

# Color, Flavor, and Texture: Which Blackberry Sensory Attribute is the Most Important to Consumers?

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**ABSTRACT** Blackberries have received more recognition recently, compared to other berries, because of the high nutritional value and source of antioxidants. Nevertheless, regarding the important sensory attributes, such as color, flavor, and texture, consumers do not evaluate these attributes equally. This study focuses on the sensory attributes: color, flavor, texture, and overall appeal of six different blackberry cultivars, i.e., Apache, Chesapeake, Chickasaw, Kiowa, OAL-W6, and Ouachita. The attributes were measured and analyzed by a sensory examination, which was implemented by the Food Systems Innovation Center at the University of Kentucky. Results indicate that the taste and appearance of selected blackberry cultivars are different and can be distinguished based on color, flavor, and texture. Especially, flavor is considered the most important attribute in sensory examination compared to color and texture. Along with prior experiences of consuming blackberries, cooking experiences also enhance overall appeal of the taste of a blackberry.

**Key Words:** Blackberry, food sensory, consumption.

## I. Introduction

Worldwide production of commercial blackberries, *Rubus* spp., has increased more than 45% since 1995, and North America accounted for 42% of the production, the largest contribution of worldwide production<sup>[11,16]</sup>. With growing consumer demand for blackberries in the U.S., research scientists<sup>[2,7,13]</sup> have attempted to improve blackberry cultivars and tackle the potential constraints like: first, higher labor costs in production<sup>[6,16]</sup>; second, more than 70 cultivars/species create inconsistent taste and sweetness of blackberries, is spreading around North America according to the Plants Profile (USDA/Natural Resources Conservation Service); third, the blackberry is the most perishable berry<sup>[12]</sup>, so it enhances marketing challenges of shipment and shelf life. These constraints would require more time to overcome, but another important

question is how likely consumers prefer one blackberry cultivar over another based on the specific attributes of color, flavor, texture, and overall appeal in the consumer market.

Blackberry production in the U.S. has been concentrated in Oregon (72%) and California (7%) in 2005<sup>[16]</sup>. The blackberry production in Arkansas (4%) is increasing because of an interest for the value-added crop and one of the largest blackberry breeding programs is located at the University of Arkansas<sup>[11]</sup>. Similar to other southeastern states, Kentucky farmers look for new alternative crop opportunities after the announcement of the suspended tobacco-quota support system<sup>[5]</sup>. Further, high quality blackberries are readily marketable in Kentucky since blackberries continue to be popular in the market<sup>[3]</sup>. Kentucky consumers generally perceive that the taste of thorny blackberries is better than thornless cultivars<sup>[19]</sup>.

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Though breeding advances may enhance quality and flavor for thornless blackberries, changing consumer perception for the quality and flavor between thorny and thornless blackberries would require further examination.

The market popularity of blackberries has received more focus in the U.S. because of the recognition of high nutritional values and as a source of antioxidants<sup>[15]</sup>. Blackberries have been the top choice for the juice blend market. Nutraceutical marketers, a combination meaning of nutrition and pharmaceuticals, have focused on health-related fruit juice that usually blends blackberry, blueberry, Concord grape, etc. The health-related fruit juice has a high consumer acceptance in the market<sup>[8,10]</sup>. Lawless *et al.*<sup>[8]</sup> found a positive consumer willingness-to-pay for a nutraceutical-rich juice blend. Consumers do have a higher purchase intent if they were informed of the potential health properties, like anthocyanin content in the juice<sup>[9]</sup>. Therefore, the blackberry market, when associated with nutrition and health properties, would receive consumer attention. Nevertheless, consumer preferences on blackberry taste and flavor among different cultivars would require further study.

Each blackberry cultivar has its own unique aroma and flavor which may vary if grown in different climates, regional environments, and soil types<sup>[18]</sup>. This study focuses blackberry cultivars in Kentucky. Research scientists have investigated the attributes of color, flavor, and texture profiling individually among different blackberry cultivars<sup>[1,4,10,14,18]</sup>. However, with all these attributes together, do consumers evaluate each attribute equally or differently? If equally, it is reasonable to focus on each attribute individually regarding any specific study; if differently, the biggest concern is finding which attribute is the most important. Particularly, prior consumer experience in consumption and cooking using blackberries would have potential different effects on their preference and should be further investigated as well.

The objectives of this study were: (1) to find out how consumers evaluate these attributes differently in terms of their overall appeal of the given blackberry cultivars, (2) to interpret what attribute is the most important to blackberry consumers, and (3) to identify how prior experience in blackberry consumption and cooking with blackberries influences consumer perception for each cultivar.

## II. Materials and Methods

### 1. Study Area

Blackberries have become more popular as an alternative crop in Kentucky<sup>[3]</sup>. With the growing demand of locally produced fruits, blackberry growers are interested in expanding their scale and offering high quality blackberries in Kentucky. The growing conditions and climate in Kentucky are very suitable for many different blackberry cultivars, at least 30 different cultivars according to the Plants Profile (USDA/Natural Resources Conservation Service). Nevertheless, growers may have difficulty deciding which cultivars will receive the most acceptance from consumers. Regardless of the differences between costs and profits for each cultivar, this study solely focuses on the taste and flavor of blackberry cultivars in the market based on a consumer sensory examination in Kentucky.

### 2. Blackberry Samples

Based on the growth habit of blackberry, it can be grouped as: erect (thorny and thornless), semi-erect (thornless), and trailing, which is not suitable for commercial production in Kentucky<sup>[3]</sup>, so the trailing type is not included in this study. Since semi-erect cultivars, which were not ripe at the time of evaluation, were not included, this study focuses fresh blackberries on the thorny erect (including *Chesapeake*, *OAL-W6*, *Kiowa*, and *Chickasaw*) and thornless erect (including *Apache* and *Ouachita*) cultivars. Four thorny erect cultivars, i.e., *Chesapeake*, *OAL-W6*, *Kiowa*, and



categories: *Low Appeal (1-4)*, *Middle Appeal (5-8)*, and *High Appeal (9-12)*. A Multinomial Logit model<sup>2</sup> would be suitable to explain these attributes among the overall appeal segments. The summary and descriptive for each variable is presented in Table 1.

### III. Results and Discussion

This study focuses on three research questions: first,

whether these six blackberry cultivars are different to panelists regarding the attributes of color, flavor, texture, and overall appeal; second, whether the attributes of color, flavor, texture, and prior experiences have any potential impact on overall appeal; third, if the prior experiences, i.e., consumption and cooking, have any significant difference, and how consumption and cooking are associated with each attribute in respect to

**Table 1 Definitions and Sample Statistics of Variables (N = 688)**

Variables	Description of Variables	Mean	Std. Dev.	Min.	Max.
<i>Overall Appeal</i>	Discrete variable; panelists were asked to indicate the overall appeal for the taste comparison in each trial, with 1 being least appealing and 12 being most appealing.	7.30	3.35	1	12
<i>Color</i>	Discrete variable; panelists were asked to indicate the color score for each observing, with 1 being least preferred and 8 being most preferred.	6.06	1.48	1	8
<i>Flavor</i>	Discrete variable; panelists were asked to indicate the flavor score for each tasting, with 1 being least preferred and 8 being most preferred.	5.15	2.04	1	8
<i>Texture</i>	Discrete variable; panelists were asked to indicate the texture score for each tasting, with 1 being least preferred and 8 being most preferred.	5.53	1.73	1	8
<i>Consumption</i>	Binary variable=1 if panelist had blackberry consumption during the past 12 months, 0 otherwise.	0.93	0.25	0	1
<i>Cooking</i>	Binary variable=1 if panelist did use blackberry for any purpose of cooking during the past 12 months, 0 otherwise.	0.45	0.49	0	1

**Table 2 Blackberry Evaluation on Color, Flavor, Texture, and Overall Appeal**

Cultivars	Color <sup>1</sup>	Flavor <sup>1</sup>	Texture <sup>1</sup>	Overall Appeal <sup>2</sup>
Apache <sup>4</sup>	6.523b <sup>5</sup>	5.608a	5.841a	8.016b
Ouachita	6.578b	5.260ab	5.669a	7.894ab
Chesapeake	6.116ab	5.520a	5.733a	7.635ab
OAL-W6	5.821ac	5.285ab	5.660a	7.363abc
Kiowa	5.948a	4.730bc	5.315ab	6.710ac
Chickasaw	5.398c	4.452c	4.966b	6.155c
ANOVA F-test	11.47*** <sup>3</sup>	6.10***	4.36***	5.66***

Note: <sup>1</sup> Blackberry color, flavor, texture: 1 = Least preferred; 8 = Most preferred.

<sup>2</sup> Rating blackberry for overall appeal: 1 = Unappealing; 12 = Most appealing.

<sup>3</sup> Asterisks indicate levels of significance: \*\*\* = 0.01.

<sup>4</sup> The order of varieties followed by Overall rankings' mean.

<sup>5</sup> Means within a column followed by the same letter are not significantly different (Tukey's HSD, P < 0.05).

each blackberry cultivar.

The results of ANOVA with Tukey's HSD tests are presented in Table 2. Before the multiple means comparison procedure, the ANOVA F-test was performed and highly significant, which indicates that each blackberry cultivars are different in respect to each attribute. The values of each cell show an average score of each cultivar in respect of each attribute, i.e., color, flavor, texture, and overall appeal. The indications of Tukey's HSD tests for the multiple means comparison show that each blackberry cultivar is somewhat different according each attribute. Among the attributes, texture and overall appeal ratings were not significantly different in the cultivars of *Apache*, *Ouachita*, *Chesapeake*, *OAL-W6*, and *Kiowa*. The cultivar *Apache* scored highest in flavor, texture, and overall appeal. The cultivar *Ouachita* scored highest and *Apache* second in color. It is an interesting result that the popular thorny erect cultivar, *Chickasaw*, in Kentucky scored last in color, flavor, texture, and overall

appeal in compared to other cultivars. As a result, the thornless erect cultivars *Apache* and *Ouachita* were rated first and second as most appealing to panelists, respectively. In general, the assessed outcomes significantly show that the thorny erect cultivars rated in this study do not have a better flavor and texture than the thornless erect cultivars *Apache* and *Ouachita*.

The outcomes of OLS and Multinomial Logit Models are presented in Table 3 and demonstrate that the ratings of the overall appeal of blackberries can be explained by color, flavor, texture, and prior experiences. The F-test and Wald  $\chi^2$  test show that there are strong differences overall across these attributes for OLS and Multinomial Logit Models, respectively. The results of AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) indicate that the Multinomial Logit Model has better goodness of fit over than OLS, so we utilize the results of the Multinomial Logit Model as our final interpretation. However, the coefficient estimates of OLS and Multinomial Logit Models are

**Table 3 The Outcomes of OLS and Multinomial Logit Model**

Estimators		OLS		Multinomial Logit			
Dependent Variable		<i>Overall Appeal (1-12)</i>		<i>Middle<sup>1</sup> Appeal (5-8)</i>		<i>High<sup>1</sup> Appeal (9-12)</i>	
Independent Variables	<i>Color</i>	0.267***	(0.055)	0.133	(0.085)	0.424***	(0.112)
	<i>Flavor</i>	1.078***	(0.047)	0.803***	(0.091)	1.544***	(0.123)
	<i>Texture</i>	0.296***	(0.058)	0.164*	(0.087)	0.479***	(0.115)
	<i>Consumption</i>	-0.214	(0.346)	-0.782	(0.618)	-1.092	(0.716)
	<i>Cooking</i>	0.370**	(0.155)	0.334	(0.260)	0.770**	(0.313)
	<i>Constant</i>	-1.502***	(0.503)	-3.793***	(0.931)	-11.520***	(1.255)
<i>Number of observations</i>		688		688			
<i>F-test</i>		257.710***					
<i>Adjusted R<sup>2</sup></i>		0.651					
<i>Log likelihood</i>		-1443.093					
<i>Wald <math>\chi^2</math></i>				159.240***			
<i>Pseudo R<sup>2</sup></i>				0.367			
<i>Log Pseudolikelihood</i>				-467.584			
<i>AIC</i>		4.212		1.394			
<i>BIC</i>		2925.390		1013.575			

Notes: <sup>1</sup> The base category "*Low Appeal (1-4)*" is compared. Asterisks indicate levels of significance: \* = 0.10, \*\* = 0.05, and \*\*\* = 0.01. Standard errors are reported in parentheses.

consistent. The category "Low Appeal (1-4)" is normalized to zero as a base category. In comparison to low appeal, higher scored color, flavor, and texture are associated with a higher likelihood of high appeal (9-12) for fresh blackberries. Individuals with blackberry cooking experience are more likely to have a high appeal for fresh blackberries compared to those who have not had cooking experience. Hence, the sensory attributes, i.e., color, flavor, and texture, plus cooking experience have a positive impact on the overall appeal for fresh blackberries.

The average marginal effects (in Table 4) of the Multinomial Logit Model sum up to zero in each attribute across different categories of overall appeals. The outcomes of average marginal effects represent a relative impact among categories. It is clear to observe how each attribute and prior experience are corresponding to each other among the overall appeal categories. We see that high appealing individuals are more positively affected by color, flavor, texture, and cooking experience than those who are middle and low appeals. Particularly, the flavor (11%) is the major driver (at least two times larger) for high appealing individuals in comparison to color (4%), texture (4%), and cooking experience (6%). This reveals that flavor is the most important attribute to consumers.

There did appear to be some evidence that individuals' experience associated with cooking also has a positive impact on overall appeal. The cooking experience simply indicates that whether individuals did

use blackberries for any purpose of cooking during the past 12 months or not. Figure 1 represents how cooking experiences can be associated with overall appeal ratings for each blackberry cultivar. A pairwise comparison test was performed in each figure as well. Each dot along the curve presents an average rating of overall appeal regarding their cooking experience for the specific blackberry cultivar. In Figure 1, individuals with some levels of cooking experience scored *Kiowa*, *OAL-W6*, and *Ouachita* higher in overall appeal than those who do not have cooking experience. The results in Figure 1 correspond to our regression findings in Tables 3 and 4. Particularly, these three cultivars, i.e., *Kiowa*, *OAL-W6*, and *Ouachita*, are recognized as the major drivers for the overall appeal rating. Marketers may utilize this information for potential marketing strategies to target the household meal planner with specific blackberry cultivars for the purpose of cooking.

#### IV. Conclusions

The sensory properties, i.e., color, flavor, texture, and overall appeal, are significantly different among these six blackberry cultivars. Although the mean score of flavor is lower than the mean scores of color and texture, the influence of flavor scoring is much stronger (at least two times larger) on overall appeal than on color and texture scorings. This result suggests that the future study for fresh blackberry fruits should focus on enhancing the quality and flavor-oriented component for an increasing demand of blackberries in Kentucky.

**Table 4 The Outcomes of Average Marginal Effects in OLS and Multinomial Logit Models**

Estimators		OLS		Multinomial Logit					
Dependent Variable		<i>Overall Appeal (1-2)</i>		<i>Low Appeal (1-4)</i>		<i>Middle Appeal (5-8)</i>		<i>High Appeal (9-12)</i>	
Independent Variables	<i>Color</i>	0.267***	(0.055)	-0.018**	(0.007)	-0.022*	(0.012)	0.040***	(0.010)
	<i>Flavor</i>	1.078***	(0.047)	-0.090***	(0.005)	-0.022**	(0.008)	0.112***	(0.007)
	<i>Texture</i>	0.296***	(0.058)	-0.021***	(0.008)	-0.022*	(0.012)	0.044***	(0.011)
	<i>Consumption</i>	-0.214	(0.346)	0.080	(0.057)	-0.024	(0.076)	-0.055	(0.061)
	<i>Cooking</i>	0.370**	(0.155)	-0.040*	(0.024)	-0.023	(0.034)	0.063**	(0.028)

Notes: Asterisks indicate levels of significance: \* = 0.10, \*\* = 0.05, and \*\*\* = 0.01. Standard errors are reported in parentheses.

Especially, thornless erect cultivars *Apache* and *Ouachita* receive higher overall appeal than other thorny erect cultivars, which are more popular in Kentucky.

The sensory attributes and cooking experience are highly associated with the overall appeal of blackberries. Particularly, consumers with high blackberry appeal are positively affected by color, flavor, texture, and cooking experience, while consumers with middle blackberry appeal are positively affected by flavor and texture in compared to those with low blackberry appeal. Consumers with high blackberry appeal are also influenced from their cooking experience with the utilization of blackberries. Three cultivars, i.e., *Kiowa*, *OAL-W6*, and *Ouachita*, turn out to be the major drivers among these six cultivars for blackberry overall appeal.

Blackberries have received more attention not only in fresh berry markets but also in the nutritional-oriented juice blend markets. Kentucky farmers are

highly interested in new alternative crop opportunities whenever the market is ready for it. With the aforementioned findings, blackberry farmers and marketers will have better information to decide which blackberry cultivars they can focus on growing and selling for their potential consumers. Although only six major blackberry cultivars are used in this study, the blackberry attributes among different cultivars still present somewhat different results. For future studies, it would be necessary to pull in different cultivars that are also available in Kentucky, because consumers do have diversified experiences that may associate how they consume blackberries.

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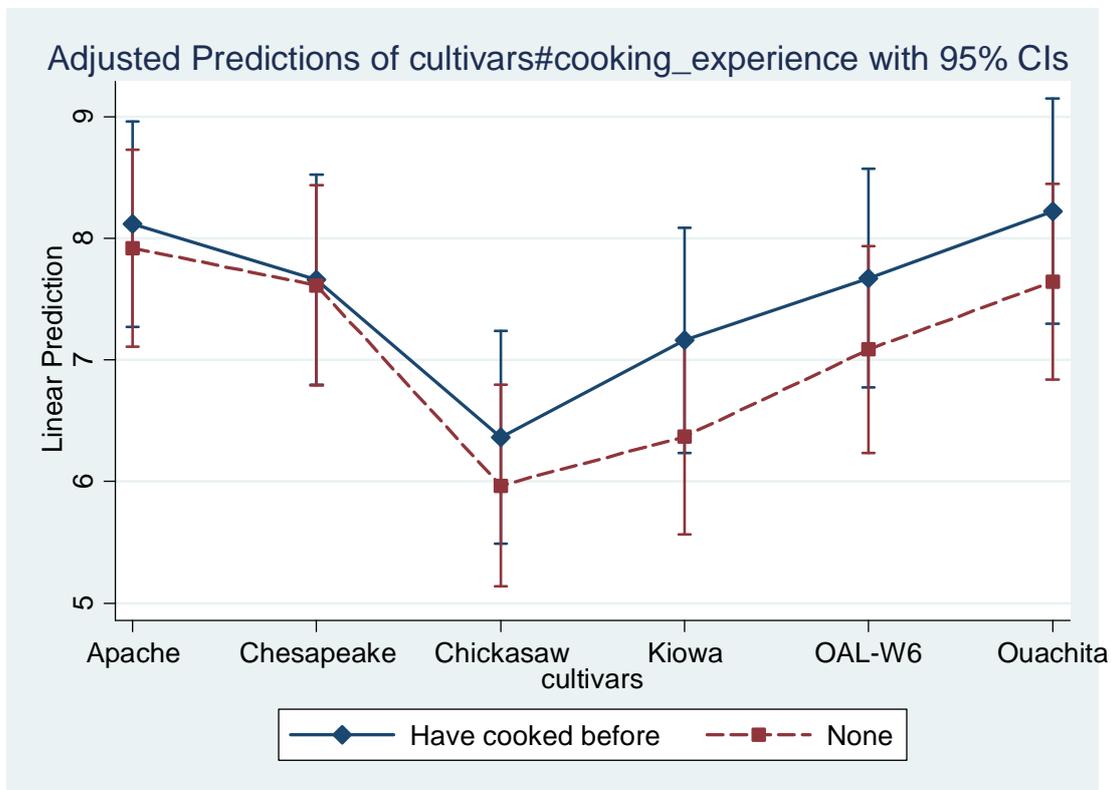


Figure 1 A Pairwise Comparison for Six Blackberry Cultivars between Overall Appeal and Cooking

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