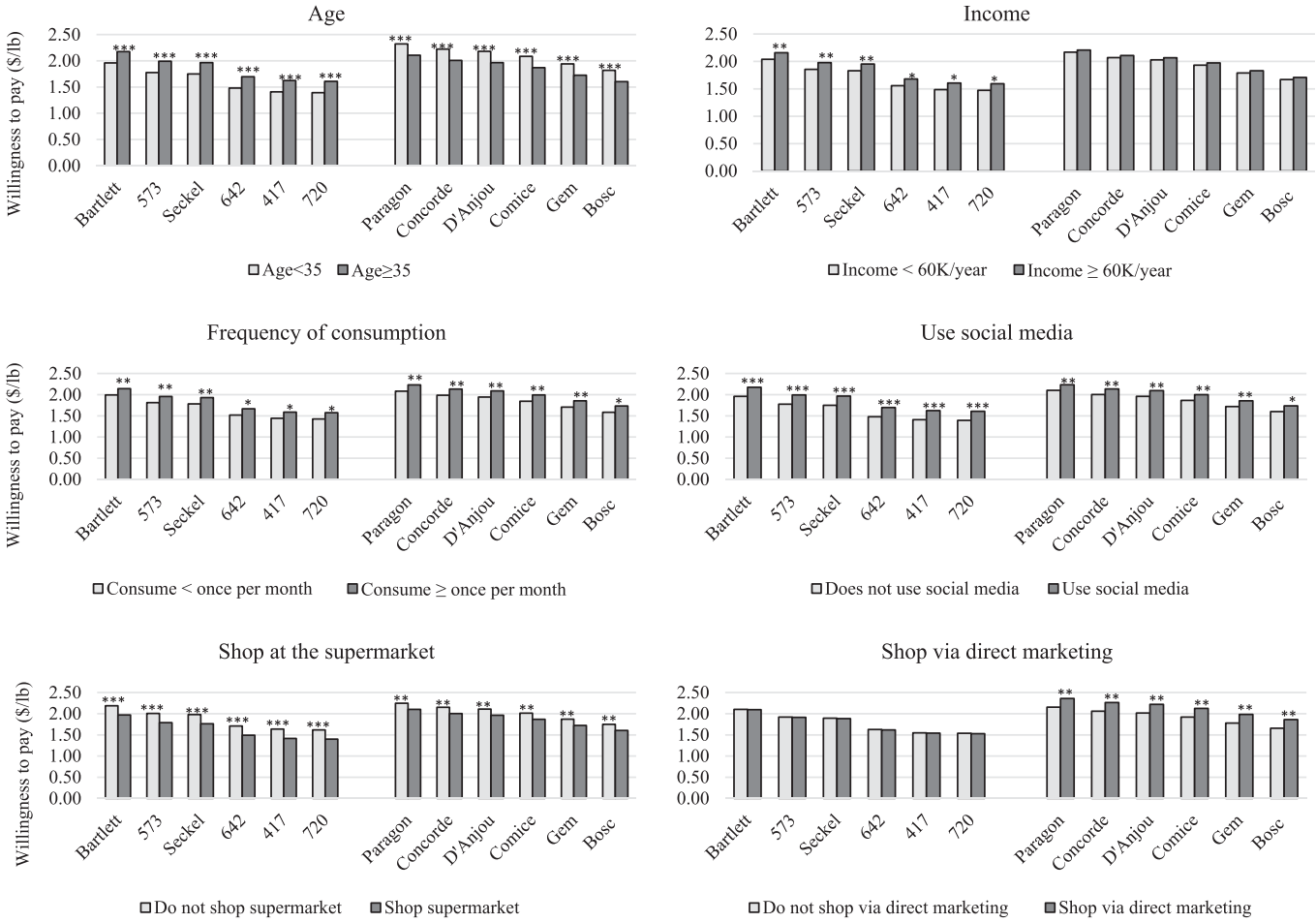

Fig. 2. Willingness to pay for early- and late-season pear cultivars according to participants' sociodemographics [consumer age (top row, left), consumer income (top row, right), frequency of consumption (middle row, left), and uses social media (middle row, right)] and purchase habits [does or does not shop at the supermarket (bottom row, left) and does or does not shop via direct marketing (bottom row, left)]. A pairwise *t* test comparison was performed between each group. NS, *, **, *** nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

'Green Anjou', except for 'Bosc', which was rated significantly lower. In terms of flavor, sweetness, and juiciness ratings, respondents assigned similar scores to 'Green Anjou', 'Paragon', 'Comice', and 'Concorde'. These scores were higher than the scores given to 'Bosc' and 'Gem'. For firmness, respondents rated 'Comice' significantly lower.

For early-season pears, 'Bartlett', 573, 720, and 417 received higher ratings for overall appearance compared with 'Seckel' and 642. In terms of flavor and sweetness, 'Bartlett', 'Seckel', and 573 received higher ratings in comparison with 729, 642, and 417. Conversely, respondents gave a lower rating for liking the firmness and juiciness of 720 compared with the other samples. This disparity might be attributed to the fact that 720 was less ripe than the other samples.

Model findings. Table 5 displays the parameter estimates derived from the double-bounded dichotomous choice model concerning the early-season pear cultivars, whereas Table 6 presents the corresponding outcomes for the late-season pear cultivars. Overall findings indicate that the bids for the different pear cultivars were influenced primarily by participants' preferences for the sensory quality attributes.

Upon inclusion of both indicator variables and the average liking scores in the model (full model) for analysis, only the average liking scores exhibit statistical significance, whereas the indicator variables representing the cultivars do not show significant effects. This significance in the liking scores remains consistent even when the model omits the cultivar indicator variables. Interestingly, the cultivar indicator variables do gain statistical significance in the model that excludes the average liking scores of the sensory quality attributes.

For the early-season pear model, the baseline for comparison was 'Bartlett'. The bid for 'Bartlett' was notably significant and exceeded that of all the other pear cultivars. Following 'Bartlett', the second highest bid was observed for 573, then 'Seckel', 642, and 417. In the complete model, the bid for cultivar 720 (which was less ripe) did not differ from the baseline for comparison (Bartlett). Nonetheless, when the liking scores for sensory quality attributes were omitted from the analysis, the parameter estimates for cultivar 720 became statistically significant, and they were less than the bid for Bartlett (as shown in Table 5). These findings correspond with those of Turner et al. (2005), underscoring the importance of familiarity with the cultivar for consumer acceptance. Within this assortment of pears, the traditional Bartlett cultivar emerged as the most favored option, commanding the highest bids.

In contrast to the findings of Gamble et al. (2006), our study observed that appearance did not exhibit statistical significance in relation to the variation in bids. However, the liking scores for flavor, firmness, and juiciness displayed a direct and statistically significant correlation with the bids, as indicated in Table 5. This suggests that higher average ratings for liking flavor, firmness, and juiciness are associated with higher bid amounts. These results align with the conclusions drawn by Zhang et al. (2010) and Gallardo et al. (2011).

When examining participants' sociodemographics and purchasing behaviors, a consistent pattern emerged across all three regression analyses. Bids tended to be higher when there was a larger proportion of individuals who consumed pears frequently (e.g., once a month or more often) and when a greater proportion of participants used social media to gather information about pears. Conversely, bids were consistently less when a greater proportion

Table 5. Double-bounded dichotomous choice model parameter estimates for early-season pear cultivars.

Variable	Full model		Model without indicator variables for cultivar		Model with indicator variables for cultivar	
	Parameter estimate	*SE*[i]	Parameter estimate	*SE*	Parameter estimate	*SE*
Pear cultivar[ii]						
720[iii]	0.076	0.089	—	—	−0.572***[iv]	0.096
573[v]	−0.006	0.074	—	—	−0.185**	0.089
Seckel	−0.048	0.073	—	—	−0.211**	0.089
417[vi]	−0.101	0.083	—	—	−0.550***	0.096
642[vii]	−0.112	0.080	—	—	−0.478***	0.094
Sensory quality attribute liking ratings						
Overall appearance	0.017	0.015	0.022	0.014	—	—
Flavor	0.108***	0.021	0.120***	0.021	—	—
Sweetness	0.006	0.022	0.008	0.022	—	—
Firmness	0.074***	0.014	0.072***	0.014	—	—
Juiciness	0.072***	0.019	0.056***	0.016	—	—
Participant sociodemographics and purchasing habits						
Age, > 35 years	−0.080	0.049	−0.082*	0.049	−0.073	0.060
Female	−0.053	0.049	−0.046	0.048	−0.064	0.060
≥ 4-Year college degree	0.002	0.050	0.007	0.050	0.137**	0.062
Family members > 2	−0.045	0.055	−0.041	0.055	0.038	0.067
Self-reported healthy	−0.001	0.048	0.001	0.048	0.113*	0.060
Income, ≥ $60,000/year	0.084*	0.046	0.079*	0.046	0.094	0.057
Consume often, ≥ once a mo.	0.114**	0.050	0.116**	0.050	0.181***	0.062
Uses social media	0.173***	0.050	0.173***	0.049	0.196***	0.060
Buys fresh pears at the supermarket	−0.234***	0.055	−0.232***	0.055	−0.228***	0.067
Buys fresh pears via direct marketing	−0.134**	0.058	−0.128**	0.058	−0.101	0.072
Constant	0.037	0.192	−0.012	0.173	1.820***	0.133
Sigma	0.426***	0.025	0.427***	0.025	0.576***	0.035
No. of observations	642		642		642	
Akaike information criterion	1320.312		1316.308		1594.171	

[i] *SE* = standard error.
[ii] The cultivar Bartlett is the omitted variable and the baseline for comparison.
[iii] This 'Bartlett' heritage pear is a numbered US selection cross with large fruit and yellowish skin with a red blush.
[iv] NS, *, **, *** nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.
[v] This 'Bartlett' heritage pear is yellow-green with some blush, a denser texture, and is sweet.
[vi] This proprietary pear cultivar is an Asian/European cross that is bright red, crisp, and juicy, with a low acidity and slightly sweet flavor.
[vii] This red-blush hybrid nashi-type pear is apple-like in taste, and is juicy with a crisp texture.

of individuals purchased fresh pears from supermarkets.

Results for the late-season cultivars are presented in Table 6. Here, 'D'Anjou' served as the baseline for comparison. The bids for 'Paragon' and 'Concorde' were the highest, yet were not statistically significant when compared with the bids for 'D'Anjou'. Similarly, the bids for 'Comice' were less than those for 'D'Anjou', but this difference lacked statistical significance. Conversely, the bids for 'Gem' and 'Bosc' were significantly lower than the bids for 'D'Anjou'.

Interestingly, the bid dynamics for this group of pear cultivars differ somewhat from the early-season counterparts. In contrast to the anticipated preference for the established 'D'Anjou', the relatively new cultivar Paragon garnered the highest bids. In addition, the distinction in bids among the different cultivars is not as pronounced for these late-season options as it was for the early-season ones.

Also different from the early-season cultivars, for the late-season cultivars, all sensory quality attributes included in the model—overall appearance, flavor, sweetness, firmness, and juiciness—were directly proportional and statistically significant to the bids. This implies that the higher the average liking ratings for the sensory quality attributes, the higher the bids. When looking at participants' sociodemographics and purchase habits consistently across the three regressions, the bids were higher when the proportion of participants were older than 35 years, were female, had self-reported as healthy, used social media, and bought fresh pears using direct marketing. These results differ from those of Zhang et al. (2010), where age, gender, ethnicity, and income were not statistically significant for variations in the bids.

Table 7 outlines the WTP values for early- and late-season pear cultivars. These results exhibit consistency with the data presented in Tables 5 and 6. Considering the early-season pears, the WTP for Bartlett—the most traditional cultivar in the set—was higher than the WTP for the other cultivars. There were no discernible differences between the WTP for 573 and 'Seckel', but both were superior to the WTP for 642, 417, and 720. Moreover, there were no significant distinctions across the WTP for 642, 417, and 720. These findings correspond with those of Turner et al. (2005), underscoring the importance of familiarity with the cultivar for consumer acceptance.

Concerning the late-season pear cultivars, the WTP for Paragon exhibited a statistically significant increase compared with the traditional D'Anjou. However, there were no significant differences observed in the WTP between 'Paragon' and 'Concorde', nor was one noted between 'Concorde' and 'D'Anjou'. Notably, the WTP for 'Paragon', 'Concorde', and 'D'Anjou' was higher in comparison with the WTP for 'Comice', 'Gem', and 'Bosc'. These findings somewhat align with the outcomes identified in Turner et al. (2005), as the WTP for the traditional 'D'Anjou' ranked among the top three highest within the selection of pear cultivars.

The results we obtained indicate that the participants in our study (notably recognized for their frequent consumption of pears) exhibited a preference for European pear cultivars and, among them, the well-known D'Anjou and Bartlett. These findings have important implications for growers who are considering changing their current orchards to different pear cultivars. It is advisable for them to consider the insight that pear consumers tend to favor European-cultivar profiles.

Willingness-to-pay estimates by participant sociodemographics and purchasing habits. The WTP was estimated separately (see Fig. 2), considering two age and income groups. Participants 35 years and older were consistently willing to pay more for all the early-season pears than participants younger than 35. Participants 35 years and older were willing to pay less for the late-season pears than participants younger than 35. Participants who made more than

Table 6. Double-bounded dichotomous choice model parameter estimates for late-season pear cultivars.

Variable	Full model		Model without indicator variables for cultivar		Model with indicator variables for cultivar	
	Parameter estimate	*SE*[i]	Parameter estimate	*SE*	Parameter estimate	*SE*
Pear cultivar[ii]						
Paragon	0.055	0.071	—	—	0.138	0.089
Concorde	0.022	0.072	—	—	0.048	0.089
Gem	−0.010	0.074	—	—	−0.235***[iii]	0.090
Comice	−0.056	0.071	—	—	−0.094	0.089
Bosc	−0.133*	0.075	—	—	−0.360***	0.092
Sensory quality attribute liking ratings						
Overall appearance	0.029**	0.014	0.030**	0.014	—	—
Flavor	0.095***	0.023	0.096***	0.023	—	—
Sweetness	0.054**	0.023	0.058**	0.023	—	—
Firmness	0.041**	0.017	0.040**	0.016	—	—
Juiciness	0.053***	0.020	0.057***	0.020	—	—
Participant sociodemographics and purchasing habits						
Age, > 35 years	−0.127***	0.045	−0.123***	0.045	−0.242***	0.056
Female	−0.147***	0.045	−0.146***	0.045	−0.190***	0.055
≥ 4-Year college degree	−0.027	0.050	−0.030	0.051	−0.032	0.062
Family members > 2	0.086*	0.051	0.084	0.051	0.065	0.063
Self-reported healthy	0.113**	0.050	0.111**	0.050	0.213***	0.061
Income, ≥ $60,000/year	0.006	0.046	0.005	0.047	0.004	0.058
Consume often, > once a mo.	0.120**	0.049	0.118**	0.049	0.097	0.060
Uses social media	0.145***	0.047	0.145***	0.047	0.191***	0.058
Buys fresh pears at the supermarket	−0.044	0.047	−0.041	0.047	−0.112*	0.058
Buys fresh pears via direct marketing	0.104*	0.061	0.101*	0.061	0.193**	0.076
Constant	−0.003	0.180	−0.079	0.172	1.971***	0.108
Sigma	0.441***	0.025	0.445***	0.025	0.585***	0.034
No. of observations	672		672		672	
Akaike information criterion	1424.013		1421.817		1699.872	

[i] *SE* = standard error.
[ii] D'Anjou is the omitted variable and the baseline for comparison.
[iii] NS, *, **, *** nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

$60,000/year would pay more for all the early-season pears. However, no statistically significant differences existed between the WTP from either income category for the late-season pears.

Participants who consumed fresh pears once a month or more were willing to pay more for all early- and late-season cultivars than those who consumed pears less often. Consistently, individuals who indicated using social media as a source of information about fresh pears exhibited a greater WTP for both early- and late-season pear cultivars. Users who engaged with food-related content on social media, usually consisting of showcasing of food trends, culinary experiences, gourmet presentations, appealing images, videos, and reviews, might perceive this content as indicators of higher quality and uniqueness (Wiedenroth and Otter 2022). In addition, seeing others enjoying these foods might create a sense of aspiration, leading individuals to be willing to pay more for these similar experiences. This highlights the importance of social media as a platform for disseminating information about pears.

Participants who bought fresh pears at supermarkets were consistently willing to pay

Table 7. Willingness to pay estimates and pairwise comparison for early- and late-season pears.

Pear cultivar	WTP ($/lb)[i]	*SD*[ii]	Pairwise *t* test comparison (*t* value)[iii]					
Early-season pears			Bartlett	573	Seckel	642	417	720
Bartlett	2.10	0.07	—	—	—	—	—	—
573[iv]	1.92	0.07	–2.83**	—	—	—	—	—
Seckel	1.89	0.07	–3.28***	–0.43	—	—	—	—
642[v]	1.62	0.07	–6.54***	–4.19***	–3.81***	—	—	—
417[vi]	1.55	0.08	–7.64***	–5.08***	–4.72***	–0.97	—	—
720[vii]	1.54	0.08	–7.80***	–5.25***	–4.88***	–1.13	–0.15	—
Late-season pears			Paragon	Concorde	D'Anjou	Comice	Gem	Bosc
Paragon	2.19	0.07	—	—	—	—	—	—
Concorde	2.09	0.07	–1.46	—	—	—	—	—
D'Anjou	2.05	0.07	–2.07**	–0.60	—	—	—	—
Comice	1.96	0.07	–3.55***	–2.05**	–1.45	—	—	—
Gem	1.81	0.07	–5.58***	–4.11***	–3.54***	–2.14**	—	—
Bosc	1.69	0.07	–7.14***	–5.71***	–5.16***	–3.83***	–1.72*	—

[i] WTP = willingness to pay. $1/lb = $2.2046/kg.
[ii] *SD* = standard deviation.
[iii] The null hypotheses for the pairwise *t* test is WTP_cultivar column = WTP_cultivar row. NS, *, **, *** nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.
[iv] This 'Bartlett' heritage pear is yellow-green with some blush, a denser texture, and is sweet.
[v] This red-blush hybrid nashi-type pear is apple-like in taste, and is juicy with a crisp texture.
[vi] This proprietary pear cultivar is an Asian/European cross that is bright red, crisp, and juicy, with a low acidity and slightly sweet flavor.
[vii] This 'Bartlett' heritage pear is a numbered US selection cross with large fruit and yellowish skin with a red blush.

lower prices for all early- and late-season pear cultivars compared with those who did not buy at supermarkets. Participants who bought fresh pears via direct marketing stated they would pay more for late-season pear cultivars. In contrast, there were no statistically significant differences between the WTP in these two groups for the early-season cultivars. Supermarkets are able to buy products in bulk, promoting economics of scale. This enables them to offer price discounts routinely (Nicholson and Young 2012). It is possible that consumers associate supermarkets with affordability and anticipate lower prices, which possibly influenced their lower willingness to pay. In sum, our results provide interesting cues of how participants' shopping behavior influences their WTP for the cultivars presented.

Conclusion

Investigating consumers' reactions toward new fresh-fruit cultivars is essential to inferring commercial success, to guarantee the return on investing in these new cultivars. The US pear industry is no different, especially considering the need to increase per-capita consumption to enhance/improve the industry's economic prospects. To increase per-capita consumption, offering consumers pears with optimal sensory characteristics or the cultivars they most like and are willing to pay premiums for is essential. We conducted two sensory quality taste tests and CV to evaluate participants' preferences and elicit the WTP for two sets of early- and late-season pear cultivars.

We found that the sensory quality attributes—especially taste and texture—are the main drivers for the WTP for the pear cultivars we presented. There were differences in the taste and texture attributes most liked for early- and late-season pears. With regard to the early-season pears, the higher the liking score for flavor, firmness, and juiciness, the higher the WTP. With regard to the late-season pears, the entire set of quality attributes plus the overall appearance and sweetness led to a greater WTP. Consistently across the two groups of participants, using social media to obtain information about pears led to a greater WTP.

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