In Pursuit of the Perfect Peach: Consumer-assisted Selection of Peach Fruit Traits

Mercy A. Olmstead[1] and Jessica L. Gilbert
Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Thomas A. Colquhoun and David G. Clark
Environmental Horticulture Department and UF/IFAS Plant Innovation Center, University of Florida, Gainesville, FL 32611

Robert Kluson
Sarasota County Extension, University of Florida, Sarasota, FL 34241

Howard R. Moskowitz
Moskowitz Jacobs, Inc., White Plains, NY

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Abstract. **Despite production of the first domestically produced peach of the calendar year in the United States, the subtropical peach industry faces marketing challenges, particularly with small fruit size. Although important, size is only one aspect of fruit quality, and not inclusive of all possible fruit quality attributes. Thus, this research asked consumers to identify an "ideal" peach given a combination of possible peach fruit quality attributes to help determine their influence on consumer purchase. These attributes were verified with farmers' market intercept studies. The top attributes that fostered purchase likelihood included flavor, texture, size, and firmness. Psychophysics studies showed that consumers preferred peaches that were sweet, juicy, round, with freestone or semifreestone characteristics, whereas consumers were less likely to purchase peaches with mealy, dry, or meaty textures. Young consumers (ages 18–24) preferred crisp, firm peaches with good flavor, whereas older consumers (ages 51–65) preferred sweet, melting-texture peaches. Farmers' market intercept studies found consumers (ages 45–65) preferred melting-texture peaches with good flavor that led to increased overall liking. In addition, in the farmers' market studies, aroma and flavor were important attributes and were highly correlated with overall liking. Objective measurements of total soluble solids (TSS) were not correlated with overall liking, indicating that although the nationwide experiment found consumers desired sweet peaches, other attributes may contribute more favorably to overall liking.**

The Florida subtropical peach (*Prunus persica* L.) industry is expanding, with over 1200 acres in the state producing fruit predominantly for fresh market consumption. Growers are able to market the first domestically produced peach of the calendar year in late March and early April, resulting in estimated farm gate values of $1.50/lb compared with $0.80/lb in Georgia, whose production begins in early May (Morgan and Olmstead, 2013). Florida peaches are distributed predominantly to the eastern part of the United States, with national distribution likely in the next 5 years as acreage and volume increase (Harrison et al., 2008). Local and regional studies have shown favorable consumer acceptance of early season peaches (Brovelli et al., 1999; Williamson and Sargent, 1999). The stone fruit breeding program in Florida has focused on the release of nonmelting texture peaches for fresh consumption, which allows fruit to remain on the tree longer and develop improved aroma and flavor without sacrificing firmness (Do et al., 1969; Sherman et al., 1996; Sherman and Lyrene, 2003). Nonmelting texture peaches for the fresh market typically are clingstone or semifreestone with firm fruit flesh that does not breakdown as the fruit ripen (Van der Heyden et al., 1997), whereas melting-texture peaches often deteriorate in the shipping chain if harvested tree ripe (Brovelli et al., 1995; Lester et al., 1996). However, consumers can perceive this firmness as unripe fruit. Nonmelting texture, in addition to small fruit size in these early ripening varieties, presents significant marketing challenges to the growth of the subtropical peach industry.

Despite the growth in low chill, early season peach acreage from 234 acres in 2007 to over 1231 acres in 2012 (United States Department of Agriculture, 2012), overall peach and nectarine consumption has remained static or decreased (Grimm et al., 2010; United States Department of Agriculture, 2014). This may be caused by several factors such as poor fruit texture caused by flaws in the postharvest handling resulting in "wooly" or "mealy" fruit textures (Crisosto, 2002; Delgado et al., 2013; Diehl et al., 2013; Williamson and Sargent, 1999), small fruit size, low soluble solid content (SSC) (Kader, 1999), or significant reduction in skin color (e.g., blush) (Crisosto and Crisosto, 2005; Parker et al., 1991). Poor fruit quality as determined by small fruit size, low SSC, or reduced skin color may be driven by early harvests to minimize fruit damage in the shipping chain as fruit are shipped across the country to export markets overseas or for processing (Kader, 1999; Kader et al., 1982). The main drivers in initial peach purchases are appearance and aroma, and repeat purchases predominantly based on flavor and textural aspects (Baldwin, 2002; Bruhn, 1995; Bruhn et al., 1991; Delgado et al., 2013; Diehl et al., 2013). A minimum TSS of 10% has been proposed for maximum consumer acceptance (Kader, 1999); however, acidity and astringency also are important drivers in peach flavor (Predieri et al., 2006). Selection for flavor has not been a priority in perennial fruit breeding programs because of the importance of disease resistance, consistent fruit yield, and large fruit size (Gallardo et al., 2012; Laurens, 1999). In addition, fruit flavor can be affected by production practices (Olienyk et al., 1997) and postharvest supply chain conditions (Lurie and Crisosto, 2005). However, breeders, fruit growers, and market intermediaries are increasingly cognizant of the consumer demand for better fruit flavor (Colquhoun et al., 2012; Yue et al., 2013, 2014).

One important attribute that has been successfully used in fruit marketing is health benefits. For example, with blueberries, consumers were most interested in various aspects of blueberry flavor, but a significant segment of consumers was also very interested in the health benefits of consuming blueberries (Gilbert et al., 2014). Several studies have described the high antioxidant potential of peaches (Gil et al., 2002; Reig et al., 2013; Santos et al., 2013), and extracts of both peach and plum (*Prunus salicina* L.) may have cancer-suppressive properties against certain breast cancer lines (Lea et al., 2008; Noratto et al., 2009). However, there have been few marketing efforts on behalf of these health compounds in peaches and other stone fruit.

Identification of visual and sensory attributes contributing to an "ideal" peach-eating experience is key to providing the necessary

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[1]Corresponding author. E-mail: mercy1@ufl.edu.

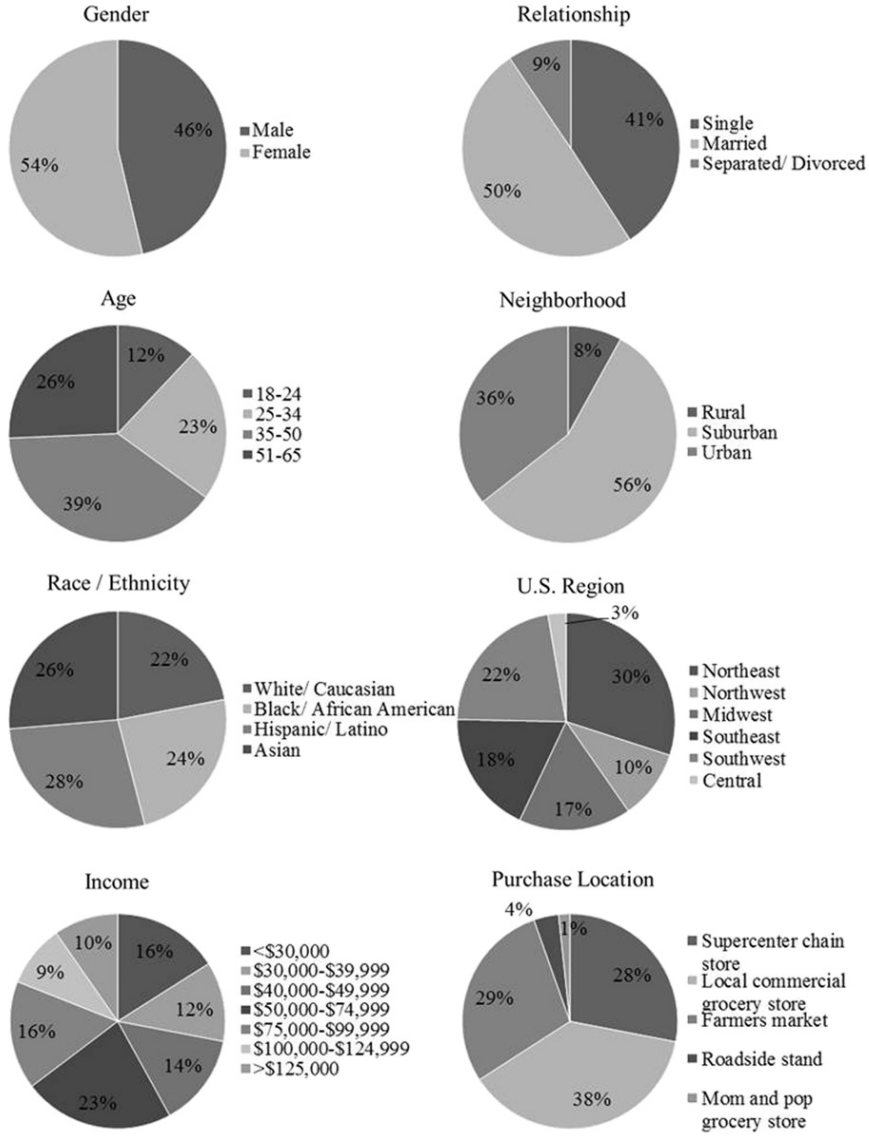

Fig. 1. Reported demographics of "The Ideal Peach" consumer perception survey (N = 300).

information that breeding programs, producers, and marketers need to drive increased consumption of peaches in the United States. Although individual fruit quality attributes have been tested in previous consumer preference studies, they have not been presented in combined formats. Thus, this study sought to identify the combination of attributes that would provide an ideal peach fruit quality profiles, which could be used by breeders, growers, and marketing intermediaries to promote peaches and encourage consumption of peaches in the United States.

Materials and Methods

Consumers were analyzed using rule developing experimentation (RDE) in which the potential consumer interest of products composed of new and different combinations of specific fruit quality attributes is assessed (Levin et al., 2012; Moskowitz and Gofman, 2007). RDE was implemented using the IdeaMap® software interface (i-Novation Inc., White Plains, NY) to identify consumer peach preferences as previously described in Gilbert et al. (2014) and Colquhoun et al. (2012). The IdeaMap® study was titled "The Ideal Fresh Peach" and was conducted in Sept. 2013. The survey participants were located across the United States and were recruited through a contracted company, Panel Direct Online (http://www.paneldirectonline.com; division of Focus Forward, LLC, New York, NY). Survey participants were initially screened for being peach consumers by asking participants if they had ever purchased peaches, followed by a question, if they had purchased fresh peaches in the current year. An ≈50% split in male/female panelists was sought. After ≈150 panelists of either gender completed the study, panelists of that gender were screened out. A total of 300 subjects completed the survey, with distribution for various demographic categories is presented in Fig. 1. This study was exempt from institutional review board approval based on category 45 CFR 46.101 (b)(2)(i), as no personal identification of subjects was collected (United States Department of Health and Human Services, 2009).

In the IdeaMap® interface, consumers were asked about unique combinations of specific fruit quality attributes that may define a peach fruit to gauge interest levels. The main peach fruit characteristics chosen were based on previous research and included firmness, texture, size, color, flavor, and health and wellness (Brovelli et al., 1995, 1999; Karakurt et al., 2000; Rouse and Sherman, 2002). Each online respondent was presented with a welcome screen and sequentially asked to rate their likelihood of purchasing a peach defined by a combination of three to four different specific fruit quality attributes presented on the screen. Each of these attributes was from the six independent categories of peach quality attributes (Fig. 2; Table 1). For each screen presenting a combination of these fruit quality attributes, consumers indicated their purchase likelihood on a 9-point scale (1 = not at all likely, 9 = very likely). Each of the 36 options (attributes; Table 1) appeared five times in 48 permutated combinations, and every study subject evaluated a unique set of 48 combinations with the same 36 attributes from the six categories.

Using regression analysis, independent variables (fruit quality attributes) were related to dependent variables (purchase likelihood/consumer interest). IdeaMap® technology uses modified conjoint analysis to determine the effect of a single independent variable presented in multiple combinations with other independent variables in a stacked six-level, six-variable matrix (Plackett and Burman, 1946). Ratings of product "concepts," the presented peach attribute combinations, were transformed to binary ratings of 0 (consumer disinterest, rating of 1 to 6) or 100 (consumer interest, rating of 7 to 9) for each panelist (Moskowitz, 2012; Moskowitz and Gofman, 2007; Moskowitz et al., 2006). This creates a matrix for each panelist of 48 rows (each attribute combination) by 38 columns (the presence/absence of an attribute in the rated combination, the panelist rating, and the transformed rating).

Regression modeling was used to determine which attributes drive liking/disliking as previously reported (Colquhoun et al., 2012; Gilbert et al., 2014), with an equation for the response matrix of each panelist of the form:

$$\begin{aligned}\text{Rating} = {} & k_0 + k_1(\text{attribute A1}) \\ & + k_2(\text{attribute A2}) + \ldots \\ & + k_{36}(\text{attribute F6}) \end{aligned} \quad [1]$$

where rating corresponds to the transformed value based on the panelist's response on the 9-point scale to a combination of three to four elements, k_0 is the mean of all ratings of that panelist, and k_1–k_{36} are coefficients

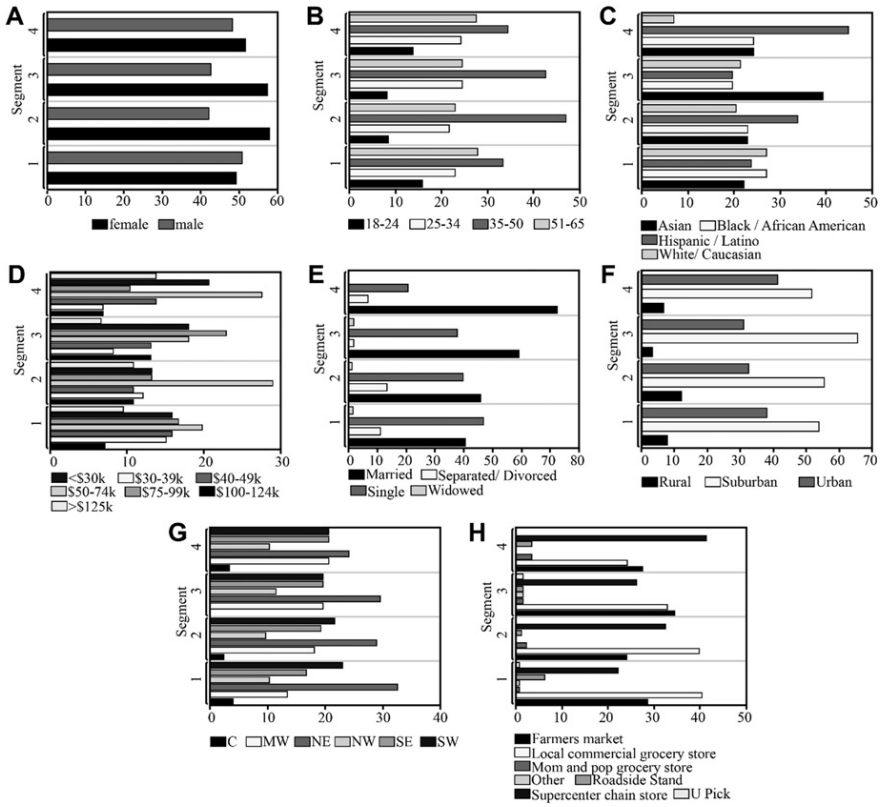

Fig. 2. An example of a combined peach attribute question presented to a survey participant in "The Ideal Fresh Peach" online survey. The participant responded to the question by indicating their likelihood of purchase for this specific combination of attributes on a 9-point scale, where 1 was not at all likely and 9 was very likely.

that correspond to the conditional probability a person will find a single element of the 36 presented interesting when the element is present in the combination (Moskowitz and Gofman, 2007). Interest values (InV) of peach fruit attributes 1–36, respectively, tested in this survey (Table 1). The InV of individual attributes describes the overall increase or decrease that a consumer would purchase that fruit relative to the baseline constant k_0 (Moskowitz et al., 2006; Moskowitz and Gofman, 2007). A higher InV indicates greater likelihood of purchase generated by a particular attribute. The additive constant represents a baseline for comparison of the impact of an individual attribute on consumer preference. This constant also represents the general interest of respondents to the initial concept of the "ideal fresh peach" regardless of attribute influence. The InV of a certain attribute is shown as the difference in respect to the additive constant to show a particular increase or decrease in overall liking for that particular attribute (Gilbert et al., 2014; Moskowitz et al., 2006; Moskowitz and Gofman, 2007).

In this study, both a priori and post hoc analyses were used to look for market segmentation in the data. To see whether consumers clustered for similar peach attribute preferences, data were subjected to K-cluster analysis as previously described (Gilbert et al., 2014). K-cluster analysis was applied to the matrices of 36 columns (one column per attribute, value corresponding to its model coefficient/InV) and 300 rows (one row per respondent) in SYSTAT 13 (Systat Software, Chicago, IL).

Consumer preference study. To complement the IdeaMap® survey, consumer preference panels were conducted at four farmers' markets in the Sarasota–Bradenton, FL area in 2013 (N = 161) and 2014 (N = 184). In 2013, 'TropicBeauty' (melting texture) and 'UFSun' (nonmelting texture) peaches were harvested from the Plant Science Education and Research Center in Citra, FL. In 2014, 'TropicBeauty' fruit harvest was delayed, thus 'TropicBeauty' and 'UFSun' ripe fruit was sourced from King Family Farms (Bradenton, FL) for the farmer's market consumer preference panels. Tree-ripe fruit in both years were harvested into coolers containing ice and transported to refrigerated storage (0 °C) until use. Fruit were allowed to ripen at room temperature 24 h before consumer acceptance studies were conducted. Flesh firmness (kgf) for every fruit that was served to consumers was measured by removing a small portion of the skin and a penetrometer reading was recorded (Model FT 10; Wagner Instruments, Greenwich, CT). This slice was subsequently removed from the fruit and used to extract juice for TSS measurement with a digital refractometer (PAL-1; Atago U.S.A., Inc., Bellevue, WA), whereas the remainder of the fruit was served to consumers.

Consumers were recruited to a booth at two local farmers' markets (Sarasota and Bradenton, FL) and were asked two demographic questions to identify their gender and age group (under 18, 18–29, 30–44, 45–65, over 65). Participants were then asked to rate visual appearance (skin color and shape) and aroma (orthonasally) of two peach samples in a questionnaire. Two slices each of the two peach cultivars were then given to subjects and they were asked to consume the peach slices and individually (by sample) rate the texture, firmness, flavor, and overall liking. Bottled water was given to each subject and used to rinse their palates between samples. Subjects rated each attribute using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely).

Statistical analyses were completed using paired t tests for each attribute, using JMP Pro (v. 11.0; SAS Institute, Cary, NC), and multivariate correlation analysis was used to determine the Pearson's correlation coefficient (R) value of a particular attribute on another. This study was exempt from institutional review board based on category 45 CFR 46.101(b)(6) due to fruit not containing additives (United States Department of Health and Human Services, 2009).

Results

Consumer peach fruit quality interest study. The demographics of IdeaMap® participants approximated our desired gender distribution with 46% male and 54% female, fairly even distribution among races and slightly higher percentage of 35- to 50-year olds compared with the other age categories (Fig. 1). Survey participants rated 48 sets of three to four individual attributes for likelihood of purchase (Table 1). The baseline constant for this study was 41, which represented the average response of all panelists to all attributes. The highest ranking attributes that increased purchase likelihood belonged to the categories of flavor, texture, size, and firmness (Table 2). The top attribute was "so sweet … no sugar needed" (InV = 12), followed by "full of juice," "plump and round," "pit comes easily free from the peach flesh," and "sweet rich flavor with mildly tart overtones." The perception of "mealy … pasty and dry" peaches was the strongest detractor of peach purchase likelihood (InV = –18). Other attributes with very negative (InV < –8) impacts on purchase decision were peaches that were "meaty … not juicy," "flat, shaped like a donut," and "elongated shape (beaked) with a characteristic suture."

Women more willing to purchase peaches compared with men (constant = 50 and 30, respectively), and this sentiment was reflected in Fresh Trends data (Fresh Trends, 2011, 2012) (Table 3). Men and women did not segregate for purchase detractors, but men responded more favorably to the description "plump, round, sweet peaches,"

Table 1. Experimental design of categories (A–F) and individual attributes (1–6) of each category for the 2014 ''The Ideal Fresh Peach'' consumer perception study.[z]

The ideal fresh peach	
Category A: peach firmness	
A1	Bite into peach … and hear a loud crunch
A2	Melts in the mouth when you bite into the peach
A3	Thin skin that melts away
A4	Tough chewy skin
A5	Peach clings to the pit
A6	Pit easily comes free from the peach flesh
Category B: peach texture	
B1	Smooth skin with very little fuzz
B2	Typical fuzzy peach skin
B3	Full of juice
B4	Meaty … not juicy
B5	Mealy … pasty and dry
B6	Crisp and firm
Category C: peach size	
C1	Plump and round
C2	Elongated shape (beaked) with characteristic suture
C3	As big as a small softball
C4	Small, bite-sized peaches
C5	Medium size, like a baseball
C6	Flat, shaped like a donut
Category D: peach color	
D1	All-over blush, almost solid red in skin color
D2	Mainly yellow skin color, with a slight blush
D3	White flesh color
D4	Bright yellow flesh color
D5	Yellow flesh color with red flesh near the pit
D6	Red skin color that bleeds into the flesh
Category E: peach flavor	
E1	Mild flavor … but compliments well
E2	Bold and intense peach flavor
E3	So sweet … no sugar needed
E4	Tart peach that wakes the taste buds
E5	Soft peach flavor, but are much more floral tasting
E6	Sweet rich flavor with mildly tart overtones
Category F: health and wellness	
F1	Full of antioxidants
F2	No fat … no cholesterol
F3	High in vitamin C
F4	A rich source of dietary fiber
F5	Organic peaches
F6	A low-carb source of nutrients

[z]Each category represents an attribute of peaches such as peach firmness, peach texture, peach size, peach color, peach flavor, and health and wellness. Within each category are six descriptive attributes related to the category resulting in a total of 36 individual attributes.

whereas women responded most favorably to ''sweet, juicy peaches,'' indicating that men were interested in visual attributes of peach fruit compared with women.

In this study, the age group that was most likely to purchase peaches (as determined by constant values) were panelists between 18 and 24 years, whereas those between 51 and 65 years were least likely to purchase peaches (constants = 54 and 26, respectively) (Table 3). In examining each age group, many of the top and bottom attributes from the study as a whole were similar. However, the 18 to 24 age group was unique in that they responded favorably to the description of crisp, firm peaches, organically produced, and unfavorably to bright yellow, mildly flavored fruit. The 51–65 age group was very motivated to purchase peaches described as melting (InV = 14) with sweet flavor (InV = 19).

When analyzed by ethnicity, Asian panelists were most interested in peaches (constant = 53), followed by Black/African American (48), Hispanic/Latino (45), with Whites/Caucasians being the least interested in peaches (13) (Table 3). As a whole, top attributes of ''so sweet … no sugar needed,'' ''sweet rich flavor …,'' ''full of juice,'' and ''pit comes easily free from the peach flesh'' were similar among the different ethnic groups.

The highest interest in peach fruit when grouped by household income brackets were those earning $100,000–$124,999 (constant = 73) (Table 3), whereas those least interested reported earning less than $30,000 a year. Earners of $75,000–$99,999 were uniquely interested in peaches with yellow skin color and a slight blush with melting texture. As with all other segments, fruit with ''meaty … pasty and dry'' attributes detracted return purchases.

Examination of responses by neighborhood location resulted in differences in top peach attributes, particularly in those classifying their neighborhoods as rural (Table 3). Panelists in rural areas highly favored peaches that were ''plump and round'' and ''small, bite-sized peaches.'' The attributes ''no fat … no cholesterol'' and ''bite into peach … and hear a loud crunch'' resulted in strongly negative effects on purchase likelihood in this group. In both suburban and urban groups, peaches with sweet flavors increased the likelihood of purchase (Table 3). There were also differences in regional areas of the United States with panelists in the northwest most receptive to peaches, whereas panelists in the central United States least receptive (constant = 61 and 30, respectively) (Table 3). Panelists in the northwest were interested in sweet peaches with rich flavor, whereas those in the central United States were interested in peaches as ''a low carb source of nutrients.'' Southwesterners were most interested in peaches with melting texture, whereas those in southeastern United States preferred sweet peaches with ''thin skin that melts away,'' freestone in nature and full of juice. Ironically, there was a fairly low interest level in peaches for consumers in the southeastern United States (Table 3), a region that is known to produce a majority of the peach volume in the eastern United States.

Point of purchase has an impact on ideal peach attributes. Panelists that purchased peaches from neighborhood grocery stores had the highest interest, compared with local commercial grocery store shoppers, who had the lowest interest (constant = 63 vs. 29) (Table 3). Local commercial grocery store shoppers made up the largest group (n = 112), yet were not interested in flavor attributes, contrary to the study as a whole. Panelists who purchased their peaches from roadside stands were most receptive to peaches with high amounts of blush and smaller diameter, but did not like peaches with little or no fuzz on the peach skin (Table 3).

To examine whether the data segmented into groups of clusters and identify unique groups of consumers, K-cluster analysis was used. Segments of two or three were not informative and produced similar results for top and bottom attributes. However, on segmentation into four clusters, distinct groups of consumers began to emerge with similar distributions of gender, age groups, and U.S. regions of residence (K = 4) (Fig. 3; Table 4). The largest segment (Segment 1, n = 126) had the lowest overall interest in peaches but was most interested in purchasing sweet, freestone peaches with thin skin. The second segment of panelists (n = 83) had very negative reactions to crisp peaches with tough chewy skin and dry texture, but had very high responses to attributes of peach flavor, including elevated sweetness. The third segment (n = 61) was most interested in descriptors of size and shape; however, they responded negatively to peach skin and flesh color attributes, particularly to peaches with white flesh. A notable characteristic of this segment is that there were more Asians than other ethnicities, in addition to being from suburban neighborhoods in the northeastern United States (Fig. 3). The final segment (n = 29) had the highest baseline

Table 2. Interest values (InV) of each attribute tested in "The Ideal Fresh Peach" consumer preference survey, ordered from highest to lowest. InV represent an increase or decrease relative to the baseline constant value (the percentage of subjects that would respond favorably to "The Ideal Peach" even if no attributes were presented).

The ideal fresh peach		
	Base Size	300
	Constant	41
	Attribute	InV
E3	So sweet … no sugar needed	12
B3	Full of juice	10
C1	Plump and round	8
A6	Pit easily comes free from the peach flesh	8
E6	Sweet rich flavor with mildly tart overtones	8
A2	Melts in the mouth when you bite into the peach	5
A3	Thin skin that melts away	4
F3	High in vitamin C	4
C3	As big as a small softball	4
E2	Bold and intense peach flavor	3
D6	Red skin color that bleeds into the flesh	2
B1	Smooth skin with very little fuzz	2
D1	All-over blush, almost solid red in skin color	2
F4	A rich source of dietary fiber	2
B6	Crisp and firm	2
F5	Organic peaches	1
D5	Yellow flesh color with red flesh near the pit	1
B2	Typical fuzzy peach skin	1
C5	Medium size, like a baseball	1
D4	Bright yellow flesh color	1
F1	Full of antioxidants	1
F6	A low-carb source of nutrients	1
D2	Mainly yellow skin color, with a slight blush	0
F2	No fat … no cholesterol	–1
E4	Tart peach that wakes the taste buds	–1
D3	White flesh color	–2
A1	Bite into peach … and hear a loud crunch	–2
E5	Soft peach flavor, but are much more floral tasting	–2
A5	Peach clings to the pit	–3
E1	Mild flavor … but compliments well	–3
C4	Small, bite-sized peaches	–3
A4	Tough chewy skin	–7
C2	Elongated shape (beaked) with characteristic suture	–8
C6	Flat, shaped like a donut	–8
B4	Meaty, not juicy	–11
B5	Mealy … pasty, and dry	–18

interest in peaches, but was uninterested in peach flavor. Instead, they were more likely to purchase peaches described as being smooth, juicy, and bright yellow in flesh. This segment was made up of a large proportion of Hispanics compared with other ethnicities, with purchases made in suburban supermarket chain stores.

Consumer preference study. In the farmers' market survey (Sarasota, FL), fewer questions were asked of the participants compared with the national online survey; however, they were asked to evaluate the sensory aspects of whole fruit and peach slices, which was not possible with the online survey. Each of the two peach samples, 'UFSun' and 'TropicBeauty', which were given to participants in the farmers' market studies embodied attributes that were included in the Ideamap® survey, such as those for melting/nonmelting texture, mild or bold peach flavors, and pit characteristics such as freestone or clingstone. 'UFSun' is a round, moderately blushed peach with nonmelting texture, yellow flesh, and a clingstone pit (Fig. 4A). 'TropicBeauty' is also a round, moderately blushed peach, but with melting texture, yellow flesh, and a semifreestone pit (Fig. 4B).

Women were the predominant subjects intercepted in the farmers' market studies in both years while the predominant age group was 45–65 years old (Fig. 5). The location of the farmer's market in a coastal Florida community with a high proportion of retirees, may have affected age group distribution. In 2013, subjects preferred the aroma, texture, firmness, and flavor of 'TropicBeauty' compared with 'UFSun' ($P < 0.05$; Table 5), which resulted in higher overall liking scores for 'TropicBeauty'. In 2014, subjects again preferred 'TropicBeauty' over 'UFSun', as indicated by higher ratings for texture, flavor, and overall liking ($P < 0.05$; Table 5).

In both years, significant strong positive correlations ($R > 0.60$) were found between color and shape, flavor and overall liking, texture and overall liking, flavor and texture, and firmness and overall liking (Table 6). The most consistent correlations were those with color, shape, texture, firmness, flavor, and overall liking in both years. There was a fairly weak correlation between TSS and all attributes, whereas objective measurements of firmness (kgf) were weakly negatively correlated with most attributes (Table 6). As expected, ratings of firmness and texture in both years were strongly correlated.

In 2013, TSS did not significantly differ in either peach variety, whereas in 2014 'TropicBeauty' had greater TSS than in 'UFSun' (Table 5). However, this objective measurement of soluble solids was not correlated with overall liking. Both peach varieties tested had typical acidity levels, and were not subacid varieties (Rouse and Sherman, 2002; Rouse et al., 2004) (Fig. 4).

Discussion

Peach fruit vary in size, shape, skin/flesh color, aroma compounds and phytochemical attributes, and appeal to multiple senses, including visual, olfactory, and tactile attributes that are important in peach purchases (Bruhn, 1995; Bruhn et al., 1991). The combination of these fruit quality attributes drives not only initial purchases, but return purchases, driving consumer demand. In this study, the "ideal peach" depended on different combinations of these fruit quality attributes that allowed the panelists to respond to a potential peach purchase situation and helped reduce cognitive bias directed at individual attributes (DellaVigna, 2009; Price and Riis, 2012; Redelmeier and Dickinson, 2011).

Peaches that were "so sweet … no sugar needed" were most likely to increase consumer purchase likelihood, similar to those studies conducted in reference to strawberries and blueberries (Colquhoun et al., 2012; Gilbert et al., 2014). In peach, a minimum of 10% TSS has been recommended for consumer acceptance, and fruit with less than 10% TSS were rated as having low fruit quality (Crisosto and Crisosto, 2005; Robertson et al., 1989). However, in the farmers' market validation study, TSS (%) was not related to overall liking (Table 6). Thus, although consumers perceive high sugar content as related to flavor and liking, sugar content alone is not the likely driver of overall liking in fresh peaches. In one study, a significant relationship was not found between individual sugars in peach and sensory panel ratings of sweetness, yet there was a significant relationship between the sugar to acid ratio and perceived sweetness (Colaric et al., 2005). Acidity and astringency were found to have strong positive relationships with liking of peach samples ($R^2 = 0.60$ and 0.65, respectively) (Predieri et al., 2006). However, the relationship between liking and sweetness was weak ($R^2 = 0.21$) and the authors hypothesized that the relationship may not even be linear. In 'Harvester' peaches, as sucrose and volatiles increased and acid concentration decreased, the sensory panel acceptability increased; however, no statistical tests of the data were done to show significance of this relationship (Meredith et al., 1989). High TA has been correlated to lower consumer acceptance of peach fruit (Crisosto et al., 2006); however, a combination of acidity, aroma, and flavor components are optimal when fruit are physiologically ripe

Table 3. The two highest and lowest attribute interest values (InV) for the "The Ideal Fresh Peach" compared by reported gender, age, ethnicity, income, relationship status, neighborhood classification, U.S. region of residency, and peach point of purchase. InV are relative to the baseline constant value (the percentage of subjects that would respond favorably to "The Ideal Peach" even if no attributes were presented) to compare the tested attributes and are presented next to their corresponding attribute in parentheses.

	Gender	
	Male	Female
Base size	139	161
Constant	*30*	*50*
Highest	Plump and round (14)	So sweet … no sugar needed (13)
Highest	Sweet rich flavor with mildly tart overtones (14)	Full of juice (8)
Lowest	Meaty … not juicy (–8)	Meaty … not juicy (–14)
Lowest	Mealy … pasty and dry (–13)	Mealy … pasty and dry (–21)

	Age			
	18–24	25–34	35–50	51–65
Base size	36	69	118	77
Constant	*54*	*49*	*41*	*26*
Highest	Full of juice (19)	Plump and round (15)	So sweet … no sugar needed (15)	So sweet … no sugar needed (19)
Highest	Crisp and firm (16)	Pit easily comes free from the peach flesh (12)	Sweet rich flavor with mildly tart overtones (10)	Melts in the mouth when you bite into the peach (14)
Lowest	Bright yellow flesh color (–17)	Mealy … pasty and dry (–14)	Tough chewy skin (–10)	Flat, shaped like a donut (–11)
Lowest	Mild flavor … but compliments well (–18)	Meaty … not juicy (–18)	Mealy … pasty and dry (–21)	Mealy … pasty and dry (–19)

	Ethnicity			
	White/Caucasian	Black/African American	Hispanic/Latino	Asian
Base size	66	72	83	79
Constant	*13*	*48*	*45*	*53*
Highest	Melts in the mouth when you bite into the peach (18)	So sweet. No sugar needed (16)	Plump and round (18)	Pit easily comes free from the peach flesh (10)
Highest	Sweet rich flavor with mildly tart overtones (18)	Full of juice (9)	So sweet … no sugar needed (10)	So sweet … no sugar needed (5)
Lowest	Meaty … not juicy (–5)	Meaty … not juicy (–15)	Peach clings to the pit (–12)	Meaty … not juicy (–12)
Lowest	Mealy … pasty and dry (13)	Elongated shape (beaked) with characteristic suture (–16)	Mealy … pasty and dry (–23)	Mealy … pasty and dry (–20)

	Income						
	Under $30,000	$30,000–$39,999	$40,000–$49,999	$50,000–$74,999	$75,000–$99,999	$100,000-$124,999	$125,000 plus
Base size	48	36	42	68	49	28	29
Constant	*28*	*41*	*41*	*42*	*31*	*73*	*43*
Highest	Plump and round (17)	So sweet … no sugar needed (14)	Pit easily comes free from the peach flesh (18)	So sweet … no sugar needed (10)	Melts in the mouth when you bite into the peach (14)	So sweet … no sugar needed (4)	Full of juice (17)
Highest	So sweet … no sugar needed (16)	Plump and round (14)	So sweet … no sugar needed (16)	Sweet rich flavor with mildly tart overtones (10)	Mainly yellow skin color, with a slight blush (12)	Pit easily comes free from the peach flesh (4)	So sweet … no sugar needed (14)
Lowest	Mealy … pasty and dry (–8)	Meaty … not juicy (–15)	Mealy … pasty and dry (–17)	Bite into peach … and hear a loud crunch (–12)	Elongated shape (beaked) with characteristic suture (–16)	Tough chewy skin (–20)	Meaty … not juicy (–13)
Lowest	Flat, shaped like a donut (–12)	Mealy … pasty and dry (–19)	Meaty … not juicy (–19)	Mealy … pasty and dry (–14)	Mealy … pasty and dry (–34)	Mealy … pasty and dry (–34)	Mealy … pasty and dry (–22)

(*Continued on next page*)

Table 3. (*Continued*) The two highest and lowest attribute interest values (InV) for the "The Ideal Fresh Peach" compared by reported gender, age, ethnicity, income, relationship status, neighborhood classification, U.S. region of residency, and peach point of purchase. InV are relative to the baseline constant value (the percentage of subjects that would respond favorably to "The Ideal Peach" even if no attributes were presented) to compare the tested attributes and are presented next to their corresponding attribute in parentheses.

Marital status			
	Single	Married	Separated/divorced
Base size	121	147	28
Constant	*34*	*46*	*43*
Highest	So sweet … no sugar needed (12)	So sweet … no sugar needed (12)	Sweet rich flavor with mildly tart overtones (17)
Highest	Full of juice (12)	Pit easily comes free from the peach flesh (9)	So sweet … no sugar needed (15)
Lowest	Meaty … not juicy (–9)	Meaty … not juicy (–12)	Elongated shape (beaked) with characteristic suture (–22)
Lowest	Mealy … pasty and dry (–14)	Mealy … pasty and dry (–22)	Flat, shaped like a donut (–24)

Neighborhood			
	Rural	Suburban	Urban
Base size	24	169	107
Constant	*31*	*37*	*48*
Highest	Plump and round (18)	So sweet … no sugar needed (13)	So sweet … no sugar needed (11)
Highest	Small, bite-sized peaches (16)	Full of juice (12)	Sweet rich flavor with mildly tart overtones (9)
Lowest	No fat … no cholesterol (–10)	Elongated shape (beaked) with characteristic suture (–10)	Meaty … not juicy (–15)
Lowest	Bite into peach … and hear a loud crunch (–13)	Mealy … pasty and dry (–15)	Mealy … pasty and dry (–24)

U.S. region						
	Northeast	Northwest	Midwest	Southeast	Southwest	Central
Base size	90	31	50	55	66	8
Constant	*40*	*61*	*43*	*35*	*36*	*30*
Highest	Full of juice (15)	So sweet … no sugar needed (14)	Plump and round (8)	So sweet … no sugar needed (12)	Melts in the mouth when you bite into the peach (13)	A low-carb source of nutrients (23)
Highest	So sweet … no sugar needed (13)	Sweet rich flavor with mildly tart overtones (8)	Full of juice (8)	Thin skin that melts away (10)	So sweet … no sugar needed (13)	Sweet rich flavor with mildly tart overtones (23)
Lowest	Meaty … not juicy (–14)	Tough chewy skin (–12)	Small, bite-sized peaches (–11)	Tough chewy skin (–11)	Flat, shaped like a donut (–10)	Crisp and firm (–35)
Lowest	Mealy … pasty and dry (–18)	Mealy … pasty and dry (–21)	Mealy … pasty and dry (–16)	Mealy … pasty and dry (–13)	Mealy … pasty and dry (–23)	Elongated shape (beaked) with characteristic suture (–48)

Peach point of purchase					
	Supercenter chain store	Local commercial grocery store	Farmers market	Roadside stand	Neighborhood grocery store
Base size	83	112	85	11	5
Constant	*44*	*29*	*51*	*42*	*63*
Highest	So sweet … no sugar needed (9)	So sweet … no sugar needed (18)	Thin skin that melts away (13)	All-over blush, almost solid red in skin color (12)	Melts in the mouth when you bite into the peach (12)
Highest	Yellow flesh color with red flesh near the pit (6)	Full of juice (14)	Pit easily comes free from the peach flesh (13)	Medium size, like a baseball (12)	So sweet … no sugar needed (8)
Lowest	Tough chewy skin (–11)	Sweet rich flavor with mildly tart overtones (–8)	Mealy … pasty and dry (–14)	Smooth skin with very little fuzz (–19)	Peach clings to the pit (–32)
Lowest	Meaty … not juicy (–13)	Bold and intense peach flavor (–25)	Meaty … not juicy (–16)	Typical fuzzy peach skin (–21)	Mainly yellow skin color, with a slight blush (–35)

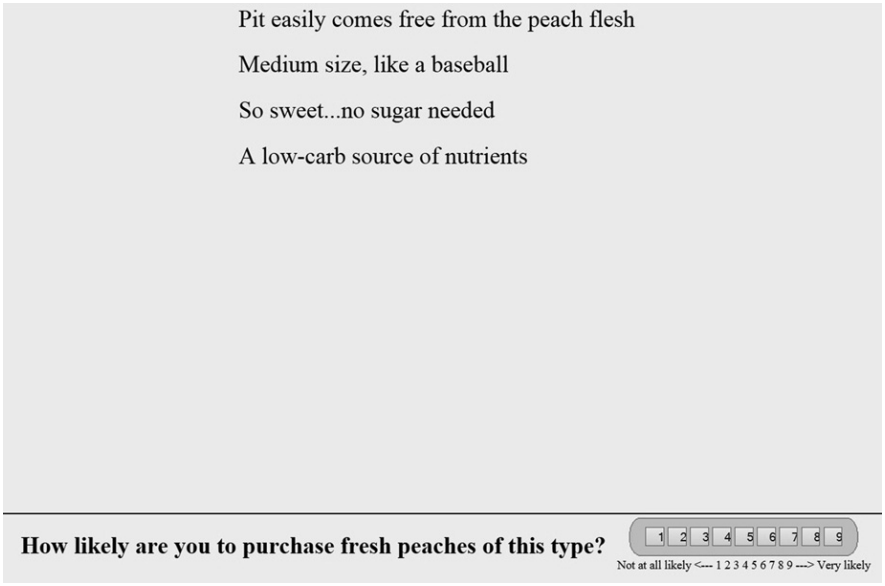

Fig. 3. Reported demographics (%) that make up each of the four segments discovered in "The Ideal Peach" consumer perception survey ($N = 300$): Segment 1 "Sweet and Smooth"; Segment 2 "Peachy Flavor"; Segment 3 "Sees Size, Not Color"; Segment 4 "Canned Peaches." (**A**) Gender, (**B**) Age group, (**C**) Ethnicity, (**D**) Income, (**E**) Relationship Status, (**F**) Neighborhood Classification, (**G**) US Region, and (**H**) Purchase Location.

Table 4. K-cluster analysis ($K = 4$) of the 300 subjects who completed "The Ideal Fresh Peach" survey revealed four segments of peach consumers that respond strongly to different groups of peach attributes.

		Segment 1	Segment 2	Segment 3	Segment 4
	Base Size	126	83	61	29
Attribute	*Constant*	*30*	*37*	*56*	*62*
A1 Bite into peach … and hear a loud crunch		7	–20[y]	6	–10
A2 Melts in the mouth when you bite into the peach		12	–7	9	–1
A3 Thin skin that melts away		15[z]	–10	4	–4
A4 Tough chewy skin		0	–20[y]	–1	—8
A5 Peach clings to the pit		6	–16	4	–12
A6 Pit easily comes free from the peach flesh		15[z]	–4	12	3
B1 Smooth skin with very little fuzz		5	2	–10	17[z]
B2 Typical fuzzy peach skin		3	3	–7	3
B3 Full of juice		13	8	6	10[z]
B4 Meaty … not juicy		–16[y]	—6	–11	–3
B5 Mealy … pasty and dry		–19[y]	–19[y]	–25[y]	8
B6 Crisp and firm		3	1	–4	9
C1 Plump and round		6	14	11	1
C2 Elongated shape (beaked) with characteristic suture		–14	–6	1	–4
C3 As big as a small softball		2	1	18[z]	–10
C4 Small, bite-sized peaches		–11	1	16[z]	–17
C5 Medium size, like a baseball		–1	3	10	–13
C6 Flat, shaped like a donut		–15[y]	–11	13[z]	–8
D1 All-over blush, almost solid red in skin color		7	5	–14	7
D2 Mainly yellow skin color, with a slight blush		2	4	–13	6
D3 White flesh color		8	–7	–15[y]	1
D4 Bright yellow flesh color		6	–1	–13	12[z]
D5 Yellow flesh color with red flesh near the pit		2	3	–6	6
D6 Red skin color that bleeds into the flesh		6	5	–6	–1
E1 Mild flavor … but compliments well		–6	14	–14	–12
E2 Bold and intense peach flavor		3	17[z]	–3	–27[y]
E3 So sweet … no sugar needed		15[z]	26[z]	3	–19
E4 Tart peach that wakes the taste buds		4	8	–8	–28[y]
E5 Soft peach flavor, but are much more floral tasting		–7	11	–4	–20[y]
E6 Sweet rich flavor with mildly tart overtones		8	21[z]	0	–17
F1 Full of antioxidants		10	–7	–6	–2
F2 No fat … no cholesterol		6	–3	–12	3
F3 High in vitamin C		12	–1	–2	–1
F4 A rich source of dietary fiber		11	0	–15[y]	5
F5 Organic peaches		6	–2	–4	2
F6 A low-carb source of nutrients		9	–4	–7	0

[z]Three most positive defining attributes.
[y]Three most negative defining attributes.

(Delgado et al., 2013; Do et al., 1969; Kao et al., 2012; Schwieterman et al., 2014). In this study, TA of fruit served to farmer's market survey participants was not examined as there are few inexpensive in-field instruments for TA.

Fig. 4. 'UFSun' fruit (**A**) and 'TropicBeauty' fruit (**B**) used in farmers' market intercept surveys showing shape and color attributes.

Consumers in all segments and categories had a very negative response to the description of mealy, pasty, dry peaches, which mirrored previous studies in blueberry and apple (Gilbert et al., 2014; Jaeger et al., 1998). In peaches, this mealy texture is most often caused by internal tissue breakdown due to chilling injury (CI) (Lurie and Crisosto, 2005), and can significantly lower the consumer acceptability of fruit with above-average peach flavor metrics (Crisosto, 2002). In peach, mealy texture is partly determined by texture type (melting) and genetic tests have been developed to screen for susceptible varieties in breeding programs (Martínez-García et al., 2012).

Given this strong aversion to mealy texture, we were interested to test whether the difference between melting texture and nonmelting texture resulted in changes to overall liking. In a previous study, panelists scored peaches higher that were firmer; however, the four peach varieties tested were melting texture and is therefore not informative in comparing nonmelting varieties (Robertson et al., 1989). Sensory differences can be detected between melting and nonmelting peach texture, but preference for one texture type over another has not been measured (Brovelli et al., 1999). Our online study and the farmers' market survey suggests that most consumers prefer melting peaches, but small segments of the population are receptive to crisp and firm peaches (18–24 age group). This could indicate a shift in preferences for nonmelting peach texture or slightly underripe fruit as this younger generation become the major produce buyers in their household.

Despite inquiries about the interest in the health aspects of peaches, this category was not of major interest for any group of survey participants. Although peaches have been shown to have antagonistic properties for different cancer types, consumers may not be aware of the health benefits of peaches. For marketing intermediaries, this is an educational opportunity for those striving to increase peach consumption in the United States.

Age had a particular influence on those purchasing fresh peaches, with those between 51 and 68 years of age were the least interested, whereas those with the greatest interest were aged 18–24 years. Older consumers may have experienced repeated purchases of poor peach fruit quality that their interests have shifted to other fruit

Table 5. Consumer acceptance of skin color, fruit shape, fruit aroma, fruit texture, fruit firmness, flavor, and overall liking for two peach varieties, 'UFSun' and 'TropicBeauty' during farmers' market intercept studies in 2013. Objective measurements of °Brix and firmness (kgf) were correlated with individual surveys.

		Variety		
Yr	Sensory measure	UFSun	TropicBeauty	*P* value
2013	Skin color	7.5	7.6	NS
	Fruit shape	7.6	7.6	NS
	Fruit aroma	6.3	7.6	<0.001
	Fruit texture	6.7	7.3	0.02
	Fruit firmness	6.6	7.4	<0.001
	Flavor	6.7	7.4	0.04
	Overall liking	6.6	7.3	0.03
	Soluble solids (%TSS)	9.3	9.3	NS
	Firmness (kgf)	1.1	0.7	0.002
2014	Skin color	7.5	7.7	NS
	Fruit shape	7.6	7.4	0.04
	Fruit aroma	7.5	7.6	NS
	Fruit texture	7.0	7.4	NS
	Fruit firmness	7.0	7.2	NS
	Flavor	6.9	7.4	0.009
	Overall liking	6.9	7.4	0.009
	Soluble solids (%TSS)	10.4	11.2	<0.001
	Firmness (kgf)	1.1	0.1	<0.001

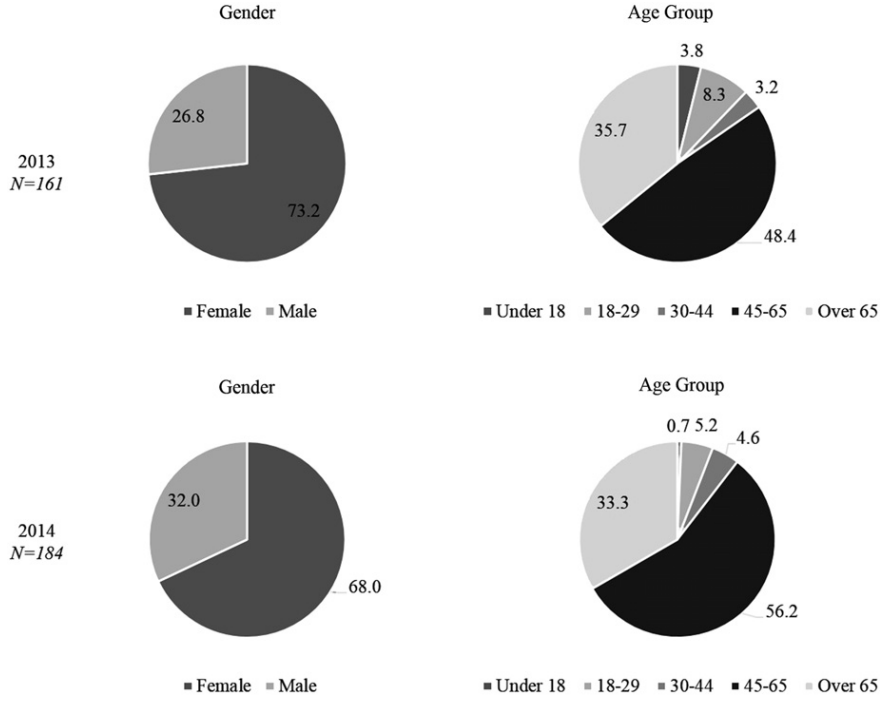

Fig. 5. Reported demographics of the 2013–14 farmers' market intercept surveys (N = 345).

categories; however, this was not examined in this study. In regard to the younger generation, their interest is perhaps indicative of the successful fruit purchasing messages to increase fruit consumption. Repeated follow-up surveys of this group as they age may show a sustained interest in peach purchases.

Consumers that most often purchased from local commercial grocery stores or supercenter chain stores did not respond favorably to flavor attributes, possibly indicating that their past peach purchases have not consistently provided good fruit flavor. Postharvest efforts on peach/stone fruit ripening over several decades have shown harvesting of fruit that is physiologically ripe must be properly handled to deliver an acceptable product (Crisosto, 2006). Recent efforts from major supermarket chains to promote ''local'' produce with better flavor is one way marketers can increase peach purchases in urban markets, provided fruit have excellent flavor.

The segmentation of panelists by their responses revealed four unique groups of consumers who value different peach attributes (Table 4). The largest group (Segment 1), ''Sweet/Freestone,'' made the majority of their purchases from roadside stands and was more receptive to small-sized fruit that were freestone. For growers, selling produce via road stand markets is an important avenue for sales of fruit that do not meet minimum commercial standards, which are often based on peach fruit size. The second segment, the ''Peachy Flavor'' cluster, was made up by more suburban subjects than any other segment. Consumers in this segment wanted sweet peaches with bold or rich peach flavors, and were largely Hispanic consumers that purchased peaches in either their local commercial grocery store or a supercenter chain store. As this segment of the U.S. population increases, marketing messages should target this sector of consumers in both local and superchain grocery stores. Segment 3, which ''Sees Size, Not Color,'' was largely composed of those from Asian descent. Thus, visual appearances and large fruit size may trigger an initial purchase, but a range of textures will drive repeat purchases based on the responses of this segment. Segment 4 may have most exposure or increased preference for ''Canned Peaches'' or ''Nectarines'' based on their affinity for smooth, juicy, bright yellow peaches. These panelists were far more likely to be married than single, and had the largest proportion of Hispanics compared with other segments. In fact, there was not one combination of peach attributes that was ideal for all segments, but four different combinations of attributes that targeted a majority of the consumers in this study. Differentiation in the peach market based on these segments may draw in new consumers with targeted marketing efforts, and focus on the most important traits for each segment may reinforce repeat purchases.

Overall, we found that consumers in both the online and the farmer's market studies preferred peaches that were sweet, had melting texture and good flavor. In breeding programs with a strong focus on nonmelting textures, this information indicates that having a diversified portfolio of melting, slow-melting, and nonmelting texture selections will target a broader consumer base. The ideal peach shape was one that was ''plump and round'' as shown by the preference of farmers' market survey participants to 'UFSun', a characteristically round fruit compared with 'TropicBeauty'. Fruit with elongated shapes and prominent sutures are often not selected in breeding programs in favor of uniformly round peach fruit. There were segments of consumers that could be targeted with peaches that have unique attributes such as crisp, firm texture (e.g., nonmelting texture), but additional marketing and educational efforts are needed for unique fruit shapes such as peen-to or donut-shaped peaches to increase consumer acceptance. Future research will address specific interests in health attributes, peach fruit consumption by category (i.e., fresh consumption, processed in yogurt, smoothies, etc., or desserts), and detailed texture descriptions to examine the relationship between consumer acceptance and melting/nonmelting texture peaches.

Table 6. Pearson correlation coefficient (R) values between sensory and quantitative scores for all peach atributes measured among during farmers' market surveys [Sarasota, FL, in 2013 (N = 161) and 2014 (N = 184)].

Yr	Category/measurement	Color	Shape	Aroma	Texture	Firmness	Flavor	Overall liking	°Brix	Firmness (kgf)
2013	Color	1.00	**0.65***[z]	0.39*	0.39*	0.36*	0.34*	0.39*	0.15*	–0.03
	Shape		1.00	0.39*	0.34*	0.40*	0.27*	0.32*	0.21*	–0.03
	Aroma			1.00	0.38*	0.37*	0.38*	0.39*	0.14*	–0.15
	Texture				1.00	**0.76***	**0.72***	**0.79***	0.16*	–0.05
	Firmness					1.00	**0.60***	**0.69***	0.16*	0.01
	Flavor						1.00	**0.93***	0.23*	–0.03
	Overall Liking							1.00	0.23*	0.01
	°Brix								1.00	0.00
	Firmness (kgf)									1.00
2014	Color	1.00	**0.62***	0.41*	0.26*	0.17*	0.21*	0.22*	0.04	–0.06
	Shape		1.00	0.39*	0.23*	0.19*	0.22*	0.21*	–0.02	0.03
	Aroma			1.00	0.22*	0.19*	0.33*	0.32*	0.01	–0.07
	Texture				1.00	**0.80***	**0.70***	**0.74***	0.11	–0.15*
	Firmness					1.00	**0.67***	**0.69***	0.09	–0.09
	Flavor						1.00	**0.86***	0.10	–0.22*
	Overall Liking							1.00	0.14*	–0.20*
	°Brix								1.00	–0.29*
	Firmness (kgf)									1.00

[z]Asterisks that follow a column indicate statistical significance of pairwise correlation ($P < 0.05$).
Strongly correlated attributes ($R > 0.60$) are highlighted in bold text, whereas minus signs indicate negative correlations.

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