Consumer-assisted Selection of Blueberry Fruit Quality Traits

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Abstract. Blueberries are a high-value fruit that has experienced extraordinary growth in consumption in the past decade. Maintaining this growing market requires an understanding of the current market and its potential for expansion. To assay the impact of 36 specific blueberry sensory and psychological traits on consumer interest, a blueberry fruit quality study was constructed using techniques that allow many features to be tested in an analysis by combining specifics from different categories that describe a product. Individual traits that most impact the likelihood of fruit purchase were identified. Sweet and intense blueberry flavor yielded the most positive purchase interest, whereas bad texture attributes such as seediness were the most detrimental to interest. It was also possible to define two interest segments within the survey population that shared similar responses to particular experimentally assayed traits. The larger segment of the sample population (61%) was most interested in the aspects of blueberry flavor, whereas the second segment of respondents (39%) was most influenced by health aspects commonly associated with blueberry fruit consumption. Both segments responded negatively to bad texture. This study suggests that breeders and producers should exploit genetic and environmental variables that contribute to improved blueberry flavor and that marketing strategies to sell blueberry cultivars of superior flavor may be appropriate.

Blueberries [northern highbush (*Vaccinium corymbosum*), southern highbush (*V. corymbosum* hybrids), rabbiteye (*V. virgatum*), and lowbush (*V. angustifolium*)] are an economically important small fruit crop in the United States with 277 million pounds harvested for fresh production valued at \$850.8 million U.S. in 2012 (USDA, 2013). Blueberry acreage continues to increase worldwide in accordance with growing demand for these antioxidant-rich fruit. Although native to North America, breeding programs have developed blueberry cultivars that grow in a wider array of climates, allowing production to flourish in South America, Europe, Asia, and Australia. Global highbush blueberry production passed the one billion pound mark in 2012 and continues to accelerate (Brazelton, 2013). Historically, many traits have been selected for in blueberry breeding programs with producers in mind, including climatic adaptation, yield, mechanical harvest potential, and disease resistance. Conversely, the fruit quality traits of interest to the consumer

are what should ultimately fuel production and profitability. In recent surveys, only 48% of U.S. consumers had bought blueberries in the past 12 months compared with 88% of consumers who had bought the highest selling fruit, bananas (Fresh Trends, 2013). Of the 48% of U.S. consumers who purchased blueberries in the past year, 15% of these consumers were reportedly regular buyers of blueberries (Brazelton, 2013; Fresh Trends, 2013). Converting seldom purchasers into frequent purchasers through product satisfaction could have a beneficial impact on the blueberry market. To provide this level of product satisfaction, it is critical to assess the expectations and desires of the current blueberry consumer to make sure these parameters are being met. Increasing market penetration for the 50% of consumers who did not purchase blueberries in the past 3 years will be important to drive continued expansion of blueberry production as well (Brazelton, 2013; Fresh Trends, 2013).

Developing a new blueberry cultivar with improved traits for the producer or consumer is a long-term process. From the time an initial cross between two blueberry parents is made, the earliest a resulting progeny is typically considered for release is 10 years. This plant must then be marketed to nurseries or farmers who mass propagate the clones, which means that the blueberry breeder designing the

parental crosses is catering to an industry nearly two decades in the future. Breeders often work closely with the producers and are therefore aware of the changing needs of farmers. However, consumer satisfaction with the end product is influencing new directions in research and development of horticultural crops, encouraging breeder focus on traits such as improved strawberry (*Fragaria ×ananassa*) flavor (Colquhoun et al., 2012) and flower fragrance (Levin et al., 2012). With lengthy breeding cycles, it is critical to empirically assay the psychological influences of consumer blueberry purchases before committing to years of manipulating traits that may not actually affect marketability. Additionally, this information could be used to tailor messages directed to the consumer through commercial marketing, in advertisements, and on packaging.

When a consumer encounters a product, multiple attributes of the product may influence their purchase decision. The consumer may not necessarily be rational or consciously aware of the reasoning for this decision, and outright asking of the consumer to identify their desires may introduce cognitive bias (DellaVigna, 2009; Price and Riis, 2012; Redelmeier and Dickinson, 2011). Additionally, attempting to test a high number of variables for psychological impact can cause subject frustration and cognitive burden (Park and Lessig, 1981). Both of these issues can be tackled using modified conjoint analysis and rule-developing experimentation. In this approach, the consumer is presented with sets of three to four individual descriptive phrases or elements at a time, which reduces the variable load on the respondent. By posing many scenarios in which a product has a few attributes in different combinations, it is then possible to pull out individually impactful elements from the scheme (Behe, 2006; Behe et al., 1999, 2013; Jaeger et al., 2011; Moskowitz, 2012; Moskowitz et al., 2006; Moskowitz and Gofman, 2007). This method has been previously implemented to analyze favorable characteristics of fresh strawberries and flowers as a tool to guide breeding efforts in these horticultural crops (Colquhoun et al., 2012; Levin et al., 2012). The strawberry study identified sweetness and complex flavors as the most important traits to consumers, resulting in a large amount of effort and resources that have been devoted to biochemically characterizing strawberry flavor for identification of enhanced quality cultivars (Schwieterman et al., 2014).

This study was conducted as part of an ongoing effort to implement consumer-assisted selection in horticultural breeding programs. Consumer-assisted selection is an approach to product development that seeks to identify which features are of most importance to the end user, an ambition that can be sometimes be diluted along a complex supply chain. We sought to identify which blueberry traits are of most importance to consumers and may motivate purchase likelihood. We conducted two consumer-assisted marketing

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experiments each entitled “The Ideal Fresh Blueberry” to measure favorability of various blueberry attributes to guide research objectives, breeding priorities, and marketing messages that may characterize a superior blueberry experience to be delivered to the consumer.

Materials and Methods

Rule developing experimentation (RDE), developed by Moskowitz Jacobs Inc. in cooperation with the Wharton School of Business at the University of Pennsylvania, Philadelphia, PA, and implemented with the IdeaMap® interface, was used to identify consumer blueberry preferences. RDE is an experimental design used to assay the potential consumer interest of products comprised of new and different combinations of specific features. Many features may be tested in an analysis by combining specifics from different categories that describe a product. The consumer responds by indicating their interest (on a 9-point scale) to each unique product feature package. Using regression analysis, the independent variables (product specifications) are related to the dependent variable (consumer interest). IdeaMap® technology uses modified conjoint analysis to determine the effect of a single independent variable when presented in multiple combinations with other independent variables in a matrix setup in which product “concepts” and their constituent elements are assigned a binary rating of either 0 (consumer disinterest, rating of 1 to 6) or 100 (consumer interest, rating of 7 to 9) (Moskowitz, 2012; Moskowitz et al., 2006; Moskowitz and Gofman, 2007). This methodology was previously used by Colquhoun et al. (2012) and Levin et al. (2012) to evaluate consumer-desired traits in fresh strawberry and flowers, respectively. Setup of the two blueberry experiments and statistical analyses of the data are summarized below.

Two studies entitled “The Ideal Fresh Blueberry” were conducted: the first in Oct. 2011 and a second in June 2013. The subjects for the surveys were recruited independently through Panel Direct Online (<<http://www.paneldirectonline.com>>), a division of Focus Forward, LLC (<<http://www.focusfwd.com>>). Recruits logging into the study were initially asked their gender and ethnicity. We chose to recruit an approximate 50/50 split between male and female consumers because it closely approximates the likelihood of blueberry purchase based on gender as reported by Fresh Trends (2012, 2013). A total of 306 and 300 subjects completed the first and second “The Ideal Fresh Blueberry” studies, respectively.

In each study, six categories of blueberry traits were tested: firmness, texture, size, color, flavor, and human nutrition. These categories are major breeding objectives in the University of Florida blueberry breeding program. The categories were further divided into six specific elements for a total of 36 independent elements listed in Table 1.

Responses from the first study were used to grammatically modify a few of the elements in the second study for descriptive clarity. In both studies, each subject was introduced to the study by a welcome screen and was sequentially asked to rate their interest in fresh blueberry experiences consisting of a combination of three to four randomized elements (each from a different category) on a 9-point scale (1 = not at all likely, 9 = very likely). In the second study, the interest rating question was reworded to test likelihood of purchase rather than just favorability (Fig. 1). Subjects responded to 48 of these permuted element combinations and 10 demographic questions before completing the study. Unless otherwise indicated, the data tables presented in this article are from the 2013 study.

Regression modeling was used to determine which elements drive liking/disliking. Regression modeling related the independent variables (elements) to the dependent variable (rating) and assigned numerical values to each element using an additive equation of the form:

$$\text{Rating} = k_0 + k_1(\text{element A1}) + k_2(\text{element A2}) + \dots + k_{36}(\text{element F6}),$$

where k_0 is the additive constant and k_1 to k_{36} are coefficients that correspond to interest values (InV) of elements 1 to 36, respectively. This equation is calculated per respondent. The value k_0 is the sum of all the respondents’ ratings divided by the number of questions rated. The average of k_0 for all respondents is a representative baseline control called an additive constant and sets the benchmark for the impact of individual elements on consumer preference. The constant represents interest of subjects responding to the concept of an “ideal fresh blueberry” without influence of the subsequent elements. The averages of the coefficients of this equation are used to assign values to elements in the study as a whole or within segments. The InV of a particular element is shown as the difference respective to the constant to show incremental or decremental effects on overall liking (Moskowitz et al., 2006).

Market segmentation is an important concept that assumes heterogeneity in consumers’ preferences. There are two approaches that can be used to identify market segments, a priori segmentation and post hoc segmentation. In a priori segmentation, consumers are grouped by reported demographic differences such as gender, ethnicity, and income. In post hoc segmentation, consumers score aspects of product variables and are then clustered into groups with similar product preferences (Green and Krieger, 1991). Both approaches to market segmentation were explored with the data.

K-cluster analysis was applied to the matrices of 36 columns (one column per element) and 300 rows (one row per respondent) to identify post hoc segments within the surveyed populations and was performed in

SYSTAT 13 (Systat Software, Chicago, IL). Clusters comprise a fraction of the total population and separate the total population by differing impact values regarding the elements rated. Within a cluster, the strongest performing elements (positive or negative) are shared (Moskowitz, 2012). The two studies were compared for significant differences (Student’s *t* test, $\alpha = 0.005$) in reported InVs between the two respondent pools in JMP Pro 10 (SAS Institute Inc., Cary, NC). The reproducibility of population segmentation was analyzed by testing for significant differences between top-most and bottom-most defining elements in corresponding segments.

Results

The goal of this experiment was to determine consumer perceptions of the ideal fresh blueberry experience. Using RDE, we assayed sensory and psychological components of blueberry consumption that humans perceive as favorable or unfavorable by assaying how individual elements affected likelihood of purchase. Table 1 lists the six categories tested (firmness, texture, size, color, flavor, and nutrition), each comprised of six more specific elements. Experimental design of the descriptive elements was tested in the preliminary 2011 study. The study was replicated in 2013 with a separately recruited respondent pool and with six elements slightly reworded or completely changed for enhanced descriptive clarity. In each study, subjects rated 48 permuted combinations of three to four elements (Fig. 1) and answered 10 demographic questions (Fig. 2).

The baseline constant for both studies was similar at 55 and 41 for 2011 and 2013, respectively. Overall, responses to the same elements were not significantly different between the two respondent pools (Table 1). Six elements were altered from the 2011 study to the 2013 study for improved description of the sensory experience being portrayed. Element A1 was changed from “Bite down on a berry...hear a loud crunch” to “Crispy berry...pops in your mouth” to more adequately describe the experience of eating a crisp berry with a grape-like pop. The respondent reactions to the wording of these two elements were significantly different ($P < 0.005$). Interest values went from a sample average of -6 for “crunchy berries” in the first study to +4 for “crispy berries.” Similarly, a change in element D4 from the original “Blueberries with a waxy white coating” to “Blueberries with a soft, cloudy white coating” generated a significant change in InV ($P < 0.005$) from a sample average of -12 to -2. The clarification “like a grape” was added to element A4, “Firm with no give,” element B6 was changed from “Not mealy...at all” to “Light and airy,” C1 from “Plump and round” to “The biggest berries you’ve ever seen,” and C6 from “Medium size” to “Medium, dime-sized,” all with no significant difference in InV.

Table 1. Experimental design of categories (A–F) and individual elements (1–6) of each category for the 2013 “The Ideal Fresh Blueberry” consumer perception study.^z

2011 study			2013 study		
	Base size	302	Base size	300	
	Constant	55	Constant	41	
		InV		InV	
Category A: Berry Firmness					
A1	Bite down on berry...hear a loud crunch	–6	Crispy berry...pops in your mouth	4	*
A2	Mushy...melts in the mouth	–8	Mushy...melts in your mouth	–14	NS
A3	A soft berry	–5	A soft berry	–5	NS
A4	Firm with no give	–8	Firm with no give, like a grape	–2	NS
A5	Thin skin that melts away	–1	Thin skin that melts away	–2	NS
A6	Tough chewy skin	–19	Tough, chewy skin	–17	NS
Category B: Berry texture					
B1	Smooth texture without seeds	7	Smooth texture without seeds	2	NS
B2	Lots of seeds...a bit of grit	–21	Lots of seeds, a bit of grit	–19	NS
B3	Full of juice	10	Full of juice	7	NS
B4	Meaty...not juicy	–5	Meaty, not juicy	–9	NS
B5	Mealy...pasty and dry	–17	Mealy, pasty, and dry	–23	NS
B6	Not mealy...at all	–1	Light and airy	1	NS
Category C: Berry size					
C1	Plump and round	3	The biggest berries you’ve ever seen	5	NS
C2	Petite berries	–4	Petite berries	0	NS
C3	Tiny...to eat bunches at a time	–5	Tiny...to eat bunches at a time	–3	NS
C4	As big as a large marble	0	As big as a large marble	5	NS
C5	Small...pea sized	–7	Small, pea-sized	–4	NS
C6	Medium size	–1	Medium, dime-sized	4	NS
Category D: Berry color					
D1	Deep blue, almost black color	2	Deep blue, almost black color	5	NS
D2	Berries that are a shade of light blue	–2	Berries that are a shade of light blue	–1	NS
D3	Berries that are bright blue in color	–1	Berries that are bright blue in color	3	NS
D4	Blueberries with a waxy white coating	–12	Blueberries with a soft, cloudy white coating	–2	*
D5	Berries are dark blue throughout	3	Berries are dark blue throughout	6	NS
D6	Dark blue outside...pale inside	1	Dark blue outside, pale inside	3	NS
Category E: Berry flavor					
E1	Fruity flavor	6	Fruity flavor	6	NS
E2	Bold and intense blueberry flavor	7	Bold and intense blueberry flavor	11	NS
E3	Complex flavor with a hint of bitter	–9	Complex flavor with a hint of bitter	–6	NS
E4	So sweet...no sugar needed	10	So sweet, no sugar needed	13	NS
E5	Tart berry that wakes the taste buds	1	Tart berry that wakes the taste buds	–3	NS
E6	Mild flavor...but compliments well	1	Mild flavor, but compliments well	–3	NS
Category F: Human nutrition					
F1	Full of antioxidants	6	Full of antioxidants	7	NS
F2	No fat...no cholesterol	1	No fat, no cholesterol	0	NS
F3	High in vitamin C	6	High in vitamin C	2	NS
F4	A rich source of dietary fiber	6	A rich source of dietary fiber	2	NS
F5	Organic berries	5	Organic berries	5	NS
F6	A low-carbohydrate source of nutrients	0	A low-carbohydrate source of nutrients	–1	NS

^zEach category represents an aspect of blueberries such as: berry firmness, texture, size, color, flavor, and human nutrition. Within each category are six descriptive elements related to the category, resulting in a total of 36 individual elements. Interest values (InV) for elements measured by “The Ideal Fresh Blueberry” consumer-preference studies. InV compare the tested elements and are relative to the baseline constant value (the percentage of subjects that would respond favorably to “The Ideal Fresh Blueberry” even if no elements were presented) of 55 or 41 (2011 and 2013, respectively). A high InV indicates a positive effect on consumer liking; a low InV indicates a negative effect on consumer liking. InVs close to zero may be considered neutral on consumer affect. The two studies were compared for significant differences (Student’s *t* test, $\alpha = 0.005$) in reported interest values between the two respondent pools. Only elements A1, A4, B6, C1, C6, and D4 were changed between studies.

NS = nonsignificant.

Among both sample populations, the two elements that scored highest in consumer favorability by InV (Table 2) were the flavor elements “so sweet...no sugar added” and “bold and intense blueberry flavor.” Also among the five highest InVs in the final study were three elements from three separate categories: “full of juice,” “full of antioxidants,” and “berries are dark blue throughout.” In contrast, five quality traits most detrimental to purchase were from the berry firmness and texture categories, including

“mealy, pasty, and dry,” “lots of seeds, a bit of grit,” “tough chewy skin,” “mushy, melts in your mouth,” and “meaty, not juicy.” In general, the elements with the highest and lowest InVs were consistent between the two studies (Tables 1–3). Because the final study was a superior test of the complete set of blueberry traits, we present the data from the 2013 study in detail.

Of the 300 subjects who completed the final study, 99% had previously purchased blueberries in their lifetime, and 96% had

purchased fresh blueberries in the past year. The data were grouped by reported gender, age, ethnicity, income groups, and relationship status (Table 3) to see whether any a priori market segments could be distinguished (Green and Krieger, 1991). Flavor elements remained among the top two most favorable berry qualities in a majority of the groups, whereas tactile elements of seediness, chewiness, mealiness, or mushiness had the strongest potential to decrease purchase likelihood.

Mealy, pasty and dry
Berries that are a light shade of blue
So sweet, no sugar needed
No fat, no cholesterol

How likely are you to purchase fresh blueberries of this type?

1 2 3 4 5 6 7 8 9

Not at all likely <--- 1 2 3 4 5 6 7 8 9 ---> Very likely

Fig. 1. An example of a blueberry element combination presented to a survey subject. The subject responded to the interest rating question by indicating likelihood of purchase of this combination of elements.

Fig. 2. Reported demographic sections of the “Ideal Fresh Blueberry” consumer perception survey (total subjects = 300).

There was no difference between the elements with the two highest and lowest InVs when the data were grouped by gender

(Table 3). Females were more interested in the concept of the ideal fresh blueberry than males (constant = 44 and 37, respectively).

Both groups shared some of the most impactful high and low elements (Supplemental Table 1); however, males were more interested in fruity flavor and deep blue color, whereas females were more responsive to juicy berries as big as a large marble. Females responded more negatively to a seedy blueberry than males (InV = -25, female; -13, male). Additionally, females in this study were strongly opposed to tart and bitter berries.

The only age group to deviate from the flavor-interest norm was the 25- to 34-year age group, who were most driven to purchase by “medium, dime-sized” and “organic berries” (Table 3). The youngest group (18 to 24 years) was the most interested in blueberries (constant = 56, followed by the oldest age group (constant = 50), whereas the 35- to 50-year age group was least interested in the topic (constant = 28). Although they were most interested in the ideal fresh blueberry, the youngest group was not particularly interested in many specified aspects of blueberries listed in the study. The most impactful positive element for this age group was the element of bold and intense blueberry flavor. The 35- to 50-year age group was the only one that had a high InV for crispness, large size, fruity flavor, and antioxidants (Supplemental Table 2). Although organic berries were positive among those 25 to 34 years and 35 to 50 years of age, they elicited a negative response from those in the 51- to 65-year group.

When compared by reported ethnic group (Table 3), tactile elements reappeared consistently among the most unfavorable qualities for all groups. The Hispanic/Latino group was most responsive to “fruity flavor” and the Asian group also responded positively to “full of juice.” The white/Caucasian group was the only group to favor bright blue and dark blue elements (Supplemental Table 3). The only uniquely impactful element in the black/African American group was a strongly negative InV for “Firm with no give, like a grape.”

When the data were sorted by income, the groups with highest overall interest in the ideal fresh blueberry were those reporting earnings of \$100,000 to \$124,999 and under \$30,000 (Table 3). One of the top two highest scoring (InV) elements from the whole study was a top purchase influencer in each income group other than for subjects who reported earnings of \$100,000 to \$124,999. This group was most receptive to juicy, organic berries. Other elements besides the common flavor traits that revealed high InVs included crispy berries for the \$40,000 to \$49,999 group, big berries for the \$75,000 to \$99,999 group, and juicy berries for the \$125,000+ group. The group with earnings of \$50,000 to \$74,999 was the only group to show interest in soft berries, a sensory descriptor that most groups found to be strongly negative (Supplemental Table 4). The group with earnings of \$30,000 to \$39,999 was the only group to respond favorably to petite berries. Those earning \$50,000 to \$74,999 were the only ones to

Table 2. Element interest values (InV) for all 300 subjects of the “The Ideal Fresh Blueberry” consumer preference study are ordered from highest to lowest.²

	Element	InV
E4	So sweet, no sugar needed	13
E2	Bold and intense blueberry flavor	11
B3	Full of juice	7
F1	Full of antioxidants	7
D5	Berries are dark blue throughout	6
E1	Fruity flavor	6
C1	The biggest berries you’ve ever seen	5
C4	As big as a large marble	5
D1	Deep blue, almost black color	5
F5	Organic berries	5
A1	Crispy berry...pops in your mouth	4
C6	Medium, dime-sized	4
D3	Berries that are bright blue in color	3
D6	Dark blue outside, pale inside	3
B1	Smooth texture without seeds	2
F3	High in vitamin C	2
F4	A rich source of dietary fiber	2
B6	Light and airy	1
C2	Petite berries	0
F2	No fat, no cholesterol	0
D2	Berries that are a shade of light blue	-1
F6	A low-carbohydrate source of nutrients	-1
A4	Firm with no give, like a grape	-2
A5	Thin skin that melts away	-2
D4	Blueberries with a soft, cloudy white coating	-2
C3	Tiny...to eat bunches at a time	-3
E5	Tart berry that wakes the taste buds	-3
E6	Mild flavor, but compliments well	-3
C5	Small, pea-sized	-4
A3	A soft berry	-5
E3	Complex flavor with a hint of bitter	-6
B4	Meaty, not juicy	-9
A2	Mushy...melts in your mouth	-14
A6	Tough, chewy skin	-17
B2	Lots of seeds, a bit of grit	-19
B5	Mealy, pasty, and dry	-23

²InV are relative to the baseline constant value of 41 (the percentage of subjects that would respond favorably to “The Ideal Fresh Blueberry” even if no elements were presented) to compare the tested elements.

be interested in “tiny... to eat bunches at a time”; all other groups responded negatively to this size descriptor. A berry that is dark blue throughout received positive interest from the \$75,000 to \$99,999 group, where all other income groups responded neutrally to this element. The \$50,000 to \$74,999 group responded favorably to the concept of blueberries with a dark blue outside and a pale inside.

The single, married, and separated/divorced groups only differed in that (Table 3) the divorced/separated group was partial toward “berries that are a light shade of blue” but disliked “petite berries” (Table 3; Supplemental Table 5).

Respondents were asked to classify their neighborhoods as rural, suburban, or urban. Study interest as indicated by the constant value was the same between rural and urban respondents (constant = 37 and 36, respectively) (Table 3). The suburban group was more interested in the blueberries in general (constant = 45). The rural group was most interested in fruity flavored blueberries with a dark blue outside and pale inside; it was the only group in this classification scheme to respond favorably to this element (Supplemental Table 6).

Respondents reported the region of the United States in which they resided: Northeast

(NE), Northwest (NW), Midwest (MW), Southeast (SE), or Southwest (SW). Subjects in the SE and SW were most interested in blueberries (constant = 56 and 53, respectively), whereas the NW and MW had the lowest constant values (constant = 24 and 27, respectively) (Table 3). The NE was the only region interested in large, crisp berries. The SW responded favorably to the elements “full of juice” and “full of antioxidants.” The SE only responded positively to “so sweet, no sugar needed” (Supplemental Table 7).

Purchase location provided another variable for classification of blueberry consumers. Most consumers purchased their blueberries at their local commercial grocery store (n = 126) or at a supercenter chain store (n = 101) (Table 3). A smaller subset of respondents reported purchasing blueberries from a farmers market (n = 52). One percent to 2% of respondents reported purchasing berries at a roadside stand, mom and pop grocery store, u-pick, or other. The farmers’ market shoppers had a much higher interest in the general concept of blueberries than the store-bought groups (constant = 61 vs. 38 and 34). Given such a high constant value, no elements stood out as having a significant impact (Supplemental Table 8).

Two independent post hoc market segments (Green and Krieger, 1991) from “The

Ideal Fresh Blueberry” were defined using K-cluster analysis. K-cluster analyses of the two studies resulted in similar segments when K = 2 (Table 4). In either study, the interest of one segment was driven by the perceived flavor experience and the other by recognized health benefits associated with consuming blueberries. However, on further segmentation (K = 3, K = 4), the studies diverged in agreement. Therefore, we only report on the reproducible two-segment analysis. The larger first segment, composed of 61% of subjects surveyed (n = 184), had a slightly lower constant (39) than the study average (41). Elements from the flavor category (Table 1, Category E) scored very highly within this segment of the study with respondents indicating blueberries of sweet, bold, and fruity attributes as most desirable. The second segment (n = 116) had a constant value slightly higher (43) than the average and scored elements from the human nutrition category (Table 1, Category F) most favorably. This group wanted to purchase organic berries packed with antioxidants, fiber, and vitamin C. Both segments were uniformly demotivated to purchase blueberries that were seedy, mealy, chewy, and dry.

The reported demographics of the individual respondents falling into either segment are shown in Figure 3. Because the “flavor” segment was the larger of the two, there were generally more respondents from each demographic category in this segment. This being said, respondents of both segments had similar distributions of age, neighborhood classification, and blueberry purchase locations. The “health” segment was evenly represented by males and females, but the “flavor” segment was 57% female and captured 65% of total female respondents of the study. The white/Caucasian group made up the largest portion of the “flavor” segment with 70% of respondents from this group clustering into this segment. Asians made up a larger proportion of the “health” segment than the “flavor” segment (28% vs. 20%, respectively). The Hispanic and black/African American ethnic groups made up similar proportions of both segments. A higher proportion of respondents who reported making less than \$30,000 a year were grouped into the “health” segment.

Discussion

Because the blueberry buying decision and blueberry sensory and psychological experiences are composed of a complex and diverse set of traits with many different variables contributing to consumer preference, breeders have many avenues through which to attempt to improve their product. By assaying consumer preference for blueberry traits, breeders are better equipped to determine which aspects of blueberries result in the highest consumer favorability leading to purchase (and repetition of this behavior). With 50% of consumers having purchased blueberries in 2010, 2011, and 2012, and of

Table 3. The two highest and lowest elements and interest values (lnV, in parentheses) for the “The Ideal Fresh Blueberry” compared by reported gender, age, ethnicity, income, relationship status, neighborhood classification, U.S. region of residency, and blueberry purchase location.^z

Table 3. (Continued) The two highest and lowest elements and interest values (InV, in parentheses) for the “The Ideal Fresh Blueberry” compared by reported gender, age, ethnicity, income, relationship status, neighborhood classification, U.S. region of residency, and blueberry purchase location.²

	Neighborhood					
	Rural	Suburban	Urban	U.S. region		
Base size	38	158	104			
Constant	37	45	36			
Highest	Dark blue outside, pale inside (12)	So sweet, no sugar needed (12)	Bold and intense blueberry flavor (20)			
Highest	Fruity flavor (10)	Bold and intense blueberry flavor (7)	So sweet, no sugar needed (16)			
Lowest	Lots of seeds, a bit of grit (–18)	Lots of seeds, a bit of grit (–20)	Lots of seeds, a bit of grit (–20)			
Lowest	Mealy, pasty, and dry (–20)	Mealy, pasty, and dry (–24)	Mealy, pasty, and dry (–21)			
U.S. region						
Base size	97	33	65	47	52	
Constant	39	24	27	56	53	
Highest	Bold and intense blueberry flavor (15)	Bold and intense blueberry flavor (23)	So sweet, no sugar needed (19)	So sweet, no sugar needed (11)	Full of antioxidants (7)	
Highest	So sweet, no sugar needed (13)	So sweet, no sugar needed (19)	Organic berries (17)	As big as a large marble (5)	Full of juice (7)	
Lowest	Lots of seeds, a bit of grit (–21)	Tough, chewy skin (–22)	Lots of seeds, a bit of grit (–19)	Tough, chewy skin (–20)	Mealy, pasty and dry (–17)	
Lowest	Mealy, pasty, and dry (–23)	Mealy, pasty, and dry (–24)	Mealy, pasty, and dry (–24)	Mealy, pasty, and dry (–22)	Lots of seeds, a bit of grit (–20)	
Purchase location						
			Local commercial grocery	Farmers’ market		
Base size	101	126	52			
Constant	38	34	61			
Highest	So sweet, no sugar needed (11)	So sweet, no sugar needed (19)	Bold and intense blueberry flavor (4)			
Highest	As big as a large marble (11)	Bold and intense blueberry flavor (16)	Smooth texture without seeds (4)			
Lowest	Lots of seeds, a bit of grit (–18)	Lots of seeds, a bit of grit (–21)	Lots of seeds, a bit of grit (–26)			
Lowest	Mealy, pasty, and dry (–20)	Mealy, pasty, and dry (–23)	Mealy, pasty, and dry (–29)			

²InV are relative to the baseline constant value (the percentage of subjects that would respond favorably to “The Ideal Fresh Blueberry” even if no elements were presented) to compare the tested elements and are presented next to their corresponding element in parentheses.

that 15% repeat consumers, there exists plenty of room for market expansion (Brazelton, 2013; Fresh Trends, 2011, 2012, 2013).

The development of cogent phrases to describe aspects of the blueberry experience is a critical step in the construction of an IdeaMap study. This is underscored by the significantly differing responses to particular elements when reworded between the initial and final studies in this article (Table 1). Crispness is a novel blueberry texture that is present in few commercial cultivars, including ‘Bluecrisp’, ‘Sweetcrisp’, ‘Reveille’, ‘Dolores’, ‘Hortblue Poppins’, and ‘FL98-325’ (marketed under the trademarked name Indigocrisp) (Clark and Finn, 2010; Okie, 1999; Scalzo et al., 2009). On initial mastication of these blueberries, an audible, grape-like pop occurs on breaking the skin. However, the words used to describe this potentially unfamiliar blueberry trait affect the appeal of the hypothetical sensory experience. Respondents were unfavorable to the scenario “Bite down on berry...hear a loud crunch.” However, “Crispy berry...pops in your mouth” induced a positive response from test subjects. When the clarification “...like a grape” was added to element A4 “Firm with no give...” in the 2013 study, a small but statistically insignificant increase in response occurred. This element scored low negative InVs in both studies. This information is important for the marketing potential of these novel berries. Use of particular words may confuse the consumer and lead to rejection of the product, whereas others may garner genuine purchasing interest.

The lexicon used to describe the “bloom” of a blueberry fruit also presented difficulty. The bloom is a naturally occurring, fragile coat of wax that reflects light off the fruit, causing dark blueberry fruit to appear bright blue to powdery light blue in color. Different blueberry cultivars vary in the amount and type of wax deposited on the outer surface of the skin, resulting in variations in blueness (Albrigo et al., 1980; Retamales et al., 2014). In a consumer sensory panel by Saftner et al. (2008), a regression analysis of individual blueberry color values and visual appeal resulted in a weak but significant relationship between consumer preference and lighter blue fruit. This trait was described in the first IdeaMap study as “blueberries with a waxy white coating” and scored an InV of –12 (Table 1). On reflection, it was agreed on that the element as such did not communicate this blueberry characteristic adequately and was modified to “blueberries with a soft, cloudy white coating.” With the new wording, the element jumped from strongly negative to neutral (InV = –2). This information suggests that blueberry consumers would not be receptive to the verbal communication of this trait’s botanical jargon. Consumers motivated to purchase by color distinctions will simply make this decision visually.

A possible explanation for the variation of interest in relation to different descriptions of crispness and bloom may have to do

Table 4. K-cluster analysis (K = 2) of the 300 subjects who completed “The Ideal Fresh Blueberry” survey revealed two segments of current or potential fresh blueberry purchasers that responded highly favorably to different groups of blueberry attributes.^a

Element	Base size Constant	Segment 1 “Flavor”	Segment 2 “Health”
		184	116
A1	Crispy berry...pops in your mouth	3	5
A2	Mushy...melts in your mouth	-17	-8
A3	A soft berry	-7	-1
A4	Firm with no give, like a grape	-2	-2
A5	Thin skin that melts away	-6	4
A6	Tough, chewy skin	-21	-10
B1	Smooth texture without seeds	7	-5
B2	Lots of seeds, a bit of grit	-20	-19
B3	Full of juice	5	11
B4	Meaty, not juicy	-2	-20
B5	Mealy, pasty, and dry	-23	-23
B6	Light and airy	0	2
C1	The biggest berries you’ve ever seen	7	2
C2	Petite berries	6	-9
C3	Tiny...to eat bunches at a time	2	-11
C4	As big as a large marble	8	-1
C5	Small, pea-sized	0	-11
C6	Medium, dime-sized	9	-5
D1	Deep blue, almost black color	6	3
D2	Berries that are a shade of light blue	-1	-1
D3	Berries that are bright blue in color	3	2
D4	Blueberries with a soft, cloudy white coating	-3	-1
D5	Berries are dark blue throughout	8	2
D6	Dark blue outside, pale inside	1	7
E1	Fruity flavor	10*	-1
E2	Bold and intense blueberry flavor	16*	4
E3	Complex flavor with a hint of bitter	0	-15
E4	So sweet, no sugar needed	22*	-3
E5	Tart berry that wakes the taste buds	2	-10
E6	Mild flavor, but compliments well	1	-10
F1	Full of antioxidants	1	15
F2	No fat, no cholesterol	-4	6
F3	High in vitamin C	-4	11*
F4	A rich source of dietary fiber	-5	13*
F5	Organic berries	1	11*
F6	A low-carbohydrate source of nutrients	-7	8

^aThe three highest scoring elements in each segment are denoted by *.

with the lack of general consumer familiarity with these traits. A lack of exposure to crisp blueberries or to the attribute of blueberry bloom may leave the subject confused and could reduce the subject’s capacity for elaborate processing (Park and Lessig, 1981).

In contrast, three other element changes resulted in no significant variation in subject responses. The texture element “not mealy at all,” which garnered a fairly neutral InV of -1 in the first study, was replaced with “light and airy.” This element also failed to have a positive or negative impact on respondent interest with a comparably neutral InV of +1. Adding the visual “dime-sized” to the medium berry element increased the InV 5 points but was statistically insignificant. “The biggest berries you’ve ever seen” was substituted for the size element “plump and round” to create more distinction between the elements of this category and resulted in an insignificant InV increase of 2.

The consumer preference studies indicated that flavor may be the most influential category affecting human preference of fresh blueberries. Sweetness, flavor intensity, “blueberry-ness,” and fruitiness were all correlated to high consumer likelihood of

purchase (InV) in the sample surveyed as a whole and in nearly every classification dissection (Table 3). These results are similar to Saftner et al. (2008), in which overall eating quality was most highly correlated with flavor acceptability and blueberry-like flavor intensity in consumer panels. Subjects in this consumer preference study responded most negatively to mealy, seedy, mushy blueberry attributes, which were also found to be very important to eating quality in the Saftner et al. (2008) sensory acceptability study.

By segregating the data by the respondents’ answers to the classification questions, we can further understand the blueberry desires of more specific groups of the population. Within a particular classification frame, some groups are much more interested in blueberries than others. The most defining classification questions were ethnicity, income, neighborhood, region, and purchase location. There were few differences between genders, ages, or relationship status.

Those living in rural areas and those reporting income above \$100,000 were the only two classification groups to respond favorably to a blueberry with a dark blue

outside and a pale inside. This suggests that those in rural America have actually observed the inside of a fresh blueberry, which is not blue throughout as many would speculate and as the urban group found favorable (Supplemental Table 6). Those making more than \$100,000 were the most likely income group to purchase blueberries and therefore also have increased exposure to the product (Fresh Trends, 2011, 2012, 2013). Additionally, from 3 years of The Packer’s Fresh Trends (2011, 2012, 2013) data, the propensity to purchase blueberries increases relative to income, with those making \$100,000+ twice as likely to purchase blueberries as those making less than \$25,000. Furthermore, consumers in the northeastern United States are more likely to purchase blueberries than any other region (Fresh Trends, 2011, 2012, 2013).

Although a priori segmentation offered some insight into demographic variation of the ideal fresh blueberry, the observations were not much different from observing the population as a whole. Once the total panel was divided into two post hoc segments using cluster analysis, two patterns in preference became evident (Table 4). Segment 1, the largest segment comprised of 184 subjects, favored the blueberry flavor elements “So sweet...no sugar added,” “Bold and intense blueberry flavor,” and “Fruity flavor.” Above all other sensory experiences, desirable flavor had the most positive purchasing power. The smaller Segment 2 (116 subjects) had likely been influenced by the media coverage of health benefits that has helped to popularize blueberries. This “health” segment converged on aspects relating to antioxidants, fiber, vitamin C, and organic production. Antioxidants such as anthocyanins are found in high amounts in blueberry fruit and have been correlated with beneficial health effects in numerous biological systems including immunology, ophthalmology, cardiology, neurology, metabolism, and inflammation (Cassidy et al., 2013; Fan et al., 2012; Heim et al., 2012; Krikorian et al., 2010; Li et al., 2013; Liu et al., 2012; McNulty et al., 2011; Shukitt-Hale, 2012; Tipton et al., 2013; Yousef et al., 2013). The number of consumers who purchased organically produced blueberries doubled from 6% in 2010 to 11% in 2011 (Fresh Trends, 2011, 2012, 2013), reinforcing the influence of Segment 2’s preference for organic production on actual consumption.

These data suggest flavor components elicited the highest favor among blueberry sensory components in the larger population segment with nutrient-based marketing as an important psychological driver. Whether the respondents’ potential purchases were driven by sensory experience or the perceived health benefits, both segments of the study were in agreement that seedy, tough, and dry berry characteristics had a very negative impact on the likelihood of purchase. These cluster-derived segments present an opportunity to improve the blueberry market as a whole by providing focus for different points in the

Fig. 3. Reported demographics of the two segments identified through K-cluster analysis of the “Ideal Fresh Blueberry” consumer perception survey (total subjects = 300). Demographics are reported as percentage of the indicated segment. “Flavor” segment n = 184, “health” segment n = 116.

supply chain. To target the largest population segment, breeders should focus on improving blueberry flavor as experienced by the consumer. This requires study of genetically regulated blueberry biochemistry available to the breeder as well as the exploration of environmental variables controlled by the producers that could affect flavor biochemistry such as soil nutrients and postharvest storage effects. Most importantly, these studies should incorporate consumer flavor panels that empirically determine flavor biochemistry goals for the breeder. A similar approach should be taken to eliminate genetics or environmental variables that may cause the negative texture qualities rejected by consumers belonging to either segment. Marketing of individual blueberry cultivars for superior flavor could also benefit consumers desiring an enhanced sensory experience from their blueberries and could benefit producers by allowing them to set premium price points. The marketing link

of the supply chain would do well to continue highlighting the health benefits associated with eating blueberry fruit.

Literature Cited

- Albrigo, L.G., P.M. Lyrene, and B. Freeman. 1980. Waxes and other surface characteristics of fruit and leaves of native *Vaccinium elliotti* Chapm. J. Amer. Soc. Hort. Sci. 105:230–235.
- Behe, B., R. Nelson, S. Barton, C. Hall, C.D. Safley, and S. Turner. 1999. Consumer preferences for geranium flower color, leaf variegation, and price. HortScience 34:740–742.
- Behe, B.K. 2006. Conjoint analysis reveals consumers prefer long, thin asparagus spears. HortScience 41:1259–1262.
- Behe, B.K., B.L. Campbell, C.R. Hall, H. Khachatryan, J.H. Dennis, and C. Yue. 2013. Consumer preferences for local and sustainable plant production characteristics. HortScience 48:200–208.
- Brazelton, C. 2013. 2012 World blueberry acreage and production report. North American Highbush Blueberry Council, Folsom, CA.
- Cassidy, A., K.J. Mukamal, L. Liu, M. Franz, A.H. Eliassen, and E.B. Rimm. 2013. High anthocyanin intake is associated with a reduced risk of myocardial infarction in young and middle-aged women. Circulation 127:188–196.
- Clark, J.R. and C.E. Finn. 2010. Register of new fruit and nut cultivars: List 45. HortScience 45:716–756.
- Colquhoun, T.A., L.A. Levin, H.R. Moskowitz, V.M. Whitaker, D.G. Clark, and K.M. Folt. 2012. Framing the perfect strawberry: An exercise in consumer-assisted selection of fruit crops. J. Berry Res. 2:45–61.
- DellaVigna, S. 2009. Psychology and economics: Evidence from the field. J. Econ. Lit. 47: 315–372.
- Fan, Z.L., Z.Y. Wang, L.L. Zuo, and S.Q. Tian. 2012. Protective effect of anthocyanins from lingonberry on radiation-induced damages. Int. J. Environ. Res. Public Health 9:4732–4743.
- Fresh Trends. 2011. The packer. Vance Publishing, Lenexa, KS.
- Fresh Trends. 2012. The packer. Vance Publishing, Lenexa, KS.

- Fresh Trends. 2013. The packer. Vance Publishing, Lenexa, KS.
- Green, P.E. and A.M. Krieger. 1991. Segmenting markets with conjoint analysis. *J. Mark.* 55: 20–31.
- Heim, K.C., P. Angers, S. Leonhart, and B.W. Ritz. 2012. Anti-inflammatory and neuroactive properties of selected fruit extracts. *J. Med. Food* 15:851–854.
- Jaeger, S.R., R. Harker, C.M. Triggs, A. Gunson, R.L. Campbell, R. Jackman, and C. Requejo-Jackman. 2011. Determining consumer purchase intentions: The importance of dry matter, size, and price of kiwifruit. *J. Food Sci.* 76: S177–S184.
- Krikorian, R., M.D. Shidler, T.A. Nash, W. Kalt, M.R. Vinqvist-Tymchuk, B. Shukitt-Hale, and J.A. Joseph. 2010. Blueberry supplementation improves memory in older adults. *J. Agr. Food Chem.* 58:3996–4000.
- Levin, L.A., K.M. Langer, D.G. Clark, T.A. Colquhoun, J.L. Callaway, and H.R. Moskowitz. 2012. Using mind genomics (R) to identify essential elements of a flower product. *Hort-Science* 47:1658–1665.
- Li, C.Y., J. Feng, W.Y. Huang, and X.T. An. 2013. Composition of polyphenols and antioxidant activity of rabbiteye blueberry (*Vaccinium ashei*) in Nanjing. *J. Agr. Food Chem.* 61:523–531.
- Liu, Y.X., X. Song, D. Zhang, F. Zhou, D. Wang, Y. Wei, F. Gao, L. Xie, G. Jia, W. Wu, and B. Ji. 2012. Blueberry anthocyanins: Protection against ageing and light-induced damage in retinal pigment epithelial cells. *Brit. J. Nutr.* 108:16–27.
- McAnulty, L.S., D.C. Nieman, C.L. Dumke, L.A. Shooter, D.A. Henson, A.C. Utter, G. Milne, and S.R. McAnulty. 2011. Effect of blueberry ingestion on natural killer cell counts, oxidative stress, and inflammation prior to and after 2.5 h of running. *Appl. Physiol. Nutr. Metab.* 36:976–984.
- Moskowitz, H.R. 2012. ‘Mind genomics’: The experimental, inductive science of the ordinary, and its application to aspects of food and feeding. *Physiol. Behav.* 107:606–613.
- Moskowitz, H.R. and A. Gofman. 2007. Selling blue elephants. Wharton School Publishing, Upper Saddle River, NJ.
- Moskowitz, H.R., A. Gofman, J. Beckley, and H. Ashman. 2006. Founding a new science: Mind genomics. *J. Sens. Stud.* 21:266–307.
- Okie, W.R. 1999. Register of new fruit and nut varieties list 39. *HortScience* 34:181–205.
- Park, C.W. and V.P. Lessig. 1981. Familiarity and its impact on consumer decision biases and heuristics. *J. Consum. Res.* 8:223–231.
- Price, J. and J. Riis. 2012. Behavioral economics and the psychology of fruit and vegetable consumption: A scientific overview, 2012. Produce for Better Health Foundation. 12 Feb. 2014. <<http://www.PBHFoundation.org>>.
- Redelmeier, D.A. and V.M. Dickinson. 2011. Determining whether a patient is feeling better: Pitfalls from the science of human perception. *J. Gen. Intern. Med.* 26:900–906.
- Retamales, J.B., R. Godoy, C. Moggia, G.A. Lobos, and S. Romero. 2014. CPPU sprays alter blueberry (*Vaccinium corymbosum* L. ‘Duke’) fruit quality at harvest and its behavior in post-harvest. *Acta Hort.* 1017:189–193.
- Saftner, R., J. Polashock, M. Ehlenfeldt, and B. Vinyard. 2008. Instrumental and sensory quality characteristics of blueberry fruit from twelve cultivars. *Postharvest Biol. Technol.* 49:19–26.
- Scalzo, J., S. Dierking, W. Dierking, S. Miller, C. Edwards, and P. Alspach. 2009. ‘Hortblue Poppins’: New cultivar for the home garden. *Acta Hort.* 810:157–162.
- Schwieterman, M.L., T.A. Colquhoun, E.A. Jaworski, L.M. Bartoshuk, J.L. Gilbert, D.M. Tieman, A.Z. Odabasi, H.K. Moskowitz, K.M. Foltz, H.J. Klee, C.A. Sims, V.M. Whitaker, and D.G. Clark. 2014. Strawberry flavor: Diverse-chemical compositions, a seasonal influence, and effects on sensory perception. *PLoS One* 9:E88446.
- Shukitt-Hale, B. 2012. Blueberries and neuronal aging. *Gerontology* 58:518–523.
- Tipton, D.A., J.P. Babu, and M.Kh. Dabbous. 2013. Effects of cranberry components on human aggressive periodontitis gingival fibroblasts. *J. Periodontal Res.* 48:433–442.
- USDA. 2013. Noncitrus fruits and nuts 2012 summary. 25 Jan. 2013. <<http://usda.mannlib.cornell.edu/usda/nass/NoncFruitNu//2010s/2013/NoncFruitNu-01-25-2013.pdf>>.
- Yousef, G.G., A.F. Brown, Y. Funakoshi, F. Mbeunkui, M.H. Grace, J.R. Ballington, A. Loraine, and M.A. Lila. 2013. Efficient quantification of the health-relevant anthocyanin and phenolic acid profiles in commercial cultivars and breeding selections of blueberries (*Vaccinium* spp.). *J. Agr. Food Chem.* 61:4806–4815.

Supplemental Table 1. Gender group comparison.^z

Gender		Male	Female
Base size		138	162
Constant		37	44
A1	Crispy berry...pops in your mouth	6	2
A2	Mushy...melts in your mouth	-10	-17
A3	A soft berry	-5	-4
A4	Firm with no give, like a grape	1	-4
A5	Thin skin that melts away	3	-6
A6	Tough, chewy skin	-11	-22†
B1	Smooth texture without seeds	0	4
B2	Lots of seeds, a bit of grit	-13†	-25
B3	Full of juice	6	9
B4	Meaty, not juicy	-11	-7
B5	Mealy, pasty and dry	-22†	-23†
B6	Light and airy	1	0
C1	The biggest berries you've ever seen	6	4
C2	Petite berries	-1	1
C3	Tiny...to eat bunches at a time	-4	-2
C4	As big as a large marble	2	7
C5	Small, pea-sized	-4	-4
C6	Medium, dime-sized	2	5
D1	Deep blue, almost black color	8	2
D2	Berries that are a shade of light blue	3	-4
D3	Berries that are bright blue in color	1	4
D4	Blueberries with a soft, cloudy white coating	3	-6
D5	Berries are dark blue throughout	8	4
D6	Dark blue outside, pale inside	6	1
E1	Fruity flavor	8	4
E2	Bold and intense blueberry flavor	13*	10*
E3	Complex flavor with a hint of bitter	-3	-8
E4	So sweet, no sugar needed	14*	11*
E5	Tart berry that wakes the taste buds	3	-7
E6	Mild flavor, but compliments well	-2	-4
F1	Full of antioxidants	7	7
F2	No fat, no cholesterol	-3	2
F3	High in vitamin C	3	1
F4	A rich source of dietary fiber	0	4
F5	Organic berries	7	4
F6	A low-carbohydrate source of nutrients	0	-2

^zThe total sample data was separated by gender. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by †.

Supplemental Table 2. Age group comparison.²

Age (years)		18–24	25–34	35–50	51–65
Base size		33	80	120	66
Constant		56	42	28	50
A1	Crispy berry...pops in your mouth	-7	3	11	-2
A2	Mushy...melts in your mouth	-24‡	-9	-12	-18
A3	A soft berry	-12	-8	3	-9
A4	Firm with no give, like a grape	-10	-3	4	-6
A5	Thin skin that melts away	-19	-1	4	-4
A6	Tough, chewy skin	-8	-19‡	-10	-31‡
B1	Smooth texture without seeds	-9	7	3	2
B2	Lots of seeds, a bit of grit	-26‡	-15	-18‡	-25
B3	Full of juice	4	8	8	7
B4	Meaty, not juicy	-14	-6	-9	-8
B5	Mealy, pasty and dry	-22	-20‡	-22‡	-27‡
B6	Light and airy	2	-2	1	2
C1	The biggest berries you've ever seen	-7	5	10	2
C2	Petite berries	-2	4	3	-8
C3	Tiny...to eat bunches at a time	-8	-2	4	-13
C4	As big as a large marble	2	5	10	-4
C5	Small, pea-sized	-11	-2	1	-11
C6	Medium, dime-sized	-5	10*	8	-6
D1	Deep blue, almost black color	-1	9	7	0
D2	Berries that are a shade of light blue	-2	-1	0	-2
D3	Berries that are bright blue in color	-1	6	4	1
D4	Blueberries with a soft, cloudy white coating	-1	-2	1	-8
D5	Berries are dark blue throughout	3	7	10	1
D6	Dark blue outside, pale inside	-8	6	5	4
E1	Fruity flavor	-3	6	9	6
E2	Bold and intense blueberry flavor	7*	7	16*	11*
E3	Complex flavor with a hint of bitter	-1	-7	-6	-4
E4	So sweet, no sugar needed	6*	8	16*	17*
E5	Tart berry that wakes the taste buds	-9	-4	2	-4
E6	Mild flavor, but compliments well	-13	3	-1	-7
F1	Full of antioxidants	5	6	10	2
F2	No fat, no cholesterol	-6	3	4	-7
F3	High in vitamin C	-3	-3	6	5
F4	A rich source of dietary fiber	3	0	7	-3
F5	Organic berries	0	10*	10	-7
F6	A low-carbohydrate source of nutrients	-2	-6	3	-2

²The total sample data was separated by age. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by ‡.

Supplemental Table 3. Ethnicity group comparison.^z

Ethnicity		White/Caucasia n	Black/Africa n American	Hispanic / Latino	Asian
Base size		97	47	88	68
Constant		36	49	34	51
A1	Crispy berry...pops in your mouth	3	4	7	2
A2	Mushy...melts in your mouth	-21‡	-18	-6	-10
A3	A soft berry	-4	-8	0	-9
A4	Firm with no give, like a grape	-1	-7	-5	4
A5	Thin skin that melts away	-7	2	0	-2
A6	Tough, chewy skin	-21‡	-20	-18	-8
B1	Smooth texture without seeds	4	-4	5	1
B2	Lots of seeds, a bit of grit	-20	-20	-21‡	-16‡
B3	Full of juice	12	-4	8	7*
B4	Meaty, not juicy	-3	-25‡	-6	-10
B5	Mealy, pasty and dry	-21	-34‡	-23‡	-18‡
B6	Light and airy	-4	-5	7	2
C1	The biggest berries you've ever seen	4	3	7	4
C2	Petite berries	-5	5	4	0
C3	Tiny...to eat bunches at a time	-9	0	4	-5
C4	As big as a large marble	3	7	7	2
C5	Small, pea-sized	-7	-2	-1	-6
C6	Medium, dime-sized	2	5	7	2
D1	Deep blue, almost black color	5	5	5	5
D2	Berries that are a shade of light blue	-2	-1	2	-4
D3	Berries that are bright blue in color	7	-4	6	-3
D4	Blueberries with a soft, cloudy white coating	-2	-3	0	-4
D5	Berries are dark blue throughout	8	7	4	4
D6	Dark blue outside, pale inside	11	0	2	-4
E1	Fruity flavor	7	5	13*	-4
E2	Bold and intense blueberry flavor	13*	12*	7	13*
E3	Complex flavor with a hint of bitter	-3	-3	-8	-9
E4	So sweet, no sugar needed	17*	16*	12*	5
E5	Tart berry that wakes the taste buds	2	0	-6	-6
E6	Mild flavor, but compliments well	-2	2	-6	-5
F1	Full of antioxidants	5	11	11	2
F2	No fat, no cholesterol	3	-4	3	-5
F3	High in vitamin C	-1	11	7	-6
F4	A rich source of dietary fiber	5	1	6	-7
F5	Organic berries	0	8	10	4
F6	A low-carbohydrate source of nutrients	2	-1	-2	-4

^zThe total sample data was separated by ethnicity. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by *, and the bottom two ranked elements are denoted by ‡.

Supplemental Table 4. Income group comparison.²

Income		Under \$30,00	\$30,00 0– \$39,99	\$40,00 0– \$49,99	\$50,00 0– \$74,99	\$75,00 0– \$99,99	\$100,00 0– \$124,99	\$125,000 +
Base size		54	29	37	72	47	24	37
Constant		54	32	56	27	47	56	22
A1	Crispy berry...pops in your mouth	–2	–1	11*	7	–3	10	9
A2	Mushy...melts in your mouth	–11	–14	–20	–4	–25‡	–23	–7‡
A3	A soft berry	–11	–4	–10	7	–15	–4	0
A4	Firm with no give, like a grape	–9	7	–1	3	–7	1	–4
A5	Thin skin that melts away	–3	–5	–6	6	–11	–10	5
A6	Tough, chewy skin	–15	–9	–21‡	–14	–30‡	–21	–8‡
B1	Smooth texture without seeds	–6	5	5	9	–5	–3	8
B2	Lots of seeds, a bit of grit	–23‡	–20‡	–28‡	–15‡	–14	–34‡	–12
B3	Full of juice	7*	1	3	5	7	13*	19*
B4	Meaty, not juicy	–13	–1	–18	–2	–17	–14	1
B5	Mealy, pasty and dry	–29‡	–28‡	–19	–18‡	–23	–37‡	–12
B6	Light and airy	–2	–6	0	2	–2	–3	11
C1	The biggest berries you've ever seen	–4	–1	9	11	10*	–1	3
C2	Petite berries	–3	8	–8	2	3	–12	7
C3	Tiny...to eat bunches at a time	–12	5	–8	8	–8	–10	–2
C4	As big as a large marble	3	13	5	5	5	–10	8
C5	Small, pea-sized	–10	–7	–4	1	–1	–16	1
C6	Medium, dime-sized	–5	9	–1	7	7	–4	10
D1	Deep blue, almost black color	1	2	10	7	4	–2	9
D2	Berries that are a shade of light blue	5	–7	–2	5	–10	–7	0
D3	Berries that are bright blue in color	0	11	–5	7	–2	–3	10
D4	Blueberries with a soft, cloudy white coating	–2	–2	–9	4	–8	–1	0
D5	Berries are dark blue throughout	3	4	6	6	9	–2	13
D6	Dark blue outside, pale inside	2	–8	–6	9	5	2	12
E1	Fruity flavor	3	6	5	11	4	–8	12
E2	Bold and intense blueberry flavor	6	6	13*	16*	5	10	21*
E3	Complex flavor with a hint of bitter	–13	–7	–14	–6	–10	–3	15
E4	So sweet, no sugar needed	9*	20*	6	17*	10*	5	17
E5	Tart berry that wakes the taste buds	–10	–1	3	2	–7	–5	0
E6	Mild flavor, but compliments well	–6	0	–7	1	–6	–9	0
F1	Full of antioxidants	4	16*	5	7	8	0	10
F2	No fat, no cholesterol	–3	–4	5	2	4	–3	–4
F3	High in vitamin C	6	–1	–6	10	–4	–1	2
F4	A rich source of dietary fiber	2	4	6	–3	9	–3	2
F5	Organic berries	6	5	6	11	1	12*	–9
F6	A low-carbohydrate source of nutrients	0	–13	2	–3	–2	–1	9

²The total sample data was separated by income. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by ‡.

Supplemental Table 5. Relationship group comparison.^z

Relationship status		Single	Married	Separated/divorced
Base size		118	151	26
Constant		37	42	49
A1	Crispy berry...pops in your mouth	5	3	5
A2	Mushy...melts in your mouth	-13	-15	-11
A3	A soft berry	-7	-1	-8
A4	Firm with no give, like a grape	-3	-2	-2
A5	Thin skin that melts away	-2	-2	-2
A6	Tough, chewy skin	-14	-19†	-11
B1	Smooth texture without seeds	0	4	2
B2	Lots of seeds, a bit of grit	-22†	-16	-27†
B3	Full of juice	8	8	3
B4	Meaty, not juicy	-14	-5	-7
B5	Mealy, pasty and dry	-23†	-23†	-17
B6	Light and airy	-1	2	0
C1	The biggest berries you've ever seen	7	3	4
C2	Petite berries	4	1	-21†
C3	Tiny...to eat bunches at a time	-1	-2	-19
C4	As big as a large marble	8	4	-2
C5	Small, pea-sized	0	-5	-17
C6	Medium, dime-sized	5	5	-7
D1	Deep blue, almost black color	8	3	-2
D2	Berries that are a shade of light blue	-1	-3	10*
D3	Berries that are bright blue in color	3	4	-3
D4	Blueberries with a soft, cloudy white coating	1	-4	-3
D5	Berries are dark blue throughout	6	5	7
D6	Dark blue outside, pale inside	-1	6	7
E1	Fruity flavor	11	2	6
E2	Bold and intense blueberry flavor	12*	12*	7
E3	Complex flavor with a hint of bitter	-4	-5	-15
E4	So sweet, no sugar needed	12*	12*	15*
E5	Tart berry that wakes the taste buds	0	-5	1
E6	Mild flavor, but compliments well	-5	-2	1
F1	Full of antioxidants	6	6	6
F2	No fat, no cholesterol	-1	-1	4
F3	High in vitamin C	6	0	-6
F4	A rich source of dietary fiber	5	1	-6
F5	Organic berries	6	6	-7
F6	A low-carbohydrate source of nutrients	0	-3	-1

^zThe total sample data was separated by relationship status. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by †.

Supplemental Table 6. Neighborhood group comparison.^z

Neighborhood		Rural	Suburban	Urban
Base size		38	158	104
Constant		37	45	36
A1	Crispy berry...pops in your mouth	4	3	6
A2	Mushy...melts in your mouth	-16	-14	-12
A3	A soft berry	4	-6	-6
A4	Firm with no give, like a grape	-9	1	-3
A5	Thin skin that melts away	-1	-4	0
A6	Tough, chewy skin	-13	-17	-17
B1	Smooth texture without seeds	10	-2	6
B2	Lots of seeds, a bit of grit	-18‡	-20‡	-20‡
B3	Full of juice	4	6	11
B4	Meaty, not juicy	-5	-11	-6
B5	Mealy, pasty and dry	-20‡	-24‡	-21‡
B6	Light and airy	1	-1	3
C1	The biggest berries you've ever seen	3	4	7
C2	Petite berries	-5	0	2
C3	Tiny...to eat bunches at a time	-4	-5	1
C4	As big as a large marble	2	4	6
C5	Small, pea-sized	-11	-4	-1
C6	Medium, dime-sized	-1	4	5
D1	Deep blue, almost black color	2	3	8
D2	Berries that are a shade of light blue	5	-4	2
D3	Berries that are bright blue in color	4	0	7
D4	Blueberries with a soft, cloudy white coating	5	-6	1
D5	Berries are dark blue throughout	4	5	8
D6	Dark blue outside, pale inside	12*	2	3
E1	Fruity flavor	10*	1	12
E2	Bold and intense blueberry flavor	5	7*	20*
E3	Complex flavor with a hint of bitter	-12	-7	-3
E4	So sweet, no sugar needed	4	12*	16*
E5	Tart berry that wakes the taste buds	-1	-5	1
E6	Mild flavor, but compliments well	-4	-8	4
F1	Full of antioxidants	4	7	8
F2	No fat, no cholesterol	0	-3	5
F3	High in vitamin C	8	0	3
F4	A rich source of dietary fiber	2	2	3
F5	Organic berries	8	-1	12
F6	A low-carbohydrate source of nutrients	-2	0	-2

^zThe total sample data was separated by neighborhood classification. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by ‡.

Supplemental Table 7. U.S. region group comparison.²

U.S. region		Northeast	Northwest	Midwest	Southeast	Southwest
Base size		97	33	65	47	52
Constant		39	24	27	56	53
A1	Crispy berry...pops in your mouth	7	2	3	-1	4
A2	Mushy...melts in your mouth	-19	-6	-9	-16	-11
A3	A soft berry	-4	-4	-2	-9	-6
A4	Firm with no give, like a grape	-1	-3	-1	-3	-4
A5	Thin skin that melts away	1	-4	-3	1	-8
A6	Tough, chewy skin	-13	-22‡	-18	-20‡	-15
B1	Smooth texture without seeds	6	-1	7	-3	-5
B2	Lots of seeds, a bit of grit	-21‡	-12	-19‡	-19	-20‡
B3	Full of juice	6	19	10	-1	7*
B4	Meaty, not juicy	-4	-5	-13	-7	-14
B5	Mealy, pasty and dry	-23‡	-24‡	-24‡	-22‡	-17‡
B6	Light and airy	-2	7	4	-5	4
C1	The biggest berries you've ever seen	6	9	10	0	1
C2	Petite berries	2	10	-1	-4	-4
C3	Tiny...to eat bunches at a time	2	2	-8	-5	-5
C4	As big as a large marble	10	6	4	5	-4
C5	Small, pea-sized	-8	4	1	-6	-5
C6	Medium, dime-sized	4	14	4	4	-1
D1	Deep blue, almost black color	6	5	9	-1	3
D2	Berries that are a shade of light blue	3	-3	0	-13	4
D3	Berries that are bright blue in color	8	5	11	-10	-5
D4	Blueberries with a soft, cloudy white coating	-1	8	-2	-13	1
D5	Berries are dark blue throughout	6	4	10	4	3
D6	Dark blue outside, pale inside	6	5	10	-4	-5
E1	Fruity flavor	9	12	6	0	2
E2	Bold and intense blueberry flavor	15*	23*	13	3	1
E3	Complex flavor with a hint of bitter	-1	-5	-7	-7	-11
E4	So sweet, no sugar needed	13*	19*	19*	11*	2
E5	Tart berry that wakes the taste buds	-2	6	7	-11	-12
E6	Mild flavor, but compliments well	-3	-3	-3	1	-9
F1	Full of antioxidants	12	-11	13	-1	7*
F2	No fat, no cholesterol	0	1	3	-5	1
F3	High in vitamin C	6	-11	10	-2	-4
F4	A rich source of dietary fiber	10	-5	7	-10	-1
F5	Organic berries	9	5	17*	-6	-6
F6	A low-carbohydrate source of nutrients	1	-2	0	-2	-6

²The total sample data was separated by subject's U.S. region of residence. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by ‡.

Supplemental Table 8. Purchase location group comparison.^z

Blueberry purchase location		Local commercial		
		Supercenter chain store	grocery store	Farmers' market
Base size		101	126	52
Constant		38	34	61
A1	Crispy berry...pops in your mouth	6	4	1
A2	Mushy...melts in your mouth	-12	-15	-11
A3	A soft berry	-5	-3	-8
A4	Firm with no give, like a grape	-2	-1	-4
A5	Thin skin that melts away	2	-2	-11
A6	Tough, chewy skin	-13	-20	-14
B1	Smooth texture without seeds	2	4	4
B2	Lots of seeds, a bit of grit	-18‡	-21‡	-26
B3	Full of juice	10	10	-1
B4	Meaty, not juicy	-8	-5	-21‡
B5	Mealy, pasty and dry	-20‡	-23‡	-29‡
B6	Light and airy	-1	1	3
C1	The biggest berries you've ever seen	6	8	-4
C2	Petite berries	3	-3	-1
C3	Tiny...to eat bunches at a time	-2	-2	-8
C4	As big as a large marble	11*	5	-7
C5	Small, pea-sized	-1	-6	-6
C6	Medium, dime-sized	7	2	2
D1	Deep blue, almost black color	7	5	-2
D2	Berries that are a shade of light blue	1	-4	-2
D3	Berries that are bright blue in color	1	7	-3
D4	Blueberries with a soft, cloudy white coating	-4	1	-6
D5	Berries are dark blue throughout	6	8	2
D6	Dark blue outside, pale inside	3	5	3
E1	Fruity flavor	6	8	3
E2	Bold and intense blueberry flavor	11	16*	4
E3	Complex flavor with a hint of bitter	-6	1	-13
E4	So sweet, no sugar needed	11*	19*	1
E5	Tart berry that wakes the taste buds	1	-5	1
E6	Mild flavor, but compliments well	-7	1	-2
F1	Full of antioxidants	6	11	1
F2	No fat, no cholesterol	-3	4	-7
F3	High in vitamin C	5	3	-5
F4	A rich source of dietary fiber	6	3	-5
F5	Organic berries	4	8	-3
F6	A low-carbohydrate source of nutrients	3	1	-10

^zThe total sample data was separated by blueberry purchase location. The base sizes, constants, and interest ratings per element for each subject population are listed in the table. The two elements with the highest interest ranking in each group are denoted by * and the bottom two ranked elements are denoted by ‡.