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Market Intermediaries' Ratings of Importance for Rosaceous Fruits' Quality Attributes

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Abstract

We elicited market intermediaries' (i.e., shippers, packers, marketers) preferences for various fruit quality traits in apples, peaches, strawberries, and cherries in terms of ratings of importance, and identify factors significantly influencing these ratings. In general, results indicate that market intermediaries rate fruit quality traits associated with U.S. grade standards and consumer acceptability as most important. Information about preferred quality traits and factors influencing those preferences should increase the efficiency of developing improved fruit cultivars that appeal to the whole supply chain. Improved cultivars should enhance the ability of breeders, growers, and market intermediaries to supply high-quality fruit that better satisfy consumer demand.

Keywords: fruit quality traits, ordered probit model, rosaceous crop

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Introduction

The Rosaceae family includes fruits (apples, apricots, plums, cherries, peaches, pears, raspberries, strawberries), nuts (almonds), and ornamentals (roses). The Rosaceae family contributes to improved human health and well being. However, with the exception of strawberry, domestic consumption of some rosaceous fruits has stagnated or even decreased over the past decade. Between 2000 and 2012, annual per capita consumption of strawberries increased from 4.9 to 7.8 lbs., while peach consumption decreased from 5.3 to 3.9 lbs. and apple consumption slightly decreased from 17.6 to 16.1 lbs. (USDA-ERS 2014).

This overall downward trend challenges the industry's long-term sustainability (Iezzoni et al. 2010). Overcoming these challenges requires efficient development and rapid adoption of new cultivars with improved fruit quality traits. Identifying traits with maximum value to the entire supply chain is a difficult task, as supply chain members have divergent views on the importance of different plant and fruit quality traits. For example, the trait of highest importance to growers could be disease resistance, while packers might be most concerned with avoiding storage disorders, and consumers might prefer the most flavorful fruits. Market-based information concerning the importance of different traits from the various participants along the supply chain is critical in understanding and reconciling these divergent viewpoints.

This research is part of a project called RosBREED: Enabling Marker Assisted Breeding in Rosaceae. The goal of this project is to increase the efficiency of rosaceous breeding programs by applying DNA-based information to improve the probability of delivering successful cultivars. One objective of RosBREED is to study the marginal value and relative importance of targeted plant and fruit quality traits among growers, intermediaries, and consumers.

The study reported on here specifically assesses the ratings of importance that market intermediaries assign to targeted fruit quality traits. Intermediaries—defined in this study to include shippers, packers, marketers, and processors—play an important role in the fruit supply chain. They contact growers to receive, clean, sort, and store fruit; impact buying and selling prices; and establish transactions with wholesalers and retailers (Spulber 1996). Through these activities, they add value to the fruit crops being handled. In 2008, market intermediaries accounted for added 26.1 cents of value for each retail food dollar expenditure, implying that for every dollar consumers paid for food at retail, 26.1 cents was to pay for packing, shipping, and processing (U.S. Department of Agriculture 2013).

The objectives of this study are threefold. First, we assess how market intermediaries rate the relative importance of selected fruit quality traits for apples, peaches, strawberries, and cherries. Second, we estimate firm-related factors influencing these ratings. Third, we compare intermediaries' ratings with preferences of breeders, growers and consumers. The results of this study provide useful information to market intermediaries for planning purposes, to breeders for setting priorities focusing on fruit quality traits of maximum importance to the supply chain, and to growers for making decisions about planting new cultivars. This study is related to the study conducted by Gallardo et al. (2014), in which willingness-to-pay (WTP) values for targeted fruit quality traits were elicited using discrete choice experiments from the same market intermediaries studied here.

Literature Review

While studies have been conducted for some of the Rosaceae crops of interest in this research, very limited research has been done to elicit growers' and market intermediaries' preferences for fruit quality traits. Most preference studies for apple, peach, strawberry, and cherry fruit quality traits have been undertaken from the consumer perspective.

Various studies of apple growers, market intermediaries, and consumers have shown various preferences for quality traits. Yue et al. (2013) found that U.S. fresh apple growers ranked fruit flavor as the most important fruit quality trait, followed by fruit crispness, firmness, shelf life at retail, and fruit juiciness, all relative to the importance of disease resistance. Gallardo et al. (2014) found that U.S. fresh apple market intermediaries were willing to pay price premiums to improve shelf life, external appearance, firmness, flavor, and crispness. Consumer preferences have been studied in considerable detail. Researchers have found that consumers value various apple traits such as crispness, size, color, sweetness, firmness, appearance, origin, and flavor or taste (Manalo 1990, Daillant- Spinnler et al. 1996, Jesionkowska et al. 2006, McCluskey et al. 2007, Dinis et al. 2011, Yue and Tong 2011, McCluskey et al. 2013).

For sweet cherries, Yue et al. (2014a) found that U.S. growers feel that fruit size, followed by flavor, firmness, freedom from pitting, and powdery mildew resistance are more important when compared to viral disease resistance. Gallardo et al. (2014) calculated that fresh sweet cherry market intermediaries were willing to pay a price premium for an increase in soluble solids content (SSC) -a measure for sweetness-, flavor, external color, size, and firmness. Studies of consumer preferences have identified taste, freshness, color, shape/size, sweetness, flavor, firmness, uniformity, glossiness, flavor intensity, acidity, and SSC:acid ratio as important quality traits (Miller et al. 1986, Guyer et al. 1993, Dever et al. 1996, Wermund et al. 2001, Crisosto et al. 2003, Hu 2007). Kappel et al. (1996) estimated that the optimal size for sweet cherries was 29–30 mm diameter, minimum SSC was between 17–19%, and optimum acidity expressed in pH units was 3.8.

U.S. fresh peach growers place a higher importance on traits such as fruit flavor and size when compared to disease resistance, whereas fruit skin color and shape are less important than disease resistance (Yue et al. 2014b). Park and Florkowski (2003) found that U.S. peach growers valued fruit taste, texture, pit characteristics (absence of split pit and pit that does not separate from the fruit), but absence of decay and bruising were the most important fruit traits when deciding cultivar selection. Gallardo et al. (2014) estimated that peach market intermediaries in California were willing to pay a price premium to increase SSC and firmness. Peach market intermediary operations not in California were willing to pay for improved size, firmness, SSC, and external color. Among consumers, various studies have determined that fruit quality traits, including freedom from defects, color, maturity, size, high SSC, acidity, astringency, and sweetness are positively correlated with fresh peach retail prices or consumers' overall acceptance of fruit (Jordan et al. 1987, Parker et al. 1991, Ravaglia et al. 1996, Predieri 2006).

U.S. strawberry growers rated fruit traits such as flavor, firmness, shelf life at retail, external color, and size and plant traits such as open plant canopy, extended harvest seasons higher than root rot resistance (Yue et al. 2014c). Gallardo et al. (2014) estimated that market intermediaries

in the U.S. were willing to pay price premiums to improve fruit flavor, firmness, and size. Among consumers, fruit flavor, sweetness, juiciness, freshness, taste, firmness, fruit color, and fruit size, and complex flavors have been identified as important strawberry traits (Ford et al. 1996, Safley et al. 1999, Keutgen and Pawelzik 2007, Lado et al. 2010, Colquhoun et al. 2012). In general, studies indicate that growers' and market intermediaries' preferences for fruit quality traits are partially aligned with consumers' preferences. Consumers in general prefer fruit with superior flavor (e.g., sweetness and acidity), texture (e.g., flesh firmness and crispness), and appearance (e.g., external color and size). To our knowledge, except for Gallardo et al. (2014), no other studies have investigated market intermediaries' perspectives on the importance of fruit quality traits. Gallardo et al. (2014) estimate intermediaries' willingness-to-pay for a subgroup of fruit quality traits by using a discrete choice experiment. The current study focuses on intermediaries' ratings of importance of a larger set of attributes and does not focus solely on the values of attributes, although most respondents likely consider values of attributes as they rate their importance. This study also adds to the understanding at which market intermediaries share breeders', growers', and consumers' preferences. This study only focuses on fresh market products –economically the most important portion of Rosaceae fruit crops.

While Gallardo et al. (2014) estimates intermediaries' willingness-to-pay for six fruit quality traits by using a discrete choice experiment, this study focuses on intermediaries' ratings of importance (from 1=extremely unimportant to 7=extremely important) assigned to a larger (e.g., fifteen) set of fruit quality traits. The inclusion of a large set of traits in the choice experiment would require a large number of choice scenarios, which could potentially lead to respondents' fatigue and affect the response rate and the reliability of the responses (Carson et al. 1994, Hauser et al. 2004, Savage and Waldman 2008). This is not the case when eliciting ratings of importance, as the Likert scale enables the inclusion of a larger number of traits when respondents only consider one trait at a time. Also, this study illuminates on the differences obtained from two types of questions typically used to elicit preferences: ratings versus choice. When asked to rate importance, respondents do not associate cost with their preferences. This is reflected in the respondents' tendency to assign a high importance to quality traits that perhaps would not be as important when preferences are associated with a cost.

Methodology

The data used in this study were collected through a series of crop specific surveys created in consultation with scientists and industry representatives for each crop to ensure the language used was easy for survey respondents to understand. A total of five versions of the survey were used and each version targeted one fruit and was sent to market intermediaries for that specific fruit. The five market intermediary groups included those for; (1) fresh apple, (2) fresh peach handled by intermediaries located in the state of California, (3) fresh peach handled by intermediaries not located in California, (4) fresh sweet cherries, and (5) fresh strawberries.

The survey sample consists of shippers, packers, brokers, processors, and other market intermediaries for each crop. The sample was built using several information sources, including the Blue Book Online Services (a credit and marketing information agency serving the international wholesale produce industry), Washington State Tree Fruit Association, Cherry Marketing Institute, and Yakima Valley Growers' and Shippers' Association. A mixed mode

method (a combination of mail and internet survey, in which the market intermediary could select which way they wanted to respond to the survey) was used to distribute the survey. The mailing sequence (survey, reminder postcard, survey) took place from April to August 2011. The survey package included a cover letter, applicable letter of support (depending upon the fruit crop, a letter of support from industry representatives was included to encourage response), questionnaire, postage-paid return envelope, and a $4 pre-incentive. Of the total 720 surveys sent, 155 completed surveys were received (109 through the mail and 46 via the internet), representing an overall response rate of 22%. Table 1 lists the initial number of surveys sent, the number of completed responses received by mail and online, total and for each crop included in the study.

Table 1. Marketing intermediaries' survey: Initial sample sent, states represented, and response rate by crop.

Fruit	Initial sample	States represented	Number of responses		
			Mail	Online	Total
Fresh apple	146	WA, NY, CA, MI, PA, NC, VA, OH, OR	27	12	39
Fresh peach in California	132	CA	15	12	27
Fresh peach not in California	161	NJ, PA, OR, SC, GA, CO, WA, FL, IL, MA, MI, NY, TX, AZ, AL	30	6	36
Fresh sweet cherry	97	WA, CA, OR, ID, UT	22	9	31
Fresh strawberry	184	CA, FL, NC, OR, WA	15	7	22
Total	720		109	46	155

The survey requested that the respondent be the owner or manager of the market intermediary operation with final responsibility for making marketing management decisions. Each survey consisted of seven sections. Section one included questions about facility characteristics (e.g., year of establishment, number of employees, sales volume corresponding to a specific function, and fruit crops handled). Section two included questions about the importance of various fruit quality traits to the business. The list of traits was tailored to each fruit crop. To capture market intermediaries' ratings for different traits we used a seven-point Likert scale (1=extremely unimportant, …, 7=extremely important). Section three included questions about the importance of plant traits to the business and the importance of supply chain members when rating fruit quality and plant traits. Section four included questions related to the availability of new fruit cultivars, including rating the importance of supply chain members when deciding to include a new fruit cultivar in the business portfolio. Sections five and six included questions about the operation's relationship with customers and suppliers. Section seven included questions regarding the use of contracts, quality and product standards enforced by the market intermediary operation, volume of total sales in dollars, and the size of the operation.

There were several survey questions that respondents failed to answer. The simplest way to handle would have been to discard incomplete information and just analyze the complete responses. However, this could lead to biased and inefficient estimations (Allison 2002). Therefore, we used multiple imputation to generate a set of plausible estimates for each missing

value. We followed the procedure in Enders (2010). First, when a variable has missing observations *q* times, *q* (for *q* >1) distinct values following a multivariate normal distribution and based on the existing observations are generated for the variable. Then, the *q* complete data sets are analyzed using a regression analysis. The analysis is performed *q* times, once for each filled-in imputed data set thus we get *q* sets of results. Next, the results from the *q* complete data sets are combined to produce a final single set of parameter estimates. The potential pitfall of multiple imputation is that the probability distribution used to generate the missing values is at best only approximately true. However, previous research has demonstrated that the technique outperforms (the alternative of discarding incomplete information) in case of departures from the assumed distribution used in the imputation model (Rubin 1996).

Empirical Specification

Likert scales were used to measure the importance (ratings) that market intermediaries assigned to different fruit quality traits. Likert scales are widely used in marketing research given their simplicity to use and the reliability of the results (Likert 1932, Adams et al. 1965). Reliability of results is typically a function of the number of response categories (Cox 1980, Preston and Colman 2000), the inclusion of a neutral category (Guy and Norvell 1977, Garland 1991), cultural differences across respondents (Flaskerud 1988, Lee et al. 2002), experimental design (Churchill and Peter 1984), and statistical techniques (Clason and Dormody 1994) used to analyze scale-derived data.

An ordered discrete choice regression (*m*) was used separately for each fruit crop, differentiated by geographic location. In each fruit crop regression (*m* = fresh apple, sweet cherry, fresh peach in California, fresh peach not in California, and fresh strawberry), the dependent variable was a set of ordered discrete values using the seven-point Likert scale (1=very unimportant, …, 7=extremely important) from the survey. These numbers have a natural ordering but no cardinal significance. That is, the number for the rating is meaningful in terms of the ordering of the outcomes, but the numeric differences are not meaningful. The dependent variable was a set of stacked ratings for all quality traits relevant to the fruit crop. Data were tabulated such that one fruit quality trait generated seven observations, each observation corresponding to the 7 points in the Likert scale.

To analyze market intermediaries' ratings for each fruit quality trait, we used a multivariate ordinal probit model (Greene and Hensher 2010):

$$
\begin{aligned}
& y_{im}^{*} = \beta_m x_{im} + \varepsilon_{im}, \\
(1)\quad & y_{im} = j_m \text{ if and only if } \mu_{j_m-1} < y_{im}^{*} \leq \mu_{j_m}, \\
& i = 1, \ldots, I, j_m = 1, \ldots, J_m
\end{aligned}
$$

where *i* is an index for observations; *m* is an index for equations in the system (*m*= fresh apple, sweet cherry, fresh peach in California, fresh peach not in California, and fresh strawberry); j_m is an index for categories in equation *m* (j_m = extremely unimportant, very unimportant, unimportant, neutral, important, very important, extremely important); J_m are the total number of categories in equation *m* (J_m=7); y_{im}^{*} is an unobserved ordered-response or latent variable; $y_{im}$is an observed ordered-response variable ($y_{im} = 1, \ldots, 7$); μ_{j_m-1} is the lower bound for discrete

level j_m and $\mu_{j_m}$is the upper bound, $x_{im}$is a vector of independent variables, including fruit quality traits and firm-specific characteristics; $\beta_m$is a vector of the parameters to estimate; and ε_{im} is the random error term, which is assumed to be distributed independent and identical across observations.

In the ordered probit model, the parameter, β'_m, is the marginal change in unobserved latent variable y^*_{im} due to a change in x_{im}, everything else constant. However, the interest usually is in the changes in the observed dependent variables, y_{im}. These changes involve considering probabilities. Specifically the probability that y_{im} equals j_m is given by

$$(2)\quad Prob(y_{im} = j_m|x_{im}) = \Phi\left(\mu_{j_m} - \beta'_m x_{im}\right) - \Phi(\mu_{j_m-1} - \beta'_m x_{im}),$$

where Φ is a univariate standard normal distribution (Cameron and Trivedi, 2005).

The marginal effects are then calculated by:

$$(3)\quad \frac{\partial Prob(y_{im}=j_m|x_{im})}{\partial x_{im}} = [\phi\left(\mu_{j_m-1} - \beta'_m x_{im}\right) - \phi\left(\mu_{j_m} - \beta'_m x_{im}\right)]\beta'_m$$

where $\phi(x) = \frac{\delta\Phi'(x)}{\partial x}$ (Cameron and Trivedi 2005). Equation (3) emphasizes that the effect of a

change in a single x_{im} is impacted by all parameters and data used in the model, and varies by the probability levels *j*.

In this study, the explanatory variables included a set of binary variables for each fruit quality trait. A binary variable was equal to 1 if the fruit quality trait was given the rating corresponding to the rating in the dependent variable and 0 otherwise. To avoid perfect multicollinearity due to inclusion of redundant information, the fruit quality trait variable of phytonutrient content (e.g., vitamins, antioxidants) was omitted across all crops for estimation purposes only. Thus, the variable phytonutrient content serves as the reference for interpretation of the estimated coefficients of the rest of binary variables. Since ratings close to 7 suggest more important traits, a positive and statistically significant coefficient indicates that the fruit quality trait is more important than phytonutrient content. The value of the coefficient indicates the difference in importance for each trait relative to the importance of the phytonutrient content.

In addition, the set of explanatory variables included variables referring to the characteristics of the market intermediary operation. Including all these variables could potentially result in a high level of multicollinearity (due to high correlation of the variables), a subset of market intermediary operations' characteristics was selected for inclusion for each fruit crop. These were identified using linkage criteria based on variable clusters and principal component and factor-analysis-based algorithms (Johnson and Winchern 2007). The market intermediary operation could have multiple functions, such as shipping or handling the fruit as packers. To control for such effects, the variables measuring the percentage of total sales volume sold when the operation acted, as packer and percentage of total sales volume for shipper were included. Since the market intermediary operation could handle more than one fruit, we also included the variables measuring the percentage of total sales volume for each fruit (i.e., apple, peach,

strawberry, and cherry). In addition, binary variables for brokers and repackers were included to control for differences in response when the market intermediary operation did not sell directly to the retailer but to other intermediaries. To investigate whether consumers' opinions mattered to intermediaries, the discrete variable rating for importance (1=very unimportant, …, 7=extremely important) assigned to consumers' preferences was included. Finally, facility size as viewed by the respondent was included. To control for the different data collection methods, i.e., a mail and an online survey, we included a binary variable representing the survey mode and it equals 1 if the survey was conducted online and 0 otherwise. Past research has shown that the mode of administration can have an effect on the data collected. Nonetheless, differences between mail and online survey responses are shown to be minimal as both are self-administered. Both have great cognitive burden, high recall and social desirability bias, low "yes-saying" bias and high unwillingness to disclose sensitive information. Differences stem in that online surveys have lower population coverage for sampling, response rates, and question order effects compared to mail surveys (Bowling 2005).

The specification of equation (1) for each crop is as follows. For fresh apples, the set of independent variables included external appearance, internal appearance, shelf life at retail, crispness, firmness, storage life, external color, flavor, size, juiciness, sweetness, shape, tartness, aroma, firm's year of establishment, percentage of total sales volume handled as shipper, percentage of apples handled by the firm, discrete variable for importance of consumers' preferences, binary variable for firm sells to repackers, firm size, and survey mode. For the sweet cherry equation, the set of independent variables included size, firmness, external appearance, storage life, shelf life at retail, stem attractiveness, flavor, sweetness, tartness, shape, internal color, percentage of fruit handled as packer, percentage of cherries handled by the firm, discrete variable for importance of consumers' preferences, binary variable if firm sells to broker, firm size, and survey mode. For the fresh peach in California and not in California equations, the independent variables included flavor, external appearance, external color, absence of split pit, sweetness, size, storage life, firmness, aroma, shape, internal color, tartness, firm's year of establishment, percentage of fruit handled as shipper, percentage of peaches handled by the firm, discrete variable for importance of consumers' preferences, binary variable for firm sells to repackers, firm size, and survey mode. Finally, for the fresh strawberry equation, the set of independent variables included external appearance, flavor, external color, seediness, absence of cap, seed color, internal color, sweetness, shape, size, firmness, shelf life, juice color, tartness, drip loss, continuous variable for firm's year of establishment, percentage of fruit handled as shipper, percentage of fruit handled as packer, discrete variable for importance of consumers' preferences, binary variable for firm sells to repackers, firm size, and survey mode.

Results

Summary statistics of the characteristics of the facilities surveyed are listed in Table 2. In general, operations handling fresh apples had more years in business compared to the other crops. Operations handling fresh sweet cherries had more permanent and seasonal employees compared to the other crops. Most facilities (72%) handling fresh apples sold the bulk of their fruit regionally and nationally. Most facilities (57%) located in California handling fresh peaches sold nationally, whereas facilities (47%) not in California handling fresh peaches sold regionally. Fifty three percent of the facilities handling sweet cherries, and 48% handling fresh strawberries,

sold nationally. In general, across crops, facilities procured their fruit within 100 miles. Most fresh apple (59%) and strawberry (61%) facilities considered themselves medium sized, fresh peach facilities located in California were both small (39%) and medium sized (39%), fresh peach facilities not in California (63%) and fresh sweet cherries (43%) considered themselves as small sized. The average ratings assigned to each fruit quality attribute are reported in Table 3. For apples, external appearance was the attribute with the highest mean rating, for sweet cherries it was size, for all peaches it was flavor, and for sweet cherries it was external color.

Table 2. Summary statistics of characteristics of market intermediaries' firms for each crop surveyed.

	Fresh apple	**Fresh peach in California**	**Fresh peach not in California**	**Fresh sweet cherry**	**Fresh strawberry**
Average number of years since the facility was established (base year 2015)					
Years	52	33	47	43	27
Average number of employees in 2010					
Permanent	122	50	24	167	19
Seasonal	287	355	182	997	200
Percentage of firms by geographic area where the majority of the fruit was sold in 2010					
Within 100 miles	10%	10%	19%	16%	44%
Regional but not national	36%	4%	47%	9%	4%
National	36%	57%	31%	53%	48%
International	18%	29%	3%	22%	4%
Percentage of firms by geographic area where the majority of the fruit was procured in 2010					
Within 100 miles	72%	61%	66%	69%	65%
Regional but not national	25%	26%	13%	25%	22%
National	0%	7%	16%	6%	13%
International	3%	6%	5%	0%	0%
Percentage of firms that considered their business small, medium, or large sized in 2010					
Small	23%	39%	63%	43%	26%
Medium	59%	39%	35%	27%	61%
Large	18%	22%	6%	29%	13%

The ordered probit parameter estimates and marginal effects for market intermediaries' ratings of importance for selected fruit quality traits by crop are presented in Tables 4–8. Table 9 provides a comparison of the top five quality traits to breeders, growers, intermediaries, and consumers. Information for breeders, growers, and market intermediaries comes from previous studies, which are part of the overall RosBREED project. Information on consumers' preferences was obtained from other studies not related to RosBREED.

Apples

Fresh apple market intermediaries consider fruit external appearance, internal appearance, shelf life at retail, crispness, firmness, storage life, external color, flavor, size, juiciness, sweetness, and shape as more important than phytonutrient content. The marginal effect results for the observed dependent variable indicates that the probability that external appearance was rated 7 or extremely important was 34.1% higher than phytonutrient content. Following external appearance, in importance, the highest rated traits were internal appearance with 34%, shelf life at retail 32.4%, crispness 32%, and firmness 31.4% higher probability of the attribute being rated 7 compared to phytonutrient content (Table 4, see Appendix).

External appearance is a criterion for the U.S. grade standards for apples (U.S. Department of Agriculture 2002), which, in part, impacts apple market prices and potentially affects intermediaries' profitability. Poor internal appearance includes the various types of internal browning disorders that could affect final packouts if detected during storage, or consumer satisfaction and hence repeat purchases if not detected in packing. Improved shelf life at retail will decrease the probability of fruit losses due to spoilage, and could result in an increase in intermediaries' profitability. Market intermediaries rated fruit texture traits such as crispness and firmness followed by flavor higher than phytonutrient content. These eating quality traits are important determinants of consumer acceptance of the fruit. Preserving fruit quality traits during storage and controlling storage length improves market intermediaries' negotiating power with retailers (Tronstad et al. 1992, Carew 2000). Advances in storage technologies (e.g., controlled atmosphere, 1-methylcyclopropene) have made apples of desirable quality available year round (Fan et al. 1999, Watkins et al. 2000). However, the genetic variation among cultivars makes them respond differently to storage technologies (Calderon-Lopez et al. 2005). Similar to external appearance, fruit external color, size, and shape are also criteria for the U.S. grade standards for apples (USDA 2002).

Among the firm characteristics included in the model, the percentage of total sales volume handled as shipper had a negative effect on assigning ratings extremely important to fruit quality traits. Conversely, firms with higher percentages of apples handled gave the highest ratings of importance to fruit quality traits and to consumer preferences. Firm size did not significantly impact the intermediaries' assigning ratings to traits. In relation to the survey mode used, firms responding to the survey online, on average, assigned lower ratings to fruit quality traits compared to firms responding via mail.

Preferences among apple market intermediaries are partially aligned with traits preferred by U.S. apple breeding programs, since crispness and shelf life were rated as extremely important by breeders and had a probability higher than 87% of being selected in new cultivar development (Yue et al. 2012, Gallardo et al. 2012). Results for market intermediaries are comparable to ratings of importance assigned by apple growers, who rated fruit flavor as the most important quality trait, followed by fruit crispness, firmness, shelf life at retail, and juiciness, compared to disease resistance (Yue et al. 2013). Results are also partially aligned with consumers' preferences (Table 9). Existing literature for consumers indicate that improved texture (i.e., crispness, firmness), flavor (i.e., sweetness, tartness) and appearance (i.e., size, external color, external appearance) traits positively impact acceptance of apples (Manalo 1990, Daillant-Spinnler et al. 1996, Jesionkowska et al. 2006, McCluskey et al. 2007, Yue and Tong 2011, McCluskey et al. 2013).

Cherries

Market intermediaries rated sweet cherry fruit size, firmness, external appearance, storage life, shelf life at retail, stem attractiveness, flavor, and sweetness, as higher in importance compared to phytonutrient content. The marginal effect results show that the probability that size was rated 7 was 38.4% higher compared to phytonutrient content. Following size in importance, the highest rated traits were firmness with 32.7%, external appearance 30.5%, storage life 26.6%, and shelf life at retail 25.9% higher probability of the attribute being rated 7 compared to phytonutrient content (Table 5, see Appendix).

Fruit size has become a dominant quality attribute in the sweet cherry industry. Hinman and Hoheisel (2007) observed that larger fruit (more than one inch in diameter) could earn 50 cents or more per pound than smaller fruit at the FOB level. In addition, external appearance, size, and firmness are traits included in the U.S. grade standards for sweet cherries (U.S. Department of Agriculture 2005), which impacts market prices. Improved storage and shelf life at the retail impact intermediaries' profitability in a positive way, through a reduction in product loss. Sweet cherry fruits deteriorate rapidly due to moisture loss, color change, softening, surface pitting, stem browning, and loss of acidity (Serrano et al. 2005) and consequently have a shorter marketing window with lower lengths of storability and shelf life, compared to other crops such as apples. Additionally, operations that place a higher importance on consumers' preferences, sell to brokers, and consider themselves to be a large business tend to give higher ratings of importance to fruit quality traits.

Sweet cherry breeders signaled that fruit firmness and size were the traits that had the highest probability of being included in selections (100% probability) for new cultivar development (Yue et al. 2012, Gallardo et al. 2012). Growers considered fruit size, followed by fruit flavor, fruit firmness, freedom from pitting, and powdery mildew resistance as more important than viral disease resistance in their decisions to grow a specific cultivar (Yue et al. 2014a). Intermediaries and growers rate size higher in importance than sweetness and flavor, but intermediaries indicated that they would pay more for sweetness and flavor compared to size. Improved fruit flavor and sweetness are important eating quality traits for consumer acceptance. Hu (2007) concluded that consumers were willing to pay premium prices for improved sweet cherry sweetness (Table 9, see Appendix).

Peaches

Intermediaries for the fresh peach market in California rated fruit flavor, external appearance, external color, shelf life, sweetness, absence of split pit, size, storage life, firmness, and aroma, as more important than phytonutrient content. The marginal effect results show that the probability that flavor was rated 7 or extremely important, was 23.9% higher compared to phytonutrient content. Following flavor in importance, the highest rated traits were external appearance with 19%, external color 18.4%, shelf life 15.7%, and absence of split pit and sweetness, both with 14.4% higher probability of the attribute being rated 7 compared to phytonutrient content (Table 6, see Appendix).

Intermediaries for peaches not in California rated fruit flavor, size, external appearance, absence of split, external color, sweetness, firmness, shelf life, shape, and storage life, as more important than phytonutrient content. The marginal effects results show that the probability that flavor was rated 7 was 30.1% higher compared to phytonutrient content. Following flavor in importance, the highest rated traits were size with 28.4%, external appearance with 26.9%, absence of split pit 26.6%, and external color 25.6% higher probability of the attribute being rated 7 compared to phytonutrient content (Table 7, see Appendix).

Intermediaries both in and outside California placed a high importance on eating quality traits such as flavor followed by appearance traits (external appearance, external color, and size). The latter are part of the U.S. grade standards for peaches (USDA 2004). Market intermediaries in California who considered consumer preferences important and who sold to repackers tended to provide high ratings of importance, whereas firms who consider themselves as large in size tended to provide lower ratings of importance to traits. Also, fresh peach intermediaries in California who responded to the survey online tended to assign higher ratings of importance to fruit quality attributes compared to firms who responded via mail. Market intermediaries not in California who considered consumer preferences important and who were large in size tended to assign higher ratings of importance. Firms that handled a lower percentage of peaches tended to assign lower ratings to fruit traits.

We observed consistency in comparing these results to U.S. peach breeding programs' targets, as fruit firmness and fruit size were rated as extremely important and highly likely (probability higher than 87%) to be included in breeding programs (Yue et al. 2012, Gallardo et al. 2012). In addition, the results are aligned with Yue et al. (2014b) who found that growers not in California felt that fruit flavor and size were more important compared to disease resistance. Also, results are partially aligned with findings from consumer studies in that freedom from defects, color, maturity, size, high SSC, acidity, astringency, and sweetness were positively correlated with fresh peach retail prices or consumers' overall acceptance of fruit (Jordan et al. 1987, Parker et al. 1991, Ravaglia et al. 1996, Predieri 2006) (Table 9, see Appendix).

Strawberries

Fresh strawberry market intermediaries rated external appearance, flavor, and external color as more important than phytonutrient content. The marginal effect results show that the probability that external appearance was rated 7 or extremely important was 14.3% higher compared to phytonutrient content. Following external appearance in importance, the highest rated traits were flavor with 13.6% and external color with 13.1% higher probability of the attribute being rated 7 compared to phytonutrient content (Table 8, see Appendix). Seediness, absence of cap, and seed color were less important than phytonutrient content. The marginal effect results show that the probability that seediness was rated 7 was 12.6% lower compared to phytonutrient content, and absence of cap was 17.9% and seed color was 17.8% lower probability than phytonutrient content being rated 7.

Consistent with other crops, strawberry intermediaries signal that traits associated with the U.S. grade standards and eating quality are the most important for their operations. External appearance and external color (as well as firmness and size) are traits considered in the U.S.

grade standards for strawberries, which partially determine market prices and thus impact intermediaries' profitability (USDA 2006). Strawberry operations handling fruit as shippers, operations that assigned higher ratings of importance to consumer preferences, and operations that considered themselves large in size tended to assign higher ratings of importance to quality traits presented in the survey. Firms selling to repackers assigned lower ratings to these quality traits. Firms responding to the survey online assigned higher ratings of importance to fruit quality attributes compared to firms who responded via mail.

U.S. strawberry breeders' current breeding targets are consistent with market intermediaries' ratings of importance, as flavor, shelf life, size, and external color were quality traits likely (probability higher than 89%) to be included in the new selections for cultivar commercialization (Yue et al. 2012, Gallardo et al. 2012). Growers rated fruit flavor as the most important trait, followed by fruit firmness, shelf life at retail, open plant canopy, external color, extended harvest season, and fruit size compared to root rot resistance (Yue et al. 2014c) (Table 9, see Appendix). Consumer preference studies for strawberries have cited flavor, sweetness, firmness, and juiciness as the most important quality traits (Ford et al. 1996, Keutgen and Pawelzik 2007, Lado et al. 2010, Colquhoun et al. 2012).

Discussion

For all fruit crops considered in this study, market intermediaries consistently rated fruit quality traits associated with U.S. grade standards (size, external appearance, external color) and eating quality characteristics (flavor, sweetness, crispness, firmness) as highly important. Traits such as shelf life at retail and storage, when applicable, were also rated high in importance. Compared to previous literature, these preferences appear to be aligned with preferences reported for breeding programs, growers, and consumers, using a consistent methodology for all levels of the supply chain. Note that the probability of inclusion for these desirable traits in breeding programs is rather high (> 87%). Recent advancements in breeding techniques such as the use of DNA markers are making this feasible (Iezzoni et al. 2010).

Despite the fundamental differences between the Likert scale ratings of importance used in this study (which does not force survey respondents to make choices across traits) and the choice experiment in Gallardo et al. (2014), one would expect the results of the two studies to be partially aligned. For fresh apples, external appearance was the fruit quality attribute rated most consistently as extremely important, followed by internal appearance and shelf life at retail. The WTP results, however, shows improved shelf life at retail is the apple fruit quality trait with the highest price premium, followed by firmness and flavor. For sweet cherry, fruit size, firmness and external appearance were rated as extremely important, and shelf life at retail, sweetness, and flavor were given the highest price premium (Table 7, See Appendix). Likert scales ratings of importance and choice experiments are different tools with the common goal of eliciting respondents' preferences. The use of a scale enables respondents to express both the direction and strength of their preferences but does not force them to make tradeoffs between traits. All traits can be rated as extremely important. The discrete choice used in the choice experiments forces a trade-off between preferences and cost associated with such preferences. With the ratings results we observe the tendency of clustered ratings of importance skewed to the highest end. For example, the marginal value for the top eight traits for fresh apples ranged from 0.34 to

0.26. This might signal that when cost consideration is not associated with a choice, respondents tend to consider traits as highly important. Despite the discrepancies, both Likert scale ratings of importance and choice experiment provide useful information to breeders and the industry in general.

Conclusion

This study investigated market intermediaries' priority setting for fruit quality traits in fresh apples, peaches, strawberries, and sweet cherries. A mixed mode survey was used to elicit market intermediaries' perceptions of the importance that different fruit quality traits have for their business success. The data were analyzed using a multivariate ordered probit model.

Results from this study can provide useful information for fruit facilities' managers about the relative impact that different fruit quality characteristics can have on their business profitability. In general, market intermediaries handling product for the fresh market placed high ratings of importance on traits recognized in the U.S. grade standards as well as fruit eating quality traits. Examples of these qualities include external appearance for apples, peaches, strawberries, and sweet cherries; fruit size for sweet cherries and strawberries; fruit firmness for apples and cherries; and fruit flavor for apples, peaches, and strawberries. Characteristics such as storage life and shelf life at retail were also important, especially for intermediaries in the apple, peach, and sweet cherry markets. Firms that assigned a higher importance rating to consumer preferences when setting priorities for fruit traits assigned higher ratings of importance to the traits themselves.

Our findings support that fruit market intermediaries underscore the importance of traits in the U.S. grade standards, which are not necessarily aligned with consumer preferences. Consumers place higher importance to eating quality whereas U.S. grade standards are based mostly on appearance attributes. As for the supply chain, this study supports that preferences of fruit market intermediaries are partially consistent with those of fruit breeders, growers, and consumers. Studies like this should serve as a guide to breeding programs to ensure that their resources—including funding, time, and genetic material—are invested in fruit quality traits of importance to the whole supply chain.

In this study we elicited preferences from market intermediaries at one point in time. However, intermediaries' preferences for fruit quality traits might change over time, in consonance with changing consumers' preferences, or with specific production, marketing, or macroeconomic circumstances surrounding each marketing year. Therefore, future research should take into consideration the dynamic effects of potential factors on supply chain preferences for fruit quality traits.

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References

Adams, Ernest W., R.F. Fagot, and R.E. Robinson. 1965. A theory of appropriate statistics. *Psychometrika* 30(2): 99-127.

Allison, Paul D. 2002. Missing data, quantitative applications in the social sciences. Thousand Oaks, CA: Sage.

Bowling, Ann. 2005. Mode of questionnaire administration can have serious effects on data quality. *Journal of Public Health* 27(3): 281-291.

Calderon-Lopez, Beatriz, J.A. Bartsch, C.Y. Lee, and C.B. Watkins. 2005. Cultivar effects on quality of fresh cut apple slices from 1-Methylcyclopropene (1-MCP)-treated apple fruit. *Journal of Food Science* 70 (3): 221–227.

Cameron, A. Colin, and Pravin K. Trivedi. 2005. Microeconometrics: Methods and Applications. Cambridge, UK: Cambridge University.

Carew, Richard. 2000. A hedonic analysis of apple prices and product quality characteristics in British Columbia. *Canadian Journal of Agricultural Economics/Revue Canadienne d'Agroeconomie* 48 (3): 241–257.

Carson, Richard T., J.J. Louviere, D.A. Anderson, P. Arabie, D.S. Bunch, D.A. Hensher, R.M. Johnson, W.F. Kuhfeld, D. Steinberg, J. Swait, H. Timmermans, and J.B. Wiley. 1994. Experimental analysis of choice. *Marketing Letters* 5(4): 351-368.

Churchill, Gilbert A. and J.P. Peter. 1984. Research design effects on the reliability of rating scales: A meta-analysis. *Journal of Marketing Research* 21(4): 360-375.

Clason, Dennis L. and T.J. Dormody. 1994. Analyzing data measured by individual Likert-type items. *Journal of Agricultural Education* 35(4): 31-35.

Colquhoun, Thomas A., L.A. Levin, H.R. Moskowitz, V.M. Whitaker, D.G. Clark, and K.M. Folta. 2012. Framing the perfect strawberry: An exercise in consumer-assisted selection of fruit crops. *Journal of Berry Research* 2: 45–61.

Crisosto, Carlos H., G.M. Crisosto, and P. Metheney. 2003. Consumer acceptance of 'Brooks' and 'Bing' cherries is mainly dependent on fruit SSC and visual skin color. *Postharvest Biology and Technology* 28 (1): 159–167.

Cox, Eli P. 1980. The optimal number of response alternatives for a scale: A review. *Journal of Marketing Research* 17(4): 407-422.

Daillant-Spinnler, Beatrice, H.J.H. MacFie, P.K. Beyts, and D. Hedderley. 1996. Relationships between perceived sensory properties and major preference directions of 12 varieties of apples from the southern hemisphere. *Food Quality and Preference* 7 (2): 113–126.

Dever, Marjorie C., R.A. MacDonald, M.A. Cliff, and W.D. Lane. 1996. Sensory evaluation of sweet cherry cultivars. *HortScience* 31 (1): 150–153.

Dinis, Isabel, O. Simoes, and J. Moreira. 2011. Using sensory experiments to determine consumers' willingness to pay for traditional apple varieties. *Spanish Journal of Agricultural Research* 9 (2): 351–362.

Enders, Craig K. 2010. Applied Missing Data Analysis. New York, NY: Guilford.

Fan, Xuetong, S.M. Blankenship, J.P. Mattheis. 1999. .1-Methylcyclopropene inhibits apple ripening. *Journal of the American Society for Horticultural Science* 124 (6): 690–695.

Ford, Anne, K. Hansen, M. Herrington, J. Moisander, S. Nottingham, S. Prytz, and M. Zorin. 1996. Subjective and objective determination of strawberry quality. *Acta Horticulturae* 439: 319–323.

Gallardo, R. Karina, D. Nguyen, V. McCracken, C. Yue, J. Luby, and J. McFerson. 2012. An investigation of trait prioritization in rosaceous fruit breeding programs. *HortScience* 47(6): 771–776.

Gallardo, R. Karina, H. Li, V. McCracken, C. Yue, J. Luby, and J. McFerson. 2014. Market intermediaries' willingness to pay for apple, peach, cherry, and strawberry quality traits. *Agribusiness: An International Journal* 31(2): 259-280.

Garland, Ron. 1991. The mid-point on a rating scale: Is it desirable? *Marketing Bulletin* 2:66-70.

Greene, William H., and D.A. Hensher. 2010. Modeling ordered choices: A primer. Cambridge, UK: Cambridge University.

Guy, Rebecca F. and M. Norvell. 1977. The neutral point on a Likert scale. *The Journal of Psychology: Interdisciplinary and Applied* 95(2): 199-204.

Guyer, Daniel E., N.K. Sinha, T. Chang, and J.N. Cash. 1993. Physiochemical and sensory characteristics of selected Michigan sweet cherry (*Prunus avium* L.) cultivars. *Journal of Food Quality* 16 (5): 355–370.

Hauser, John R. and Vithala R. Rao. 2004. Conjoint analysis, related modeling, and applications. In Advances in marketing research: Progress and prospects. New York, NY: Springer.

Hinman, H. and G. Hoheisel. 2007. Cost of establishing and producing sweet cherries in central Washington in 2007. Washington State University Extension Bulletin EB2026E.

Hu, Ying. 2007. Sensory influences on consumers' willingness to pay: The apple and cherry markets. Ph.D. diss., Washington State University, Pullman.

Iezzoni, Amy F., C. Weebadde, J. Luby, C. Yue, E. van de Weg, G. Fazio, D. Main, C.P. Peace, N.V. Bassil, and J. McFerson. 2010. RosBREED: Enabling marker-assisted breeding in Rosaceae. *Acta Horticulturae* 859: 389–394.

Jesionkowska, Katarzyna, D. Konopacka, and W. Ploscharski. 2006. The quality of apples – preferences among consumers from Skierniewice, Poland. *Journal of Fruit and Ornamental Plant Research* 14: 173–182.

Johnson, Richard A., and D.W. Wichern. 2007. Applied Multivariate Statistical Analysis. Upper Saddle River, NJ: Pearson Prentice Hall.

Jordan, Jeffrey, L., R.L. Shewfelt, and S.E. Prussia. 1987. The value of peach quality characteristics in the postharvest system. *Acta Horticulturae* 203: 175-182.

Kader, Adel A. 1994. Fruit maturity, ripening, and quality relationships. *Perishables Handling Newsletter* 80 (2).

Kappel, Frank, B. Fisher-Fleming, and E. Hogue. 1996. Fruit characteristics and sensory traits of an ideal sweet cherry. *HortScience* 31 (3): 443–446.

Keutgen, Anna, and E. Pawelzik. 2007. Modifications of taste-relevant compounds in strawberry fruit under NaCl salinity. *Food Chemistry* 105 (4): 1487–1494.

Lado, Joanna, E. Vicente, A. Manzzioini, and G. Ares. 2010. Application of a check-all-that-apply question for the evaluation of strawberry cultivars from a breeding program. *Journal of the Science of Food and Agriculture* 90 (13): 2268–2275.

Lee, Jerry W., P.S. Jones, Y. Mineyama, X.E. Zhang. 2002. Cultural differences in responses to a Likert scale. *Research in Nursing and Health* 25:295-306.

Likert, Rensis. 1932. A technique for the measurement of attitudes. *Archives of Psychology* 22: 5-55.

Manalo, Alberto B. 1990. Assessing the importance of apple traits: An agricultural application of conjoint analysis. *Northeastern Journal of Agricultural and Resource Economics* 19 (2): 118–124.

McCluskey, Jill J., B.P. Horn, C.A. Durham, R.C. Mittelhammer, and Y. Hu. 2013. Valuation of internal quality characteristics across apple cultivars. *Agribusiness* 29 (2): 228–241.

McCluskey, Jill J., R.C. Mittelhammer, A.B. Marin, and K.S. Wright. 2007. Effect of quality characteristics on consumers' willingness to pay for Gala apples. *Canadian Journal of Agricultural Economics/Revue Canadienne d'Agroeconomie* 55 (2): 217–231.

Miller, David C., K.L. Casavant, and J.R. Buteau. 1986. An analysis of Japanese consumer preferences for Pacific Northwest and Japanese sweet cherries. Washington State University Research Bulletin XB0974.

Park, Timothy A. and W.J. Florkowski. 2003. Selection of peach varieties and the role of quality traits. *Journal of Agricultural and Resource Economics* 28 (1): 138–151.

Parker, Douglas D., D. Zilberman, and K.S. Moulton. 1991. How quality relates to price in California fresh peaches. *California Agriculture* 45 (2): 14–16.

Predieri, Stefano, P. Ragazzini, and R. Rondelli. 2006. Sensory evaluation and peach fruit quality. *Acta Horticulturae* 713: 429-434.

Preston, Carolyn C., A.M. Colman. 2000. Optimal number of response categories in rating scales: reliability, validity, discriminating power, and respondent preferences. *Acta Psychologica* 104: 1-15.

Ravaglia, Gianfranco, S. Sansavini, M. Ventura, and D. Tabanelli. 1996. Indici di maturazione e miglioramiento qualitative delle pesche. *Fruitcoltora* 3: 61–66.

Rubin, Donald B. 1996. Multiple imputation after 18+ years. *Journal of the American Statistical Association* 91: 473-489.

Safley, C.D., M.K. Wohlgenant, and R.E. Suter. 1999. Factors affecting consumers' purchases direct market strawberries. North Carolina State University, Department of Agricultural and Resource Economics, ARE Report 22:1-20.

Savage, Scott J. and D.M. Waldman. 2008. Learning and fatigue during choice experiments: A comparison of online and mail survey modes. *Journal of Applied Econometrics* 23: 351-371.

Serrano, Maria, D. Martínez-Romero, S. Castillo, F. Guillén, and D. Valero. 2005. The use of natural antifungal compounds improves the beneficial effect of MAP in sweet cherry storage. *Innovative Food Science and Emerging Technologies* 6 (1): 115-123.

Spulber, Daniel F. 1996. Market microstructure and intermediation. *The Journal of Economic Perspectives* 10 (3): 135–152.

Tronstad, Russell, L. Stephens-Huthoefer, and E. Monke. 1992. Market windows and hedonic price analyses: An application to the apple industry. *Journal of Agricultural and Resource Economics* 17 (2): 314–322.

U.S. Department of Agriculture. Agricultural Marketing Service. Fruit and Vegetables Program. Fresh Products Branch. 2005. Sweet cherries shipping point and market inspection instructions. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC 5098 253 [accessed April 22, 2014].

U.S. Department of Agriculture. Agricultural Marketing Service. Fruit and Vegetables Program. Fresh Products Branch. 2002. United States standards for grades of apples. [http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050339. Accessed April 22, 2014].

U.S. Department of Agriculture. Agricultural Marketing Service. Fruit and Vegetables Program. Fresh Products Branch. 2004. United States standards for grades of peaches. http://www.ams. usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050385 [Accessed April 22, 2014].

U.S. Department of Agriculture. Agricultural Marketing Service. Fruit and Vegetables Program. Fresh Products Branch. 2006. United States standards for grades of strawberries. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050392_[Accessed April 22, 2014].

U.S. Department of Agriculture. Economic Research Service. 2014. Food availability per capita. http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx [Accessed February 4, 2015].

Watkins, Christopher B., J.F. Nock, and B.D. Whitaker. 2000. Responses of early, mid and late season apple cultivars to postharvest application of 1-methylcyclopropene (1-MCP) under air and controlled atmosphere storage conditions. *Postharvest Biology and Technology* 19 (1): 17–32.

Wermund, U., A. Fearne, S.A. Hornibrook. 2005. Consumer purchasing behaviour with respect to cherries in the United Kingdom. *Acta Horticulturae* 667:539-544.

Yue, Chengyan, R.K. Gallardo, J. Luby, A. Rihn, J.R. McFerson, V. McCracken, D. Bedford, S. Brown, K. Evans, C. Weebadde, A. Sebolt, and A.F. Iezzoni. 2013. An investigation of United States apple growers' trait prioritization—Evidence from audience surveys. *HortScience* 48 (11): 1378–1384.

Yue, Chengyan, R.K. Gallardo, J. Luby, A. Rihn, J.R. McFerson, V. McCracken, T. Gradziel, K. Gasic, G. Reighard, J. Clark, and A.F. Iezzoni. 2014b. An evaluation of U.S. peach growers trait prioritization-evidence from audience surveys. *HortScience* 49(10): 1309-1314.

Yue, Chengyan, R.K. Gallardo, J. Luby, A. Rihn, J.R. McFerson, V. McCracken, V.M. Whitaker, C.E. Finn, J.F. Hancock, C. Weebadde, A. Sebolt, and A.F. Iezzoni. 2014c. "An Evaluation of U.S. Strawberry Growers Trait Prioritization: Evidence from Audience Surveys." *HortScience* 49 (2): 188–193.

Yue, Chengyan, R.K. Gallardo, J. Luby, A. Rihn, J.R. McFerson, V. McCracken, N. Oraguzie, C. Weebadde, A. Sebolt, and A.F. Iezzoni. 2014a. An evaluation of U.S. tart and sweet cherry growers trait prioritization-evidence from audience surveys. *HortScience* 49(7): 931-937.

Yue, C., R.K. Gallardo, V.A. McCracken, J. Luby, J.R. McFerson, L. Liu, and A.F. Iezzoni. 2012. Technical and socio-economic challenges to setting and implementing priorities in North American rosaceous fruit breeding programs. *HortScience* 47 (9): 1320–1327.

Yue, C., and C. Tong. 2011. Consumer preferences and willingness to pay for existing and new apple varieties: Evidence from apple tasting choice experiments. *HortTechnology* 21 (3):376–383.

Appendix

Table 3. Average and standard deviation of market intermediaries' ratings of importance for fruit quality traits of apples, peaches, cherries, and strawberries.

	Fresh apple (N=39)	**Sweet cherry (N=33)**	**Fresh peach in California (N=28)**	**Fresh peach not in California (N=38)**	**Fresh strawberry (N=23)**
Absence of cap	--	--	--	--	3.48
	--		--	--	(1.24)
Absence of split pit	--	--	4.89	5.63	--
	--		(2.02)	(1.62)	
Aroma	4.62	--	4.57	4.66	--
	(1.16)		(1.75)	(1.30)	
Crispness	5.82	--	--	--	--
	(1.60)		--	--	
Drip loss	--	--	--	--	--
	--		--	--	
External appearance	5.95	5.71	5.11	5.62	5.39
	(1.32)	(1.64)	(2.13)	(1.64)	(2.13)
External color	5.76	--	5.04	5.59	5.43
	(1.40)		(2.24)	(1.61)	(2.04)
Firmness	5.82	5.76	4.68	5.16	5.22
	(1.59)	(1.77)	(1.89)	(1.72)	(1.93)
Flavor	5.69	5.27	5.26	5.76	5.32
	(1.36)	(1.74)	(2.40)	(1.58)	(2.36)
Internal appearance	5.89	--	--	--	--
	(1.47)		--	--	
Internal color	--	4.31	4.46	4.55	4.61
	--	(1.18)	(1.50)	(1.18)	(1.73)
Juice color	--	--	--	--	--
	--	--	--	--	--
Juiciness	5.28	--	--	--	--
	(1.39)	--	--	--	--
Nutrient	4.77	4.26	4.14	4.37	4.65
	(1.16)	(1.21)	(1.18)	(1.28)	(1.75)
Pit remove	--	--	--	--	--
	--	--	--	--	
Pit shape	--	--	--	--	--
	--	--	--	--	
Seed color	--	--	--	--	3.48
	--	--	--	--	(1.12)
Seediness	--	--	--	--	3.87
	--	--	--	--	(1.18)
Shape	5.21	4.63	4.54	4.97	4.57
	(1.24)	(1.24)	(1.53)	(1.30)	(1.53)
Shelf life at retail	5.85	5.48	5.00	5.05	5.26
	(1.51)	(1.79)	(1.91)	(1.51)	(2.07)
Size	5.66	5.91	4.82	5.70	4.87
	(1.15)	(1.77)	(2.11)	(1.70)	(1.71)

Table 3. *Continued*

	Fresh apple (N=39)	Sweet cherry (N=33)	Fresh peach in California (N=28)	Fresh peach not in California (N=38)	Fresh strawberry (N=23)
Stem attractiveness	--	5.34	--	--	--
	--	(1.52)	--	--	
Storage life	5.77	5.52	4.86	4.89	--
	(1.49)	(1.79)	(1.92)	(1.50)	
Sweetness	5.28	5.16	4.93	5.42	--
	(1.23)	(1.71)	(1.94)	(1.52)	
Tartness	4.95	4.40	4.36	4.35	--
	(1.26)	(1.10)	(1.39)	(1.36)	

Notes. Table shows the mean of the ratings of importance assigned to each fruit quality trait (1=extremely unimportant, …, 7=extremely important). Numbers in parentheses are standard deviation

Table 4. Parameter estimates and marginal effects for fresh apple market intermediaries' ratings of importance for selected fruit quality traits.

Table 4. Parameter estimates and marginal effects for fresh apple market intermediaries' ratings of importance for selected fruit quality traits.

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance						
		1	2	3	4	5	6	7
Intercept	2.731 (3.427)	--	--	--	--	--	--	--
External appearance	1.266*** (0.246)	-0.061	-0.063	-0.006	-0.101	-0.167	0.057	0.341
Internal appearance	1.259*** (0.248)	-0.058	-0.063	-0.006	-0.103	-0.166	0.056	0.340
Shelf life at retail	1.198*** (0.246)	-0.056	-0.060	-0.006	-0.098	-0.158	0.053	0.324
Crispness	1.184*** (0.247)	-0.055	-0.059	-0.006	-0.096	-0.156	0.053	0.320
Firmness	1.163*** (0.246)	-0.054	-0.058	-0.006	-0.095	-0.153	0.052	0.314
Storage life	1.109*** (0.245)	-0.051	-0.056	-0.006	-0.090	-0.146	0.049	0.300
External color	1.053*** (0.244)	-0.049	-0.053	-0.005	-0.086	-0.139	0.047	0.285
Flavor	0.962*** (0.242)	-0.045	-0.048	-0.005	-0.078	-0.126	0.043	0.260
Size	0.864*** (0.241)	-0.040	-0.043	-0.004	-0.070	-0.114	0.038	0.233
Juiciness	0.525** (0.238)	-0.024	-0.026	-0.003	-0.043	-0.069	0.023	0.142

Table 4. *Continued*

Table 4. *Continued*

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance: 1	2	3	4	5	6	7
Sweetness	0.505**	-0.023	-0.025	-0.003	-0.040	-0.067	0.023	0.136
	(0.237)							
Shape	0.427*	-0.020	-0.021	-0.002	-0.035	-0.056	0.019	0.115
	(0.236)							
Tartness	0.183	-0.008	-0.009	-0.001	-0.015	-0.024	0.008	0.049
	(0.235)							
Aroma	-0.138	0.006	0.007	0.001	0.011	0.018	-0.006	-0.037
	(0.234)							
Firm characteristics								
Firm's year of establishment	-0.002	--	--	--	--	--	--	--
	(0.002)							
Percentage of total sales volume handled	-0.003**	--	--	--	--	--	--	--
	(0.001)							
Percentage of apples handled by the firm	0.005**	--	--	--	--	--	--	--
	(0.002)							
Importance of consumers' preferences	0.329***	--	--	--	--	--	--	--
	(0.030)							
Firm sells to re-packer	0.172	--	--	--	--	--	--	--
	(0.139)							
Firm size	-0.003	--	--	--	--	--	--	--
	(0.073)							
Survey mode online	-0.217**	--	--	--	--	--	--	--
	(0.098)							
Log likelihood	-778.876							
Number of observations	581							

Notes. Standard errors are in parentheses. Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 0.10, 0.05, and 0.01 level.

Table 5. Parameter estimates and marginal effects for sweet cherry market intermediaries' ratings of importance for selected fruit quality traits.

Table 5. Parameter estimates and marginal effects for sweet cherry market intermediaries' ratings of importance for selected fruit

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance						
		1	2	3	4	5	6	7
Intercept	-1.386*** (0.386)	--	--	--	--	--	--	--
Size	1.683*** (0.277)	-0.143	-0.093	-0.037	-0.146	-0.117	0.155	0.382
Firmness	1.432*** (0.272)	-0.122	-0.079	-0.032	-0.124	-0.100	0.132	0.325
External appearance	1.341*** (0.274)	-0.114	-0.074	-0.030	-0.116	-0.094	0.123	0.304
Storage life	1.166*** (0.268)	-0.099	-0.064	-0.026	-0.101	-0.081	0.107	0.264
Shelf life at retail	1.133*** (0.267)	-0.096	-0.062	-0.025	-0.098	-0.079	0.104	0.257
Stem attractiveness	0.904*** (0.265)	-0.077	-0.050	-0.020	-0.078	-0.063	0.083	0.205
Flavor	0.889*** (0.264)	-0.076	-0.049	-0.020	-0.077	-0.062	0.082	0.202
Sweetness	0.770** (0.267)	-0.066	-0.042	-0.017	-0.067	-0.054	0.071	0.175
Tartness	0.074 (0.262)	-0.006	-0.004	-0.002	-0.006	-0.005	0.007	0.017
Shape	0.247 (0.258)	-0.021	-0.014	-0.005	-0.021	-0.017	0.023	0.056

Table 5. *Continued*

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Internal color	0.024	-0.002	-0.001	-0.001	-0.002	-0.002	0.002	0.005
	(0.257)							
Percentage of fruit	0.0002	--	--	--	--	--	--	--
	(0.002)							
Percentage of cherries	-0.001	--	--	--	--	--	--	--
	(0.005)							
Importance of	0.316***	--	--	--	--	--	--	--
	(0.046)							
Firm sells to broker	0.397**	--	--	--	--	--	--	--
	(0.134)							
Firm size	0.255***	--	--	--	--	--	--	--
	(0.007)							
Survey mode online	-0.216							
	(0.137)							
Log likelihood	-572.492							
Number of observations	384							

Notes. Standard errors are in parentheses. Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 0.10, 0.05, and 0.01 level.

Table 6. Parameter estimates and marginal effects for California fresh peach market intermediaries' ratings of importance for selected fruit quality traits.

Table 6. Parameter estimates and marginal effects for California fresh peach market intermediaries' ratings of importance for selected fruit quality traits.

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance						
		1	2	3	4	5	6	7
Intercept	-35.361*** (5.020)	--	--	--	--	--	--	--
Flavor	1.374*** (0.299)	-0.166	-0.060	-0.030	-0.070	-0.059	0.144	0.241
External appearance	1.098*** (0.289)	-0.133	-0.048	-0.024	-0.056	-0.047	0.115	0.193
External color	1.071*** (0.293)	-0.130	-0.047	-0.023	-0.054	-0.046	0.112	0.188
Shelf life	0.902** (0.285)	-0.109	-0.040	-0.020	-0.046	-0.039	0.095	0.158
Sweetness	0.830** (0.284)	-0.100	-0.036	-0.018	-0.042	-0.036	0.087	0.146
Absence of split pit	0.829** (0.284)	-0.100	-0.036	-0.018	-0.042	-0.036	0.087	0.145
Size	0.789** (0.285)	-0.096	-0.035	-0.017	-0.040	-0.034	0.083	0.138
Storage life	0.738** (0.283)	-0.089	-0.032	-0.016	-0.037	-0.032	0.078	0.129
Firmness	0.510* (0.284)	-0.062	-0.022	-0.011	-0.026	-0.022	0.054	0.089
Aroma	0.474* (0.279)	-0.057	-0.021	-0.010	-0.024	-0.020	0.050	0.083
Shape	0.343 (0.278)	-0.041	-0.015	-0.007	-0.017	-0.015	0.036	0.060

Table 6. *Continued*

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance						
		1	2	3	4	5	6	7
Internal color	0.285	-0.035	-0.013	-0.006	-0.014	-0.012	0.030	0.050
	(0.277)							
Tartness	0.242	-0.029	-0.011	-0.005	-0.012	-0.010	0.025	0.042
	(0.275)							
Firm's year of establishment	0.018***	--	--	--	--	--	--	--
	(0.003)							
Fruit handled as shipper %	0.004**	--	--	--	--	--	--	--
	(0.002)							
Peaches handled by the firm %	-0.001	--	--	--	--	--	--	--
	(0.003)							
Importance of consumers'	0.328***	--	--	--	--	--	--	--
	(0.035)							
Firm sells to re-packers	0.709***	--	--	--	--	--	--	--
	(0.255)							
Firm size	-0.473***	--	--	--	--	--	--	--
	(0.070)							
Survey mode online	0.291**							
	(0.126)							
Log likelihood	-561.120							
Number of observations	390							

Notes. Standard errors are in parentheses. Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 0.10, 0.05, and 0.01

Table 7. Parameter estimates and marginal effects for non-California fresh peach market intermediaries' ratings of importance for selected fruit quality traits.

Table 7. Parameter estimates and marginal effects for non-California fresh peach market intermediaries' ratings of importance for selected fruit quality traits.

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance						
		1	2	3	4	5	6	7
Intercept	-13.707*** (2.489)	--	--	--	--	--	--	--
Flavor	1.408*** (0.248)	-0.103	-0.049	-0.064	-0.125	-0.109	0.147	0.301
Size	1.329*** (0.249)	-0.097	-0.046	-0.060	-0.118	-0.103	0.139	0.284
External appearance	1.259*** (0.249)	-0.092	-0.043	-0.057	-0.112	-0.097	0.132	0.269
Absence of split pit	1.245*** (0.247)	-0.091	-0.043	-0.056	-0.110	-0.096	0.130	0.266
External color	1.194*** (0.247)	-0.087	-0.041	-0.054	-0.106	-0.092	0.125	0.255
Sweetness	0.999*** (0.243)	-0.073	-0.034	-0.045	-0.089	-0.077	0.104	0.214
Firmness	0.759** (0.242)	-0.055	-0.026	-0.034	-0.067	-0.059	0.079	0.163
Shelf life	0.608** (0.242)	-0.044	-0.021	-0.027	-0.054	-0.047	0.064	0.130
Shape	0.502** (0.239)	-0.037	-0.017	-0.023	-0.045	-0.039	0.052	0.107
Storage life	0.451* (0.240)	-0.033	-0.016	-0.020	-0.040	-0.035	0.047	0.097
Aroma	0.226 (0.237)	-0.016	-0.008	-0.010	-0.020	-0.017	0.024	0.048

Table 7. *Continued*

Table 7. *Continued*

Quality traits and firm characteristics	**Parameter estimate**	**Marginal effects - Probability that trait would be rated the following importance**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Internal color	0.116 (0.237)	-0.008	-0.004	-0.005	-0.010	-0.009	0.012	0.025
Tartness	0.003 (0.238)	-0.0002	-0.0001	-0.0001	-0.0002	-0.0002	0.0003	0.0006
Firm's year of establishment	0.007*** (0.001)	--	--	--	--	--	--	--
Percentage of fruit handled as shipper	0.003* (0.001)	--	--	--	--	--	--	--
Percentage of peaches handled by the firm	-0.003** (0.001)	--	--	--	--	--	--	--
Importance of consumers' preferences	0.260*** (0.031)	--	--	--	--	--	--	--
Firm sells to re-packers	0.113 (0.191)	--	--	--	--	--	--	--
Firm size	0.226** (0.074)	--	--	--	--	--	--	--
Survey mode online	-0.108 (0.147)							
Log likelihood	-775.784							
Number of observations	527							

Notes. Standard errors are in parentheses. Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 0.10, 0.05, and 0.01 level.

Table 8. Parameter estimates and marginal effects[1] for strawberry market intermediaries' ratings of importance for selected fruit quality traits.

Table 8. Parameter estimates and marginal effects[1] for strawberry market intermediaries' ratings of importance for selected fruit quality traits.

Quality traits and firm characteristics	**Parameter estimate**	**Marginal effects - Probability that trait would be rated the following importance**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Intercept	-15.861 (11.343)[2]							
External appearance	0.731**[3c] (0.320)	-0.065	-0.050	-0.029	-0.051	-0.014	0.065	0.145
Flavor	0.683** (0.326)	-0.061	-0.047	-0.027	-0.048	-0.013	0.061	0.136
External color	0.668** (0.318)	-0.059	-0.046	-0.027	-0.047	-0.013	0.059	0.133
Shelf life	0.516 (0.315)	-0.046	-0.036	-0.021	-0.036	-0.010	0.046	0.102
Firmness	0.512 (0.314)	-0.045	-0.035	-0.021	-0.036	-0.010	0.045	0.102
Size	0.085 (0.310)	-0.008	-0.006	-0.003	-0.006	-0.002	0.008	0.017
Internal color	-0.060 (0.306)	0.005	0.004	0.002	0.004	0.001	-0.005	-0.012
Shape	-0.110 (0.305)	0.010	0.008	0.004	0.008	0.002	-0.010	-0.022
Seediness	-0.624** (0.305)	0.055	0.043	0.025	0.044	0.012	-0.055	-0.124
Seed color	-0.889** (0.307)	0.079	0.061	0.036	0.063	0.017	-0.079	-0.177
Absence of cap	-0.893** (0.307)	0.079	0.062	0.036	0.063	0.017	-0.079	-0.177

Table 8. *Continued*

Quality traits and firm characteristics	Parameter estimate	Marginal effects - Probability that trait would be rated the following importance						
		1	2	3	4	5	6	7
Firm's year of establishment	0.008 (0.006)	--	--	--	--	--	--	--
Fruit handled as shipper %	0.005** (0.002)	--	--	--	--	--	--	--
Fruit handled as re-packer %	0.007 (0.007)	--	--	--	--	--	--	--
Importance of consumers'	0.151*** (0.050)	--	--	--	--	--	--	--
Firm sells to re-packers	-1.400*** (0.324)	--	--	--	--	--	--	--
Firm size	0.372** (0.123)	--	--	--	--	--	--	--
Survey mode online	0.746*** (0.154)							
Log likelihood	-424.934							
Number of observations	275							

Notes. Standard errors are in parentheses. Single, double, and triple asterisks (*, **, ***) denote statistical significance at the 0.10, 0.05, and 0.01 level.

Table 9. Top fruit quality traits across breeders, growers, market intermediaries and consumers

Table 9. Top fruit quality traits across breeders, growers, market intermediaries and consumers

Crop	**Breeders**	**Growers**	**Market intermediaries**		**Consumers**
	Online survey *Rating of importance + likelihood of including in program*	*Audience survey* *Ranking of importance*	*Mail-in and online survey* *Rating of importance*	*Mail-in survey* *Choice experiment*	*Various methodologies*
Fresh apple	Crispness Juiciness Storage life Shelf life Acid-sugar balance	Flavor Crispness Firmness Shelf life Juiciness	External appearance Internal appearance Shelf life Crispness Firmness	Shelf life Firmness Flavor Crispness Size	Crispness Size External color Texture Juiciness Sweetness Firmness Aroma External Appearance Tartness Flavor
Sweet cherry	Firmness Size Res. pow. mildew Ext. harvest season Self fertility	Size Flavor Firmness No pitting Res. pow. mildew	Size Firmness External appearance Storage life Shelf life	Shelf life Sweetness Flavor External color Size	Taste Freshness Color Shape/size Sweetness Flavor Firmness Uniformity Acidity
Fresh peach in California	Firmness[1] Fruit uniformity Fruit shape Size Prod. consistency	--	Flavor External appearance External color Shelf life Absence of split pit	Sweetness Firmness External color Appearance Size	Freedom from defects[1] Color Maturity Size Sweetness Acidity Astringency
Fresh peach not in California	Firmness[1] Fruit uniformity Fruit shape Size Prod. consistency	Flavor Size Disease resistance Productivity Prod. consistency	Flavor Size External appearance Absence of split pit External color	Size Firmness Sweetness External color External appearance	Freedom from defects[1] Color Maturity Size Sweetness Acidity Astringency
Fresh strawberry	Flavor Productivity Shelf-life Size External color	Flavor Firmness Shelf-life Open plant canopy External color	External appearance Flavor External color Shelf life Firmness	Flavor Firmness Size External color Shelf life	Flavor Sweetness Juiciness Freshness Taste Firmness Fruit color Size

[1] There was no separation from fresh peach breeding programs in California versus breeding programs not in California. Also no separation from consumers' perception of peaches fromCalifornia and not in California.

