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Evaluating Consumer Sensory and Composition Attributes of Arkansas-Grown Fresh-Market Blackberries

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Cover Page Footnote

Aubrey Dunteman is a junior with a major in Food Technology in the Department of Food Science. Renee T. Threlfall, the faculty mentor, is a research scientist in the Department of Food Science. John R. Clark is a committee member and a distinguished professor in the Department of Horticulture. Margaret Worthington is a committee member and an assistant professor in the Department of Horticulture.

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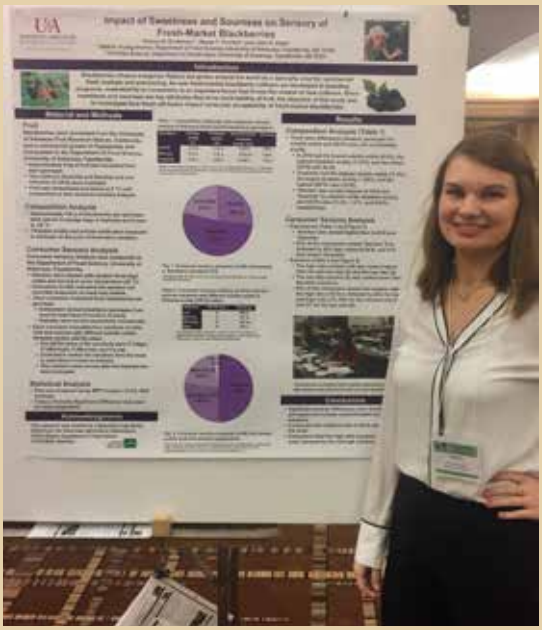
Meet the Student-Author

Aubrey Dunteman

Research at a Glance

- Consumers appear to prefer fresh-market blackberries with a medium-level balance of sweetness to sourness.
- Consumers are not strictly sweet-lovers or sour-lovers when it comes to fresh-market blackberries.
- The fresh-market blackberry, "Natchez", was the most liked of the three blackberries tested and it had a medium level of perceived sweetness.

My interest in food began at a young age, and I pursued it by taking all the cooking and nutrition courses offered in high school. I knew I wanted to study one of the sciences, though I was conflicted about which one. It wasn't until I began looking at colleges that I became aware of the Food Science track; once I looked into it, I immediately knew it was what I wanted to study. I chose to attend the University of Arkansas because the Food Science Department made what I considered to be a giant university feel more personal. The opportunity to do research allowed me to gain invaluable experience in the field of Food Science, collaborate with the Horticulture department, and compete in the Southern Region American Society for Horticultural Sciences (ASHS) poster and oral competitions. My goals after graduating in 2019 are to pursue a master's degree in Food Science and then a career in Food Science focusing on either fruit or sensory science. Thank you to Dr. Renee Threlfall for mentoring me throughout this research experience, to Dr. John Clark for allowing me to conduct research on his blackberry genotypes, and to Dr. Luke Howard and Dr. Margaret Worthington for being part of my Honors committee and giving feedback on my work. Finally, thank you to Molly Felts for teaching me numerous analytical techniques essential for my research.



Aubrey presenting her poster at the Southern Region ASHS annual conference. She won second place in the undergraduate student oral presentation competition.

Evaluating consumer sensory and compositional attributes of Arkansas-grown fresh-market blackberries

Aubrey N. Dunteman[*], *Renee T. Threlfall*[†], *John R. Clark*[§] *and Margaret L. Worthington*[‡]

Abstract

Blackberries are grown worldwide for commercial fresh markets. Three Arkansas-grown fresh-market blackberry genotypes (Natchez, Ouachita, and A-2418) were evaluated for consumer sensory and compositional attributes at the University of Arkansas System Division of Agriculture's Food Science Department, Fayetteville. The compositional attributes of the blackberries were within an acceptable range for commercial markets (soluble solids = 8.20-11.90%, pH = 2.79-3.18, titratable acidity = 1.09-1.32%). In terms of soluble solids-to-titratable acidity ratio, Ouachita (10.92) had the highest ratio, followed by Natchez (8.93) and A-2418 (6.25). A consumer sensory panel (n = 80) evaluated fresh-market blackberry attributes using a 9-point hedonic scale for overall impression, overall flavor, sweetness, and sourness and a 5-point Just-About-Right scale for sweetness and sourness. The participants also ranked the blackberries in order of overall liking from most to least liked. For overall impression, overall flavor, and sweetness, Natchez scored higher than Ouachita and A-2418, but the panelists did not detect differences in sourness. In terms of Just-About-Right for sweetness, 64% of consumers scored Natchez Just-about-Right, followed by Ouachita (39%) and A-2418 (34%). Whereas, 42% percent found A-2418 "Too Sour", followed by Ouachita (33%) and Natchez (25%). In terms of ranking the blackberries, Natchez was the most liked blackberry followed by Ouachita and A-2418. When looking only at blackberries ranked first, 53% of consumers ranked Natchez as their most-liked berry, compared to A-2418 (26%) and Ouachita (21%). The results from this research suggested that fresh-market blackberries with medium-level sweetness-to-sourness ratios were preferred though more consumers than expected preferred the blackberries with the more extreme ratios.

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Introduction

Blackberry plants (*Rubus* L. hybrids) are grown around the world, and the fruit is used in both fresh and processing markets. Blackberry cultivars produce berries with variations in traits such as size, shape, color, and flavor, along with many other new and unique attributes. Fruit with high antioxidant capacity, including blackberries, have gained consumer interest due to health-conferring qualities such as the potential to prevent illness and reduce the effects of aging (Lewers et al., 2010). With the growing demand for healthy foods, the significance of identifying consumers' perceptions of fresh-market blackberries has increased as their impression impacts the commercial marketability of the fruit. According to the United States Department of Agriculture (USDA, 2017), 1620 ha of blackberries were harvested in the United States with ~2,740,000 kg for fresh market with a value at $5 million, though these data are primarily from Oregon. Fresh-market blackberry production in the top three caneberry producing counties in California was valued at $78.7 million in 2016 (Monterey County, California Agricultural Commissioner, 2017).

There are major differences among fresh-market blackberry cultivars for traits that may affect consumer perception and acceptance. Traits that may affect the perceptions that consumers have of fresh-market blackberries differ between genotypes in part due to blackberry genetics. Over 60 blackberry cultivars have been released since 1985 from breeding programs in the United States. One of the largest public blackberry breeding programs is conducted at the University of Arkansas System Division of Agriculture (Clark, 1999; Clark and Finn, 2008). As new blackberry cultivars are developed in breeding programs, the need to identify their marketing potential is important as it can influence whether or not the genotypes will be released. Attributes of blackberries that may affect marketability include:

- sweetness, tartness, flavor, color, firmness, and seediness,

as they are important to consumers (Clark et al., 2007; Clark and Finn, 2008; Hall et al., 2002). Sweetness, in particular, has been shown to affect marketability and sales of fresh-market blackberries in the United Kingdom (Barnett, 2007).

The marketability of food is driven by consumers' acceptance, and one of the key factors determining acceptability is the sensory characteristics a food imparts (Laaksonen et al., 2016). Sensory analysis can be used to identify various qualities of fruit that may be difficult to quantify and analyze. There are typically four types of sensory analysis panels:

- highly trained experts, trained laboratory panels, laboratory acceptance panels, and large consumer panels (Poste et al., 1991).

The type of sensory panel used is dependent on the information researchers need about the product. Large consumer panels (typically more than 75 people for statistical validity) can be used to determine the consumer's reaction to the product evaluated (Poste et al., 1991).

Sensory analysis can be implemented to gain consumers' opinions on the five basic taste attributes of a food:

- sweetness, sourness, saltiness, bitterness, and umami.

An important sensory evaluation focus in fruit is how the flavor is affected by the sweetness (percent sugar measured by soluble solids) and sourness (percent acid measured by titratable acidity), and the sweetness and sourness relationship (soluble solids-to-titratable acidity ratio) (Crisosto and Crisosto, 2005; Laaksonen et al., 2016; Poll, 1981; Sandell et al., 2008). Blackberries tend to have a lower soluble solids-to-titratable acidity ratio when compared to other fruits. Previous research has shown an average ratio of 6.7 for blackberries (de Souza et al., 2014), while muscadine grapes have an optimal ratio of 30 (Flora, 1979). Since different fruits have different levels of soluble solids-to-titratable acidity ratios, determining levels that consumers prefer in blackberries helps to identify which blackberry genotypes may succeed commercially.

By investigating consumers' perception of fresh-market blackberries, we can determine if consumers prefer blackberries with high sourness/low sweetness, low sourness/high sweetness, or a balance of sourness and sweetness. In addition, this information on fresh-market blackberries will provide insight for the University of Arkansas System Division of Agriculture's blackberry breeding program to identify desirable traits. The objective of this study was to determine the potential of various fresh-market blackberry genotypes (two cultivars and an advanced selection) by identifying sensory and compositional attributes that impact marketability.

Materials and Methods

Fruit. The blackberries were harvested prior to 10:00 AM on 29 June 2017 at the shiny-black stage of ripeness. The advanced breeding selection, A-2418, was harvested from the University of Arkansas System Division of Agriculture's Fruit Research Station in Clarksville, Arkansas, and the blackberry cultivars, Natchez and Ouachita, were harvested from a commercial grower in Fayetteville, Arkansas. These genotypes were selected because they had a wide range of sourness and sweetness levels. Blackberries were hand-harvested directly into 240-g clamshells and

placed into chilled coolers. After harvest was complete, the blackberries were transported to the Department of Food Science in Fayetteville, Arkansas. Fruit was then randomly sorted into new clamshells for the compositional and sensory analysis.

Compositional Analysis. Three blackberries were placed in a plastic zip-type freezer bag in triplicate for each genotype and stored at -20 ºC until analysis. Juice was extracted from each three-berry sample by thawing and squeezing the juice of the berries through cheesecloth. The compositional attributes of the juice included:

- soluble solids, pH, titratable acidity, and the soluble solids-to-titratable acidity ratio.

Compositional analysis of the juice was done at room temperature (24 ºC). The soluble solids percent (%) was measured using a Bausch & Lomb Abbe Mark II refractometer (Scientific Instrument, Keene, New Hampshire). The pH and titratable acidity were measured using an 877 Titrino Plus titration and pH unit (Metrohm AG, Herisau, Switzerland) standardized to pH 2.0, 4.0, 7.0, and 10.0 buffers prior to analysis. The titratable acidity (%) was determined by diluting ~6 g of juice with 50 mL of deionized, degassed water, and titrating with 0.1 N sodium hydroxide to an endpoint of pH 8.2.

Consumer Sensory Analysis. Blackberries for consumer sensory analysis were stored at 2 ºC overnight for sensory analysis the day following harvest. Prior to serving, the blackberries were rinsed and allowed to air dry until they reached room temperature (24 ºC). Eighty consumers were recruited to participate in the study. Consumer responses were collected via hard-copy ballots. Three berries per genotype were placed on a plate labeled with a random three-digit code. Each genotype was served sequentially, monodically (one at a time) with a random serving order. Consumers were instructed to cleanse their palates between samples with water and unsalted crackers. Consumers evaluated the blackberries using a 9-point hedonic scale for overall impression, overall flavor, sweetness, and sourness:

- 1 = dislike extremely; 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = neither like nor dislike; 6 = like slightly; 7 = like moderately; 8 = like very much; 9 = like extremely

and a 5-point Just-About-Right scale for sweetness and sourness

- 1 = much too little; 2 = too little; 3 = just about right; 4 = too much; 5 = much too much

Blackberry genotypes were then ranked for overall liking from most to least

- 1 = most liked, 3 = least liked

Statistical Analysis. After harvest, the fruit from each genotype was randomized for sensory and compositional analysis. Statistical analysis was conducted with JMP® v. 12.0 (SAS Institute, Inc., Cary, North Carolina). A univariate analysis of variance (ANOVA) was used to determine the significance of main factors. Tukey's honest significant difference (HSD) test was used for mean separation ($P \leq 0.05$) of compositional data, while least significant difference (LSD) was used for mean separation ($P \leq 0.05$) of sensory data. Compositional attributes were evaluated in triplicate, and sensory analysis was done in duplicate.

Results and Discussion

Compositional Analysis. The compositional analysis consisted of measuring the pH, titratable acidity, and soluble solids of the blackberry genotypes, as well as calculating the soluble solids-to-titratable acidity ratio (Table 1). The soluble solids ranged from 8.20% to 11.90%, the pH values ranged from 2.79 to 3.18, and the titratable acidity ranged from 1.09% to 1.32% (Table 1). Ranges similar to these have been shown in other blackberry research where

Table 1. Compositional attributes of Arkansas-grown blackberry genotypes, 2017.

Genotype†	Soluble solids (%)	pH	Titratable acidity (%)‡	Soluble solids-to-titratable acidity ratio
A-2418	8.20 b§	3.03 a	1.32 a	6.25 b
Natchez	11.20 a	2.79 b	1.27 a	8.93 ab
Ouachita	11.90 a	3.18 a	1.09 a	10.92 a
P-Value	<0.0005	0.0010	0.1400	0.0069

† Three berries per genotype were evaluated in triplicate.
‡ Calculated as percent citric acid.
§ Means with different letter(s) for each attribute are significantly different ($P < 0.05$) using Tukey's honestly significant difference.

pH ranged from 2.5 to 4.1, titratable acidity ranged from 1.26% to 1.54%, and soluble solids ranged from 6.19% to 11.11% (de Souza et al., 2014). The soluble solids content of A-2418 (8.20%) was significantly lower than Natchez (11.20%) and Ouachita (11.90%), and Natchez and Ouachita soluble solids were not significantly different. Natchez was the most acidic genotype with a pH at 2.79 and was significantly lower than the other genotypes. Ouachita with a pH of 3.18 was not significantly different from A-2418 with a pH of 3.03. There were no significant differences found among the genotypes for titratable acidity. In general, the goal of the University of Arkansas' blackberry breeding program is to release blackberries with a titratable acidity not greater than 1% (J.R. Clark, pers. comm.); however, all three genotypes had an average titratable acidity over 1%.

As noted earlier, the soluble solids-to-titratable acidity ratio plays a large part in the consumer acceptance of certain fruits (Crisosto and Crisosto, 2005; Laaksonen et al., 2016; Poll, 1981; Sandell et al., 2008). The ratio is the balance between the two attributes that helps determine perceived sweetness and sourness of the fruit (Threlfall et al., 2016; Poll, 1981). Ouachita (10.92) had the highest ratio, indicating a higher perceived sweetness and was significantly higher than A-2418 (6.25), which had the lowest ratio, indicating a lower perceived sweetness. Natchez had a ratio of 8.93 and was not significantly different from either Ouachita or A-2418 (Table 1). These results were consistent with other research where Natchez had a similar soluble solids-to-titratable acidity ratio of 9.0, though inconsistent for Ouachita, which had a lower ratio than Natchez at 7.3 (Segantini et al., 2017). In previous research in Arkansas, Ouachita had the highest soluble solids-to-titratable acidity ratio, followed by Natchez, and then A-2418 (15.4, 11.8, and 6.9, respectively) (Segantini et al., 2017), indicating that the fruit harvested for our study was less ripe.

Consumer Sensory Analysis. All of the sensory attributes evaluated were scored an average between 5 and 8, where 5 is "neither like nor dislike" and 8 is "like very much". Natchez was liked significantly more than the other genotypes for overall impression, overall flavor, and sweetness (7.3, 7.4, and 6.9, respectively; Table 2). The panelists did not detect differences in sourness in the genotypes, though sourness ranged from 5.6 to 6.5. Overall impression, overall flavor, and overall sweetness were not significantly different between A-2418 and Ouachita.

The Just-About-Right data from the 5-point scale was collapsed to a 3-point scale ("Not Sweet/Sour", Just-About-Right, and "Too Sweet/Sour") for analysis. According to Threlfall et al. (2016), an ideal product would be rated Just-About-Right by at least 75% of consumers, as well as that any attributes with over 15% in the "Too Low" or "Too Much" selections should be reexamined. The consumer analysis in this study did not identify any of the genotypes as ideal with 75% for Just-About-Right, but Natchez had Just-About-Right values in the mid-sixties (Figs. 1 and 2). In terms of the sweetness attribute, 64% of consumers scored Natchez Just-About-Right, followed by Ouachita and A-2418, rated 39% and 34%, respectively (Fig. 1). Only 4–5% of the consumers identified the genotypes in this study as "Too Sweet". About 56% and 61% of the consumers found Ouachita and A-2418 "Not Sweet", respectively. Regarding the sourness attribute, 66% of the consumers scored Natchez as Just-About-Right, followed by Ouachita (50%) and A-2418 (44%) (Fig. 2). Consumers found these genotypes "Not Sour" (9–17%). Forty-two percent of the consumers found A-2418 "Too Sour", followed by Ouachita (33%) and Natchez (25%).

Lastly, consumers ranked their liking of the three blackberry genotypes from their most to least liked. Natchez was ranked higher than Ouachita and A-2418, but Ouachita and A-2418 were not ranked significantly different from one another (Fig. 3). When looking only at the blackberries ranked first by the consumers, 53% of consumers ranked Natchez as their most liked berry, compared to 26% and 21% selecting A-2418 and Ouachita, respectively (Fig. 4).

Table 2. Consumer sensory attributes of Arkansas-grown blackberry genotypes evaluated on a 9-point hedonic scale†, 2017.

Genotype‡	Overall impression	Overall flavor	Sweetness	Sourness
A-2418	6.8 b§	6.4 b	5.8 b	5.6 a
Natchez	7.3 a	7.4 a	6.9 a	6.5 a
Ouachita	6.6 b	6.7 b	6.2 b	5.9 a
P-Value	0.0341	0.0034	0.0030	0.0957

† Hedonic scale (1 = dislike extremely; 9 = like extremely).
‡ Genotypes were evaluated by 80 consumer panelists.
§ Means with different letter(s) for each attribute are significantly different ($P < 0.05$) using least significant difference.

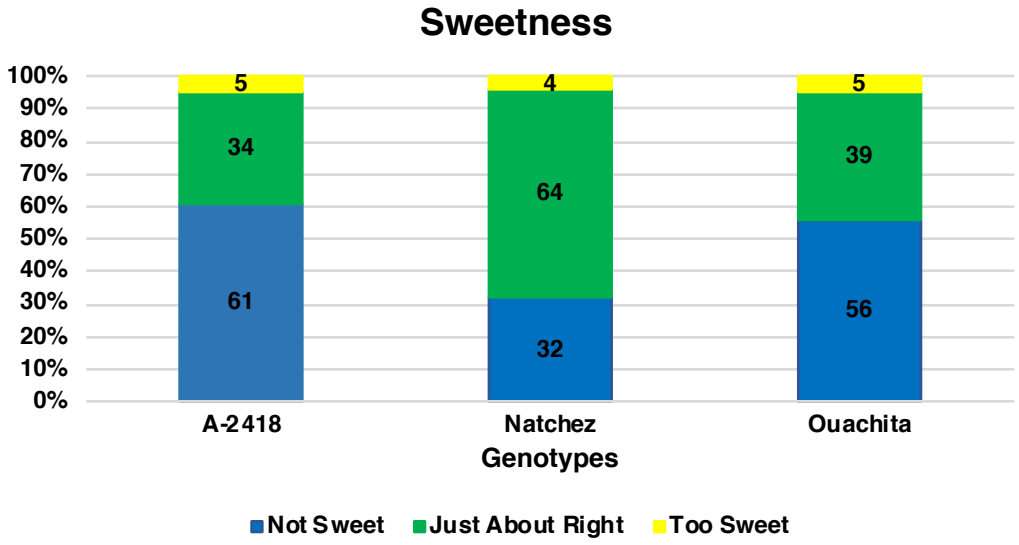

Fig. 1. Percent (%) of consumer responses for the sensory evaluation of sweetness on a collapsed 5-point Just-About-Right scale of Arkansas-grown blackberry genotypes, 2017. The 5-point Just-About-Right scale (1 = much too little, 2 = too little, 3 = just about right, 4 = too much, 5 = much too much) was collapsed to Too Low, Just-About-Right, and Too Much. Genotypes were evaluated by 80 consumer panelists.

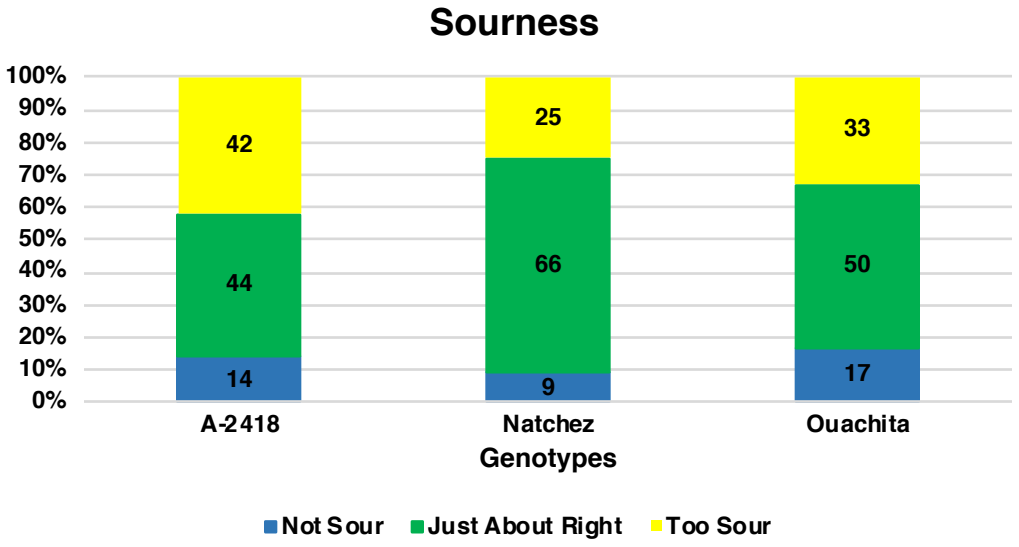

Fig. 2. Percent (%) of consumer responses for the sensory evaluation of sourness on a collapsed 5-point Just-About-Right scale of Arkansas-grown blackberry genotypes, 2017. The 5-point Just-About-Right scale (1 = much too little, 2 = too little, 3 = just about right, 4 = too much, 5 = much too much) was collapsed to Too Low, Just-About-Right, and Too Much. Genotypes were evaluated by 80 consumer panelists.

It is notable that Natchez, the most liked blackberry by ranking, had the most liked sweetness in both the 9-point hedonic scale and the Just-About-Right scale while it had a soluble solids-to-titratable acidity ratio in between the other genotypes. Interestingly, Natchez had a 16.5% higher titratable acidity than Ouachita and 3.8% lower titratable acidity than A-2418, but also had 5.9% lower soluble solids than Ouachita. These findings for fresh-market blackberries indicate that consumers are not strictly sweetness-likers or sweetness-dislikers and that other flavor aspects may influence their perception of sweet flavor. Further, since there were no differences among genotypes for sourness-liking on either scale or between titratable acidity content levels, it is possible that few, if any, other factors influence consumers' sourness perception and that titratable acidity may be the most related factor to the attribute.

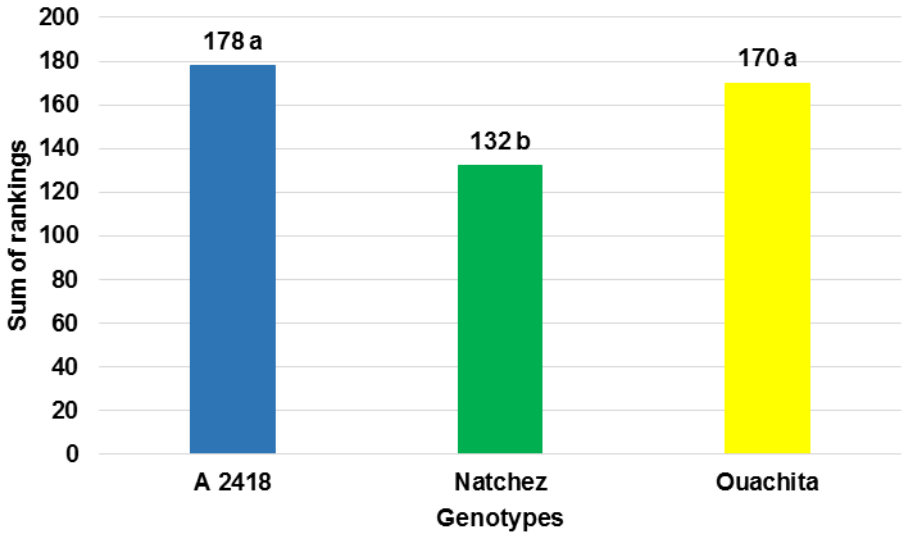

Fig. 3. Sums of consumer sensory evaluation of overall liking rankings for Arkansas-grown blackberry genotypes, 2017. Consumers ranked the genotypes for overall liking, the lower the rank sums, the sample was ranked higher. Genotypes were evaluated by 80 consumer panelists. Means with different letter(s) for each attribute are significantly different ($P < 0.05$) using least significant difference.

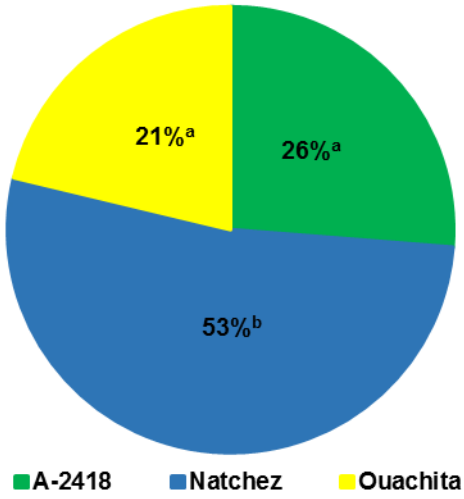

Fig. 4. Percent (%) of consumer sensory panelists that ranked each Arkansas-grown blackberry genotype as most liked, 2017. Genotypes were evaluated by 80 consumer panelists. Means with different letter(s) for each attribute are significantly different ($P < 0.05$) using least significant difference.

Conclusions

The attributes of sweetness and sourness in blackberries are important to consumers as they play a large role in consumer acceptability and therefore in marketability. Natchez was the most liked blackberry and had a medium level of soluble solids-to-titratable acidity ratio (medium level of perceived sweetness). Significant differences were found among blackberry genotypes for sweetness-liking, overall impression, overall flavor, and ranking. Other factors likely influence the sweetness perception of blackberries as the genotype with the most Just-About-Right evaluations for sweetness, Natchez, was not significantly different from the other genotypes and had a soluble solids content that was not different than Ouachita. The titratable acidity of the genotypes were not significantly different nor were the sourness evaluations indicating a possible relationship between titratable acidity and consumers' liking of sourness. These observations introduce the importance of how other factors influence consumers' perceptions of sweetness and sourness in fresh-market blackberries. Based upon the results of this study, it can be said that consumers prefer blackberries with a medium-level balance of sweetness and sourness over blackberries with high or low sweet/sour ratios, though due to personal preference and other flavor aspects, there can be consumers that prefer the more extreme ratios. Further studies would be beneficial to determine the relationship between the attributes of perceived sweetness and sourness and blackberry liking.

Acknowledgements

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