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An Evaluation of U.S. Strawberry Producers Trait Prioritization: Evidence from Audience Surveys

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***Abstract*. The primary goal of this research was to evaluate the relative importance of strawberry fruit quality and plant traits to strawberry producers. Previous studies focus on strawberry traits that impact postharvest quality and marketable yield; however, studies emphasizing the importance of these traits to strawberry producers are scarce. To investigate U.S. strawberry producer trait preferences, a series of audience surveys were conducted at four strawberry producer meetings across the United States. Results indicate that fruit firmness, fruit flavor, and fruit shelf life at retail were the most important fruit/plant traits to producers for a successful strawberry cultivar to possess. Growing state and producers' years involved in the decision-making process of strawberry farms impacted the relative importance of the fruit/plant traits. This study directly contributes to a larger investigation of supply chain members' trait preferences to improve the efficiency of Rosaceae fruit crop breeding programs and to increase the likelihood of new cultivar adoption. The overall project should result in a more efficient approach to new strawberry cultivar development and commercialization.**

Strawberry (*Fragaria ananassa* Duch. Ex Rozier) is an important fruit crop to the U.S. economy. From 2000 to 2010, U.S. strawberry production averaged 1.1 million metric tons on 20,904 ha and was worth $1.5 billion annually. Eighty-one percent of the strawberries were used fresh, whereas 19% were processed (U.S. Department of Agriculture, National Agricultural Statistics Service, 2013). From 2000 to 2010, the top production states were California (1 million t), Florida (95,000 t), Oregon (14,000 t), North Carolina (10,000 t), Washington (7,000 t), and Michigan (4,800 t) (U.S. Department of Agriculture, National Agricultural Statistics Service, 2013). Over the last 10 years, the production and value of strawberries have steadily increased. In 2002, the U.S. strawberry production was at 1.0 million t valued at $1.2 billion, whereas in 2012, production was at 1.5 million t valued at $2.4 billion (U.S. Department of Agriculture, National Agricultural Statistics Service, 2013). New cultivar development and commercialization are essential to promote the industry's long-term economic sustainability. In fact, since 2006, 74 new strawberry plant cultivars have been released in the United States (U.S. Department of Commerce, Patent and Trademark Office, 2013).

This research is a portion of a larger U.S. Department of Agriculture-funded project called "RosBREED: Enabling marker-assisted breeding in Rosaceae." The overall goal of RosBREED is to facilitate the use of DNA marker-assisted breeding in Rosaceae fruit crops to improve the efficiency of plant breeding programs. There has been an increase in the successful use of this technology for crop improvement programs in the recent past (e.g., for improving product quality, management practice efficiency, and product uniformity) (Iezzoni et al., 2010). However, the application of the technology requires extensive training, knowledge, and resources. Hence, it is critical to focus on the genetic traits of maximum value (Alpuerto et al., 2009; Luby and Shaw, 2001). Determining trait valuation is difficult, and only a few horticultural studies have evaluated trait priorities of the entire supply chain starting from breeders and ending with consumers (Zimmerman and Van der Lans, 2009). The goal of this study was to assess strawberry producers' preferences for strawberry fruit and plant quality traits. Investigations of the trait priorities of other supply chain groups are ongoing.

Published research explaining how strawberry producers select cultivars and determine the value of traits is scarce. Most research on the importance of strawberry traits to producers focuses on characteristics that improve postharvest quality and yield. For instance, Jamieson et al. (2000) found that fruit firmness and skin toughness improved postharvest quality by reducing bruising. Additional characteristics that impacted postharvest quality are achene color, berry size, surface gloss, and surface color (Jamieson et al., 2000). Differences in fruit chemical composition by cultivar have also been explored (Kafkas et al., 2007). Masny et al. (2005) investigated strawberry genotypes by examining the marketable yield, fruit weight, susceptibility to gray mold [*Botrytis cinerea* (De Bary) Whetzel], fruit color, and fruit firmness of the different genotypes. Gawronski (2011) analyzed the impact of strawberry characteristics on yield and found a positive correlation between yield and the number of fruits, inflorescences, and crowns. All of these traits impact postharvest quality and marketable yield. Although postharvest quality and yield impact overall product quality and commercial viability, no prior study of strawberry producers' preferences for plant and fruit quality traits has been conducted.

Strawberries have long been of interest to Rosaceae fruit breeders. Strawberries are different from other commercially produced rosaceous fruits in that they are herbaceous perennials, grown in many production regions as an annual crop, with a short reproductive cycle (Qin et al., 2008). Research demonstrated that goals of strawberry breeding programs were highly influenced by geographical location and end market needs (Capocasa et al., 2008; Hancock et al., 2008; Khanizadeh et al., 1992; Whitaker et al., 2011). Khanizadeh et al. (1992) reported that a breeding program in Quebec, Canada, used the following selection criteria when evaluating strawberry cultivars: high yield, suitability for mechanical harvesting (raised neck, elevated sepals, shape, skin texture, interior and exterior color, size, and firmness), suitability for processing (flavor, texture, organic acids, and sugars), root and foliar disease resistance, resistance to herbicides, and hardiness. Capocasa et al. (2008) found that the nutritional value of strawberries was an important consideration for both fresh and processed strawberries. Hancock et al. (2008) presented an overview of breeding objectives for different parts of the world and for both fresh and processing markets. Overall, these studies give some insights to breeders' preferences; however, a systematic investigation of producers' value of strawberry traits would assist in breeders' selection of traits and improve the efficiency of breeding programs.

The objective of this study is to assess U.S. strawberry producers' preferences for strawberry fruit and plant traits by analyzing how producers categorize the relative importance of these traits. A secondary objective is to compare these results with published reports on consumers' preferences for strawberries. There is potential for strawberry breeders and supply chain groups to use this information while selecting important traits to target when breeding new strawberry cultivars.

Although this study focused on producers' preferences for strawberry plant and fruit traits, it is crucial to be aware of consumers' preferences for strawberries because they drive demand. The following discussion introduces some of the existing research on consumer preferences for strawberries (Colquhoun et al., 2012; Ford et al., 1996; Keutgen and Pawelzik, 2007; Lado et al., 2010). Ford et al. (1996) determined that flavor, sweetness, and juiciness were the most important strawberry attributes to consumers. Keutgen and Pawelzik (2007) found that consumers were less willing to purchase strawberries with low soluble solids content. Lado et al. (2010) ran a sensory panel and found that consumers preferred a sweeter, firmer strawberry cultivar. Overall, flavor and texture were quality traits important to consumers. However, for producers, other fruit and plant characteristics were also important because they ultimately influence the ability to grow salable produce. Colquhoun et al. (2012) determined sweetness and complex flavors were the most important strawberry fruit attributes to consumers, whereas health benefits were of little importance.

Materials and Methods

Pre-survey producer interviews. To create a comprehensive list of fruit and plant traits important to strawberry producers and determine the factors influencing producers' adoption of new cultivars, we conducted pre-survey interviews with five strawberry growers in Florida. Producers were asked about their decision-making processes regarding cultivar selection, factors positively and negatively influencing their decision to adopt a new cultivar, major markets and uses (fresh or processed) for their strawberries, important fruit and plant traits, and their plant material sources. Additionally, producers were asked to identify "good" and "bad" levels of those traits and how those levels impacted their end use/markets.

The pre-survey interviews of producers were used to identify the nine most important fruit and plant traits to be used in the formal audience survey. The most frequently mentioned traits included fruit skin color, fruit size, fruit flavor, fruit firmness, shelf life at retail, open plant canopy, productivity, extended harvest season, and root rot resistance. An "other" category was added as the tenth trait.

Audience survey. Previous studies have highlighted the benefits of using audience survey technology in research. Several benefits include the ability to survey larger groups, elimination of data entry errors, ease of use, and decreased time when compared with traditional survey methods (Powe et al., 2009). Furthermore, the technology has been shown to be a reliable method of data collection that increases audience engagement (Hall et al., 2005; McCarter and Caza, 2009). Based on these benefits, we used TurningPoint™ (Youngstown, OH) polling software to capture strawberry producers responses to survey questions. Each respondent submitted responses through an individual Response Card keypad, hereafter referred to as a "clicker." Along with the clicker, each respondent received a pencil and a note card so they could submit additional responses or comments. The TurningPoint™ polling system allows a multiple-choice response format with a maximum of 10 response alternatives. The technology enables respondents to select only one response per question. Each question was left open for answering until most respondents submitted their answers. When the survey for each question was complete, the system displayed a graphic representation of the number of responses for each answer option.

The audience surveys were administered at four U.S. producer association meetings: 2011 Great Lakes Expo in Michigan (52 participants), 2012 Fumigation Safety Meeting in California (27 participants), the 2012 Oregon Annual Grower Meeting (21 participants), and the 2012 Strawberry Growers Association Meeting in Florida (36 participants). The four locations were selected to cover regional diversity and because the four states are top producing states in the United States and account for 98.5% of total U.S. strawberry production (U.S. Department of Agriculture, National Agricultural Statistics Service, 2013). A total of 136 strawberry producers participated in the audience survey of which 17 responses were incomplete and unusable. As a result, a total of 119 responses were used in the analysis. The locations were selected as a result of their regional diversity in terms of geography, operation volume, size of operations, and marketing channels. At each meeting, a RosBREED strawberry breeder introduced the survey by explaining the overall RosBREED goal. Next, the breeder explained the benefits of marker-assisted breeding technology in strawberry breeding programs, provided updates on current breeding program efforts, and explained the survey regarding the fruit/plant traits.

After the introduction to RosBREED, participants were introduced to the TurningPoint™ system by presenting them two PowerPoint slides with practice questions. Then, the actual survey started with the first two slides with questions asking respondents to select the "most" and then the "second most" important fruit or plant trait for a successful strawberry cultivar. Each slide included the list of 10 fruit/plant traits: fruit skin color, fruit size, fruit flavor, fruit firmness, shelf life at retail, open plant canopy, productivity, extended harvest season, root rot resistance, and other fruit/plant traits. Each trait was assigned a number, and respondents submitted answers by choosing the number, on the clicker, that corresponded to the trait that best described their preferences.

The next two slides asked respondents to select the "least" and "second least" important fruit quality/plant traits from the aforementioned list of traits. If none of the traits

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presented was the preferred choice for a respondent, they selected the option "other" and wrote, in the note card provided, the name of the trait that best described their preferences. To avoid fatigue, participants were only asked to indicate the most, second most, least, and second least important fruit/plant traits. The survey also included other questions asking participants to indicate, within provided ranges, the total hectares of strawberry fields owned/managed, the number of years of experience in the decision-making of managing the strawberry farm, the 2010 gross farm income, and the respondent's role on the strawberry farm.

Econometric model. An ordered probit model was used to analyze strawberry producers' preferences for strawberry fruit quality and plant traits. This model was chosen because responses for the importance of traits (the dependent variable) were discrete and ordinal (Greene and Hensher, 2008). There were five levels of importance for the 10 fruit quality/plant traits. The most important trait was assigned a value of five, the second most important trait was assigned four, the second least important trait was two, and the least important trait was one. The traits that were not selected for any of the importance categories were considered middle choices and assigned the value three. This method has been used to determine the importance of product attributes in previous studies (Greene and Hensher, 2008).

Producers' rankings were assumed to depend on an underlying utility/satisfaction (measurement of preference) derived from the fruit/plant traits. The producer knew what the underlying utility/satisfaction was to him or her but the researcher (econometrician) did not. Producers ranked the traits based on which would provide them with greater benefits or utility. Here, the benefits were the present value of all the elements producers considered when ranking the quality traits according to their preferences. The approach used is based on Lancaster's postulate that utility is not derived from a good itself but rather from the attribute composition of that good (Lancaster, 1966). Here, suppose U_{ij} is the utility/benefit that producer *i* derives from trait *j*, and U_{ij} can be expressed as follows:

$$
\begin{aligned}
U_{ij} = {} & \alpha_0 + \alpha_1 color_i + \alpha_2 size_i \\
& + \alpha_3 flavor_i + \alpha_4 firmness_i \\
& + \alpha_5 shelf\ life_i + \alpha_6 open\ canopy_i \\
& + \alpha_7 productivity_i \\
& + \alpha_8 harvest\ season_i + \alpha_9 root\ rot_i \\
& + \alpha_{10} other_i + \delta_1\ years_i \times firmness_j \\
& + \delta_2\ years_i \times productivity_i \\
& + \delta_3\ California_i \times flavor_i \\
& + \delta_4\ California_i \times firmness_i \\
& + \delta_5\ Florida_i \times flavor_i \\
& + \varepsilon_{ij}\ ;\ i = 1, \ldots, 119\ (n)
\end{aligned}
\tag{1}
$$

where α_j is the producer's (i) marginal utility from growing a strawberry with the traits (j) including fruit skin color, fruit size, fruit flavor, fruit firmness, shelf life at retail, open plant canopy, productivity, extended harvest season, root rot resistance, and other; $\delta_1, \ldots, \delta_5$ correspond to a row vector of the coefficients associated with the interaction effects between strawberry traits and strawberry producers' farm hectares, gross income, years involved in the decision-making of managing a strawberry farm, and the state (California, Michigan, Florida, and Oregon) where the farm was located (only significant interaction terms are included in the model and results); ε_{ij} is the residual error term not captured by the explanatory variables, which is assumed to follow a normal distribution with mean zero and SD σ_ε. The model was run in STATA™ (College Station, TX).

When a set of indicator variables is used as regressors, one category for these variables must be omitted for estimation to avoid perfect multicollinearity (Greene, 2008). This variable serves as the base for the estimated coefficients, that is, parameter estimates for each other variable are relative to the omitted/base variable. The root rot resistance trait was used as the base for estimation. [If the set of explanatory variables has n variables, and if it is desired to include an intercept term in the model, then one of the categories has to be "excluded" from the model for estimation purposes (only) to eliminate perfect multicollinearity. The issue is that there is perfectly redundant information with the inclusion of the nth variable. Because it is redundant information, nothing changes in terms of the model (overall fit stays the same) and there is no issue with biased parameter estimates as a result of the "excluded" variable. Although the magnitude and the significance of the estimated coefficients change as the excluded variable changes, there is no real change in terms of the model results because the interpretation of the coefficients changes depending on what variable is "excluded." With root rot resistance the excluded variable, all estimated coefficients (and significance) are interpreted relative to root rot resistance. If fruit flavor were the "excluded" variable, all estimated coefficients (and significance) would be interpreted relative to fruit flavor. One can show mathematically that nothing really changes in the model if one changes the excluded variable.] A trait with a statistically significant positive or negative estimate meant that respondents placed a higher or lower importance on the importance of this trait compared with root rot resistance. However, traits determined to be not statistically significant, that is, not significantly different from the base trait root rot resistance, might still be considered of some importance to producers.

The interaction effects listed in Eq. (1) were obtained by multiplying the state indicator variables by each trait. The variables account for the impact of geographical location on the importance producers assign to various fruit/plant traits. Additionally, we estimated marginal effects, which in this model quantifies the change in the predicted probability that a quality trait would be ranked in each level of importance. We used root rot resistance as the variable base for comparison. We also estimated the impact of individual states on the probability of trait selection. [We considered only the statistically significant interaction between state and fruit and plant traits. For example, marginal effect of fruit flavor for California producers = marginal effect for flavor + (marginal effect of the interaction flavor × California).]

To determine if the differences in the importance of fruit/plant traits were statistically significant, we conducted pairwise *t* tests across all fruit/plant traits included in the ordered probit model. The significance of the *t* test results indicated that most traits were assigned different levels of importance across respondents.

Results and Discussion

Summary statistics for producers by region. For the producers sampled, those in Florida owned/managed the largest farms, with an average of 54.9 ha, followed by California (28.7 ha), Oregon (25.7 ha), and Michigan (13.1 ha) producers [According to the 2007 U.S. Census of Agriculture, the average strawberry farm size in California was 19 ha, Florida 13 ha, Oregon 3 ha and Michigan 1 ha (U.S. Department of Agriculture, Census of Agriculture, 2007). Thus, our sample overrepresented larger-sized firms in all four states.] (Table 1). Oregon producers had the highest average years of experience in the decision-making of managing a strawberry farm (18.6 years) followed by Michigan (14.6 years), California (13.7 years), and Florida (9.7 years). Florida producers had the highest average gross farm income (includes strawberry farms only) in 2010 with ≈$1 million followed by California with $582,000, Oregon with $462,000, and Michigan with $106,000. Nearly 56% of participants were owners followed by 32.2% managers and 3.3% lessees. The majority of participants (42.1%) were from Michigan followed by Florida (28.1%), California (19.0%), and Oregon (10.7%).

Fruit and plant traits identified by producers. Compared with root rot resistance, fruit flavor was the most important trait with a coefficient of 1.26 (Table 2). The coefficient meant that the ordered logit for fruit flavor being ranked as the most important quality trait for a successful cultivar is 1.26 more than root rot resistance, controlling for the impact of the other variables in the model. The second most important trait was fruit firmness (1.23) followed by shelf life at retail (0.93), open plant canopy (0.68), fruit color (0.56), extended harvest season (0.39), and fruit size (0.38). Note that consumers' preference studies for strawberries cited flavor, sweetness, firmness, and juiciness as the most important quality traits (Colquhoun et al., 2012; Ford et al., 1996; Keutgen and Pawelzik, 2007; Lado et al., 2010). With the exception of size and color, we could state that producers and consumers were consistent in their ranking of most important fruit quality traits. Size and color are used as part of the criteria to determine grades and standards

Table 1. Summary statistics for producer demographic variables used in an ordered probit model for strawberry producer audience survey participants at four producer meetings in 2011–12 (n = 119).

Variable (statistic-state)	Description	Mean	SD
Hectares—California	Average total strawberry hectares owned/managed	28.65	33.48
Hectares—Michigan	Average total strawberry hectares owned/managed	13.14	47.94
Hectares—Florida	Average total strawberry hectares owned/managed	54.87	25.73
Hectares—Oregon	Average total strawberry hectares owned/managed	25.73	39.44
Years—California	California participant's years of experience in decision-making	13.73	7.79
Years—Michigan	Michigan participant's years of experience in decision-making	14.63	8.65
Years—Florida	Florida participant's years of experience in decision-making	9.71	7.53
Years—Oregon	Oregon participant's years of experience in decision-making	18.62	8.65
Income—California	Average 2010 gross farm income from all crops ($1000) in the California	582.40	1078.33
Income—Michigan	Average 2010 gross farm income from all crops ($1000) in the Michigan	106.48	146.51
Income—Florida	Average 2010 gross farm income from all crops ($1000) in the Florida	1075.81	1364.97
Income—Oregon	Average 2010 gross farm income from all crops ($1000) in the Oregon	462.42	937.62
Role	Role of participant: 1 = owner (56.19%), 2 = lessee (3.30%), 3 = manager (32.22%), 4 = other (8.26%)	1.73	0.95
Region	Geographical location of farm: 1 = California (19.00%), 2 = Michigan (42.14%), 3 = Florida (28.09%), 4 = Oregon (10.74%)	2.30	0.90

and thus the price received by producers (U.S. Department of Agriculture, Agricultural Marketing Service, 2004). Shelf life at retail is an important trait for packers and retailers because it influences the amount of fruit lost resulting from handling. The more the fruit maintains its quality characteristics when on the retailers' shelf, the more valuable the fruit will be for retailers and producers.

Open plant canopy is a trait important for the producer. A more open plant canopy increases airflow and sunlight penetration and decreases the buildup and duration of humidity reducing the risk of gray mold (Koike et al., 2012). It also allows the picker to easily find the fruit, increasing the efficiency of harvest. The plant productivity trait was not significantly different from root rot resistance. Results also indicated that producers with more years of experience in decision-making valued fruit firmness as the most important trait (0.21) and plant productivity as the least important of all the other strawberry fruit/plant traits (–0.19).

The interaction of state and fruit flavor revealed that California (–0.11) and Florida (–0.09) producers ranked fruit flavor less important when compared with producers from Michigan and Oregon. California producers also indicated that fruit firmness (–0.12) was less important compared with producers from all other states (Table 2). These results could be attributed to different market dynamics of each state. For example, California and Florida produce higher volumes of strawberries compared with Oregon and Michigan (U.S. Department of Agriculture, National Agricultural Statistics Service, 2013). Thus, producers in these states ship long distances through complex marketing chains and are less likely to be compensated for flavorful fruit. Oregon strawberries are mainly for processing; thus, sugars and acids are more important. Michigan is more likely to be marketed through direct marketing; thus, fruit flavor is more important than for other states. California and Florida tend to ship most of their fruit to out-of-the-state markets, whereas Michigan and Oregon are more likely to sell local. Therefore, intuitively, firmness would be of greater importance in

Table 2. Estimated ordered probit model coefficients indicating the relative importance of strawberry fruit quality and plant traits to strawberry producers based on audience survey data collected at four producer meetings in 2011–12 (n = 119).

Variable	Coefficient[z]	SE
Fruit flavor	1.26***	0.22
Fruit firmness	1.23***	0.32
Shelf life at retail	0.93***	0.17
Open plant canopy	0.68***	0.17
Fruit color	0.56***	0.17
Extended harvest season	0.39**	0.17
Fruit size	0.38**	0.17
Productivity	0.34	0.31
Other fruit and plant trait	0.28	0.17
Root rot resistance	Base	Base
Fruit firmness*years of experience[x]	0.21**	0.09
Productivity*years of experience[x]	–0.19**	0.08
California*fruit flavor[w]	–0.11***	0.04
California*fruit firmness[w]	–0.12***	0.04
Florida*fruit flavor[w]	–0.09**	0.04
Cutoff value 1[y]	–0.84	0.13
Cutoff value 2[y]	–0.42	0.13
Cutoff value 3[y]	1.70	0.14
Cutoff value 4[y]	2.02	0.14

[z]*, **, *** Significant at $P \leq 0.10$, 0.05, or 0.01, respectively.
[y]Cutoff value for the ordered probit model.
[x]Interaction between fruit/plant trait and years of decision-making experience. The interaction was standardized with mean of zero and SD of one.
[w]Interaction between fruit/plant trait and the states. The interaction was standardized with mean of zero and SD of one.

Table 3. Estimated marginal effect of relative importance of strawberry traits to strawberry producers based on audience survey data collected at four producer meetings in 2011–12 (n = 119).

	Ranking = 1 least important	Ranking = 2	Ranking = 3	Ranking = 4	Ranking = 5 most important
Fruit firmness	–0.23***[z]	–0.18***	–0.21**	0.23***	0.39**
Fruit flavor	–0.09***	–0.07***	–0.23***	0.12***	0.27***
Shelf life at retail	–0.07***	–0.06***	–0.13**	0.10***	0.17***
Open plant canopy	–0.06***	–0.05***	–0.07*	0.07***	0.11**
Fruit color	–0.06***	–0.04***	–0.05	0.06**	0.08**
Extended harvest season	–0.04**	–0.03**	–0.02	0.04**	0.05*
Fruit size	–0.04***	–0.03**	–0.02	0.04**	0.05*
Other fruit and plant trait	–0.03**	0.02*	–0.01	0.03	0.03
Productivity	0.05	0.05	–0.03	–0.06	–0.06
Root rot resistance	Base	Base	Base	Base	Base
California producers					
Fruit firmness	–0.19**	–0.15**	–0.21	0.2**	0.36**
Fruit flavor	–0.08**	–0.06**	–0.23	0.11***	0.26**
Florida producers					
Fruit flavor	–0.08**	–0.07**	–0.23	0.11**	0.26**

[z]*, **, *** Significant at $P \leq 0.10$, 0.05, or 0.01, respectively.

Table 4. Pairwise t test comparisons of the importance of selected strawberry fruit quality and plant traits based on audience survey data collected at four strawberry producer meetings in 2011–12.

	Fruit color	Fruit size	Fruit flavor	Fruit firmness	Shelf life at retail	Open plant canopy	Productivity	Extended harvest season	Other fruit and plant trait
Fruit color	—	0.18	–0.69**[z]	–0.67**	–0.36**	–0.12	0.21	0.16	0.27
Fruit size	—	—	–0.87***	–0.85**	–0.54**	–0.30*	0.39	–0.01	0.09
Fruit flavor	—	—	—	0.02	0.33	0.57**	0.91**	0.86***	0.97***
Fruit firmness	—	—	—	—	0.30	0.55*	0.89**	0.84**	0.95**
Shelf life at retail	—	—	—	—	—	0.24	0.58**	0.53**	0.64***
Open plant canopy	—	—	—	—	—	—	0.34	0.28*	0.40**
Productivity	—	—	—	—	—	—	—	–0.05	0.05
Extended harvest season	—	—	—	—	—	—	—	—	0.11
Other fruit and plant trait	—	—	—	—	—	—	—	—	—

[z]*, **, *** Significant at $P \leq 0.10$, 0.05, or 0.01, respectively.

California. However, the authors believe that there is much less variation in the cultivars grown in California because most are characterized as firm; thus, California growers may be less concerned with this quality trait.

As for marginal effects results, fruit flavor had a significantly higher probability of being chosen as the most important trait compared with root rot resistance. Fruit firmness was next followed by shelf life at retail, open plant canopy, fruit color, extended harvest season, and fruit size. The "other" trait identified by the producer and productivity was not statistically significantly different in importance from root rot resistance (Table 3). California producers were less likely to select fruit flavor and fruit firmness as the most important trait when compared with the whole sample of producers. Similarly, Florida producers were less likely to select fruit flavor as the most important trait compared with producers from California, Oregon, and Michigan (Table 3).

In relation to the pairwise t tests, fruit firmness and fruit flavor were the most important traits (Table 4). However, fruit firmness and fruit flavor were not significantly different from shelf life at retail. Fruit size was not significantly different from extended harvest season, plant productivity, and the other fruit and plant trait categories. Similarly, there was no significant difference between open plant canopy and plant productivity and between plant productivity and extended harvest season. Fruit color, fruit size, open plant canopy, plant productivity, and the other fruit and plant trait category were not statistically different from extended harvest season. The t test pairwise comparisons signaled a similar finding to fruit firmness and flavor being ranked the highest importance overall traits included in this study, whereas plant productivity was ranked the lowest.

Discussion on the methodology used. The audience response survey technology has many benefits and has been shown to be a reliable data collection method (McCarter and Caza, 2009; Powe et al., 2009). However, some concerns exist regarding participants' ability to view the instant feedback. Because the participants are able to view the graphic distribution of the audience responses for each question as the audience moves through the survey, this format allows the audience's response to potentially influence individuals' responses to future questions. This effect is similar to what happens in focus groups. However, we argue that producers, in general, are exposed to and influenced by external information that (in some cases) comes from their peers. As such, understanding producers' ratings of strawberry traits in a group setting can be quite valuable because decisions are typically made in an environment of multiple sources of information rather than in isolation. Therefore, we believe that the group influence is a strength, rather than a biasing artifact, in the audience survey methodology.

Conclusions

We conducted a series of audience surveys at U.S. strawberry producers' meetings. The goal of the survey, and of this study, was to ascertain which fruit and plant traits were of high importance to strawberry producers and how the different states, annual gross income of the operation, size of operation, and years of experience affected the importance assigned to traits. This information is useful to strawberry breeders to define and implement breeding target priorities for their programs. In many instances, breeders face a long list of traits on which to focus from multiple interested parties and/or supply chain members. The use of technologies such as marker-assisted breeding requires breeders to prioritize and focus efforts on those fruit and plant traits with the highest value. This study is part of a larger effort aimed to determine the value and ranking of importance for various fruit and plant traits from different supply chain members, including producers, packers, shippers, processors, marketers, and consumers. Producers are the supply chain members who would ultimately decide to grow a new and improved strawberry cultivar and their decision would likely be influenced by their markets' needs. The results from this study underline the importance of fruit quality traits that impact the marketability and salability of strawberry cultivars and ultimately influence consumers' perceptions of quality. Fruit and plant traits impact supply and demand, potentially affecting the availability and pricing of fruits to the end consumer. Combining producers' priorities with those of other supply chain members will allow breeders to more efficiently target breeding program resources to high-value traits.

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