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Culinary Treatments Affect Sensory Attributes and Consumer Preference for Sweet Potato Cultivars

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Abstract

Food quality and taste preference are important factors influencing the production and adoption of sweet potato (*Ipomea batatas* L.) cultivars in a specific growing region. There is very limited published information available on the sensory attributes and quality profile of sweet potato cultivars grown in Canada, even though there is a substantial increase in both production and consumption over the last few years. This study analyzed five different culinary treatments on sweet potato sensory attributes along with taste preferences. Oven-baked, boiled, fried, steamed and mashed culinary treatments were found significantly different ($P < 0.05$) for mealiness, sweetness and for taste profiles. Sweet potato cultivars were significant different ($P < 0.05$) for taste and sweetness attributes. A non-significant difference was recorded for interaction between culinary treatments and the tested cultivars for bitterness, mealiness, sweetness and taste profile. Expert panel preferences significantly differed ($P < 0.05$) for boiled, fried and steamed culinary treatments for tested cultivars, whereas, no difference was observed for oven-baked and mashed sweet potatoes. Boiled, fried, steamed and mashed culinary treatments for 'Covington' were most liked by the panelists, followed by 'Radiance'. These sensory analysis and preferences of tested sweet potato cultivars can provide a reference for the food processing industry in preparing sweet potatoes for Canadian consumer consumption and the study outcomes can be used to guide sweet potato variety development for specific quality traits.

Keywords: *Ipomoea batatas*, culinary, descriptive attributes, textural profile

1. Introduction

Sweet potato (*Ipomoea batatas* L.) is a warm-season root crop mainly grown in tropical and subtropical regions (Iese et al., 2018). It requires a long frost-free period and relatively high soil and air temperatures to produce quality and optimum root yields (Teow et al., 2007). In Canada, sweet potato production is limited in crop growing regions. Comparing crop production areas, the province of Manitoba has a shorter, colder, climate having 75 to 125-135 frost-free days. These shorter frost-free periods, with lower air and soil temperatures, are a major restrictive factor for commercial production of many field vegetables (Anonymous, 2021). However, some warm season crops with shorter maturity and amended agronomic practices can be grown as fresh produce in Manitoba. Increasing global temperatures have caused an increase in air and soil temperatures in the last century. Notably, within the last 15 years, there has been a more rapid rate of increase and further increase is predicted (Collins et al., 2013). As a result, crop production in temperate climates is predicted to benefit (Easterling et al., 2007). Sweet potato is a nutritionally important crop, rich in antioxidants, vitamins, and minerals in both roots and leaves. Orange fleshed, provitamin A-rich crops could combat vitamin A deficiency (Hotz et al., 2012; Tomlins et al., 2012; Truong et al., 2018).

Traditionally, sweet potatoes are prepared as boiled, roasted, fried or mashed and used in diverse local food recipes or baked products (Abidin et al., 2015). In recent years, sweet potatoes have become a snack food (for example, roasted and fried products), and are moving from traditional markets to fast food and supermarket systems. With urbanization and lifestyle changes over time, snack food consumption has increased and consumers in today are increasingly seeking healthier snack alternatives as fast food options. This change has led

to the increased demand for sweet potatoes in the market (Staatz and Hollinger, 2016).

Different culinary treatments may affect the quality of the product by changing product appearance, flavor, and taste. Shi et al. (2018) documented that aftertaste may affect consumer acceptance, and different consumer groups will be attracted by different sensory characteristics. Leksrisompong et al. (2012) analyzed the consumer preference and descriptive traits of cooked sweet potatoes and found that, overall preference for roasted sweet potatoes is mainly dominated by flavor preference, followed by taste preference. In addition, Ofori et al. (2009) studied the sensory properties of coloured sweet potatoes cultivars and found yellow fleshed cultivars are correlated with fibrous texture and sweet taste. This is due to the composition of chemical/nutritional compounds that affect the sensory attributes of sweet potato tubers, and thus consumer preference for prepared sweet potato meals.

Previous studies have targeted sensory analysis and/or consumer testing of sweet potato cultivars and used sensory descriptors to describe the characteristics of sweet potatoes including discolouration, fibrous, starchy/floury, grainy/coarse, moist/watery, smooth, sticky, soft, sweet, pumpkin flavour, and aftertaste (Tomlins et al., 2012; Leighton, 2007; Tomlins, 2004). In this study, it was aimed to evaluate the effect of culinary treatments on different sweet potato cultivars to establish sensory profiles and taste preference for various culinary treatments.

2. Material and Methods

2.1 Sweet Potato Samples

Four sweet potato cultivars viz. 'Beauregard', 'Covington', 'Orleans', and 'Radiance' were selected for this study. Three of the four cultivars 'Beauregard', 'Covington', and 'Orleans' are commercial cultivars widely grown in the U.S.A and Canada for commercial production of fresh roots for direct sale to consumers, and for the processing industry. Three kilograms of medium-sized sweet potato tubers of uniform shape and weight (approximately 2" in diameter and 7" in length) of each cultivar were selected for the evaluation. Roots were washed, dried and sent to the Manitoba Institute of Culinary Arts of Assiniboine Community College located at Brandon, Manitoba. The samples were stored at room temperature (22 ^{0}C) for 24 hours before sensory analysis.

2.2 Sensory Panel Composition and Protocol

The expert sensory panel consisted of five persons: one Red Seal Chef from the local professional industry, and four culinary diploma students from the Manitoba Institute of Culinary Arts. One additional Red Seal faculty member prepared the samples to ensure unbiased sensory analysis for the sensory panel. There was a mix of male (3) and female (3) panelists. Industry-standard sensory protocols (following the American Society for Testing and Materials standards following ASTM manual on consumer sensory evaluation by (Schaefer, 1979), were followed, including ensuring samples were presented in random order to avoid selection bias. Panel activity occurred in an odour-free quiet room at 21.5 ℃, and with reduced/dim light to disguise the appearance of samples.

2.3 Culinary Treatments

Five culinary treatments were prepared for each of four sweet potato cultivars: Oven-baked, boiled, fried, mashed, and steamed. Culinary preparation is presented in Table 1. Table 2 presents the sweet potato cultivars used and the codes assigned for each culinary treatment, whereas Table 3 presents the description of sensory attributes evaluated for each culinary treatment.

Table 1. Culinary treatments and sample preparation description

Culinary Treatments	Preparation Description
Oven-Baked	Baked, unpeeled sweet whole potatoes at 185 ℃ for 40 minutes and served with skin on, as 2.5cm^{2} sized pieces
Boiled	Heated sweet potatoes in boiling water for 15 minutes then drained potatoes sliced into 2.5cm^{2} sized pieces
Fried	Potatoes were cut into fine batonnets and then blanched in a 150 ℃ canola oil bath, then chilled. Once chilled, they were refried at 175 ℃ in a canola oil bath
Mashed	Peeled sweet potatoes simmered at 100 ℃ in an excess water, then drained and mashed without seasoning
Steamed	Potatoes steamed in a water vapor steamer until reaching a tender texture, then sliced into 2.5cm^{2} pieces

Table 2. Culinary treatments and sweet potato variety codes

BAKED		BOILED		FRIED		MASHED		STEAMED	
Code	Variety	Code	Variety	Code	Variety	Code	Variety	Code	Variety
101	Radiance	105	Orleans	109	Orleans	113	Covington	117	Beauregard
102	Beauregard	106	Beauregard	110	Covington	114	Radiance	118	Radiance
103	Orleans	107	Radiance	111	Radiance	115	Beauregard	119	Covington
104	Covington	108	Covington	112	Beauregard	116	Orleans	120	Orleans

Table 3. Description of sensory attributes examined per each culinary treatment

Culinary Treatments	Sensory Attributes	Description of Sensory Attributes
Oven-Baked	Mealiness	How crumbly the potato is when chewed
	Bitterness	Sharp taste related to the taste of a caffeine solution
	Sweetness	Taste related to the flavour of a sucrose solution
	Taste	Overall appeal in flavor
Boiled	Hardness	Force required to break the potato into two with front teeth
	Mealiness	How crumbly the potato is when chewed
	Bitterness	Sharp taste related to the taste of a caffeine solution
	Taste	Overall appeal in flavor
Fried	Mealiness	Texture of potato when bitten into in terms of firmness
	Bitterness	Sharp taste related to the taste of a caffeine solution
	Sweetness	Taste related to the flavor of a sucrose solution
	Taste	Overall appeal in flavor
Mashed	Fluffiness	Expression of the degree of 'light and airy'
	Graininess	Expression of the content of grainy particles in the mouth
	Bitterness	Sharp taste related to the taste of a caffeine solution
	Taste	Overall appeal in flavor
Steamed	Hardness	Force required to break the potato into two with front teeth
	Mealiness	Texture of potato in terms of fluffiness or density
	Bitterness	Sharp taste related to the flavor of a caffeine solution
	Taste	Overall appeal in flavor

2.4 Descriptive Sensory Evaluation

The panel analyzed the sensory attributes of the different culinary treatments (Table 1) of sweet potato cultivars using descriptive analysis, a combination of flavor profile, texture profile and sensory spectrum, (Lawless and Haymann, 1998). Panelists were presented with coded samples of each sweet potato segment on blank white plates with no other distractions to remove any possible references for sensory attributes. The description of sensory attributes examined per culinary treatments is provided in Table 3. The descriptive test involved assessment of sample attributes on a 1-5 intensity scale [1 (none/very slightly); 2 (slightly); 3 (moderately); 4 (very); 5 (extremely)]. A score sheet was developed and used by the panelists to scale the intensity of the respective attribute to best reflect their individual perception of the intensity of the given attribute for the sample in question; without consultation with the other panelists. All cultivar sample plates were labeled with a three-digit code (Table 2) and samples were tempered to 21^{o}C as panelists could best detect subtle differences in flavor at this temperature (Kemp et al., 2013). Panelists evaluated five samples per session per culinary treatment and were given room temperature deionized water and unsalted crackers to cleanse their palate between samples. Descriptive analysis of sweet potatoes was conducted by each panelist in triplicate replications in a randomized balanced design.

2.5 Preference Test

The preference test was evaluated by the same sensory evaluation panel. Samples were evaluated on a 9 hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like), a method previously used by Dery et al. (2021) using Lawless and Haymann (1998) as reference. Cultivar culinary treatment samples were evaluated for preference based on overall eating quality, considering visual, aroma, flavour, and texture properties. A score sheet was developed and used by the panelists to scale the culinary treatment preference best reflecting their individual perception of the given sample without consultation with the other panelists. All cultivar sample plates were labeled with a three-digit code (Table 2) and samples were tempered to 21^{0} as panelists could best detect

subtle differences in flavor at this temperature. Panelists evaluated five samples per session per culinary treatments and were given deionized water (at room temperature) and unsalted crackers to cleanse their palate between samples.

2.6 Experimental Design and Analysis

Data from the descriptive sensory analysis were subjected to analysis of variance (ANOVA) with means separation using Fisher's least square difference by using Cohort Software CoStat ver. 6.45 (Cohort Software Birmingham, U.K). Two-factor ANOVA (the factors are culinary treatments and cultivars) was performed to test the significant differences of individual sensory attributes for each factor and interaction. One-factor ANOVA (the factors are sensory attributes) was performed to test significant differences per cultivar, for each culinary treatment, and cultivar, as the factor, was tested for each culinary treatment in a one-factor ANOVA for preference test evaluation. If the interaction was significant it was used to explain the results. If interactions were not significant, means were separated using Fisher's least significant difference. Each cultivar was evaluated three times.

3. Results and Discussion

Sweet potato cultivars were evaluated for oven-baked, boiled, fried, steamed and mashed culinary treatments with reference to there sensory attributes (bitterness, taste, mealiness, sweetness hardness, fluffiness and graininess) on an intensity scale of 1-5 (1- none/very slightly; 2 - slightly; 3 - moderately; 4 - very; 5 - extremely). Among the sensory attributes of sweet potato, taste, mealiness, and sweetness were found significantly different ($P < 0.05$) for culinary treatments, whereas the different cultivars showed significant differences ($P < 0.05$) for taste and sweetness only.

Culinary treatment and cultivar interactions were non-significant ($P > 0.05$) for most of the sensory attributes except hardness of sweet potatoes (Table 4). Non-significant ($P > 0.05$) differences for the bitterness sensory attribute of sweet potato were recorded for all tested culinary treatments. The sweet potato taste was found significantly different ($P < 0.05$) between culinary treatments. Baked, fried and steamed sweet potatoes differed in taste with boiled and mashed treatments, whereas no difference in taste was recorded between baked, fried, and steamed treatments as well as between boiled and mashed treatments (Table 4). Similarly, no significant differences were observed between baked and boiled culinary treatments and between fried and steamed culinary treatments when evaluated for the mealiness sensory attribute. However, baked and boiled culinary treatments were significantly ($P < 0.05$) different in mealiness sensory attribute of sweet potatoes when compared with fried and steamed culinary treatments. The sweetness was significantly ($P < 0.05$) different between baked and fried culinary treatments; whereas, no significant difference was observed between boiled and steamed culinary treatments when evaluated for the hardness sensory attribute of sweet potatoes (Table 4).

Table 4. F ratios and Main effects of culinary treatments on descriptive sensory attributes of sweet potato

Source of variation	Bitterness	Taste	Mealiness	Sweetness	Hardness
Culinary Treatment	1.71ns	3.70**	5.84**	21.05***	1.93ns
Cultivar	1.05ns	6.85***	0.05ns	9.10***	1.26ns
Treatment x Cultivar	0.99ns	01.67ns	1.01ns	0.57ns	3.15*
Error mean square	0.34	0.51	0.084	0.61	0.45
Main Effect Treatments					
Baked	1.25a	2.95a	3.62a	3.58a	NA
Boiled	1.29a	2.37b	3.04ab	NA	2.35a
Fried	1.16a	3.06a	2.54b	2.54b	NA
Steamed	1.58a	3.04a	2.87b	NA	2.08a
Mashed	1.29a	2.83ab	NA	NA	NA
LSD	0.33	0.41	0.52	0.46	0.39
P Value	0.15ns	0.0075**	0.0012**	0.0001***	0.17ns

, *, **, *** significant at P=0.05, 0.01, or 0.001, ns=not significant respectively

[a-b] values in columns followed by the same letter are not significantly different at $P < 0.05$, LSD.

3.1 Descriptive Test

3.1.1 Oven-baked Culinary Treatment

Sweet potato cultivars did not vary significantly for mealiness on an intensity scale of 1-5 (Table 5) when

oven-baked. However, cultivar Radiance (3.1) was found to be better in mealiness followed by Covington (3.3) when prepared as oven-baked. Similarly, there were no significant differences (P>0.05) between cultivars for bitterness sensory attribute and cultivars Beauregard, Covington and Radiance had similar (1.1) and better bitterness sensory attribute compare to cultivar Orleans (1.5). Cultivar Covington found to be sweeter (4.1) followed by Radiance (3.8) compared to Beauregard and Orleans when processed and prepared as oven-baked culinary treatment; although no statistically significant difference (P>0.05) was observed among cultivars for the sweetness sensory attribute of oven-baked sweet potatoes (Table 5).

Table 5. Main effect of culinary treatments on descriptive sensory attributes of sweet potato cultivars

Culinary Treatments	Sensory Attributes	Sweet Potato Cultivars			
		Beauregard	Covington	Orleans	Radiance
		Mean values at Intensity Scale (1-5)			
Oven-Baked	Mealiness	4.1a	3.3a	3.8a	3.1a
	Bitterness	1.1a	1.1a	1.5a	1.16a
	Sweetness	3.0a	4.1a	3.3a	3.8a
Fried	Mealiness	2.1a	2.5a	2.5a	3a
	Bitterness	1.2a	1.2a	1.0a	1.3a
	Sweetness	1.7c	3.5a	2.0bc	3.0ab
Steamed	Hardness	1.5a	2.5a	2.3a	2.0a
	Mealiness	2.5a	3.0a	3.0a	3.0a
	Bitterness	1.0a	1.7a	1.7a	2.0a
Boiled	Hardness	3.3a	2.5a	2.8a	2.8a
	Mealiness	3.0a	3.3a	2.8a	3.0a
	Bitterness	1.0a	1.3a	1.5a	1.3a
Mashed	Fluffiness	2.8a	3.0a	3.0a	3.2a
	Graininess	2.5a	3.7a	2.5a	3.3a
	Bitterness	1.5a	1.2a	1.3a	1.2a

[a-c]=values in rows followed by the same letter are not significantly different at P<0.05, LSD.

3.1.2 Fried Culinary Treatment

Similar to the oven-baked culinary treatment, no significantly distinct (P>0.05) mealiness bitterness and sweetness was recorded, on an intensity scale of 1-5, between cultivars for the fried sweet potatoes (Table 5). However, 'Beauregard' was rated lowest (2.2) and better for mealiness sensory attribute; followed by Covington and Radiance which were rated equal in terms of mealiness by the panelist. Radiance' rated high (3.0) for mean mealiness. Similarly, there were no significant differences (P>0.05) between cultivars tested for bitterness. Though, 'Orleans' was found better for bitterness sensory trait with the lowest (1.0) ranking, followed by Beauregard (1.2) and Covington (1.2), by the panelist. 'Radiance' rated highest with a mean rating of 1.3 for bitterness, when fried. A statistically significant difference (P<0.05) was observed among cultivars for the sweetness sensory attribute of fried sweet potatoes: Cultivar 'Covington' recorded more sweeter (3.5) than cultivars 'Orleans' (2.0) and 'Beauregard' (1.7) and significantly different at an intensity scale of 1-5. However, Covington is comparable with cultivar Radiance in sweetness sensory attribute whereas, cultivar Radiance recorded more sweetness profile than Beauregard for fried sweet potatoes.

3.1.3 Steamed Culinary Treatment

Sweet potato cultivars were prepared as steamed culinary treatment and assessed for hardness, mealiness and bitterness on an intensity scale of 1-5 (Table 5). There was no significant difference (P>0.05) for sensory attributes during the individual assessments. However, cultivar Covington found better in hardness profile by the panelist and rated high (2.5)- for hardness sensory attribute compared to Orleans (2.3), Radiance (2.0) and Beauregard (1.5). 'Beauregard' rated lowest, and found better for mealiness (3.0) and bitterness (2.0) sensory attributes with compare to rest of the cultivars tested for steamed sweet potatoes. 'Covington', 'Orleans' and 'Radiance' were quite similar for hardness and mealiness sensory profile, whereas 'Covington' and 'Orleans' were also similar, with rating of 1.7 for the bitterness sensory profile. Research finding from Leighton et. al (2010) indicated orange fleshed sweet potatoes displayed a more dense and pasty texture, with the most intense texture observed in the cultivar 'Resisto' with comparison to another cultivar tested. These results support the findings of our study; 'Covington' ranked high on the intensity and hedonic scale due to its higher value for sweetness, graininess and fluffiness in selected culinary treatments.

3.1.4 Boiled Culinary Treatment

Similar to steamed culinary treatment, no significant difference (P>0.05) for hardness, mealiness and bitterness was recorded on an intensity scale 1-5, by panelist, for the sweet potato's cultivars prepared as boiled culinary treatment (Table 5). However, better hardness and bitterness recorded for Beauregard, for boiled sweet potatoes, compared to other cultivars tested. Cultivar Orleans had a slightly better mealiness sensory profile than other cultivars.

3.1.5 Mashed Culinary Treatment

Mashed culinary treatment assessment of sweet potato cultivars tested for fluffiness, graininess, and bitterness, on an intensity scale of 1-5, are presented in Table 5. There were no significant differences (P>0.05) recorded between the tested cultivars for all their sensory attributes. However, 'Radiance' fluffiness was rated highest with a mean of 3.2, followed by 'Orleans' (3.0) and 'Covington' (3.0). 'Covington' and 'Radiance' rated as the grainiest cultivar tested for mashed potatoes, with means of 3.7 and 3.3, respectively. Whereas, cultivar Covington and Radiance are recorded better in bitterness in comparison to other cultivars and recorded similar to each in bitterness profile when prepared as mashed potatoes. Similar results were reported by Leighton et al (2010), when they conducted a quantitative descriptive sensory analysis of five cultivars of sweet potato to determine sensory and textural profiles and demonstrated differences in the sensory attributes as cultivar W119' which had a grainier texture when compared with the other cultivars tested in their research.

Several researchers, including Leksrisompong et. al (2012 studies showed that panel clusters liked the smooth texture and sweet taste; while disliking bitter, umami, astringent mouthfeel, and residual fibers when examining the sensory attributes and consumer acceptance of sweet potato cultivars. In general, overall results from our study are in consistent with the previous studies in term of sensory differences between cultivar prepared for different culinary treatments and demonstrates that different culinary treatments impact the sensory attributes and the liking and disliking of sweet potatoes.

3.2 Preference Test

A non-significant (P>0.05) difference among cultivars was observed for oven-baked and mashed culinary treatments, whereas, fried, steamed and boiled culinary treatments showed significant differences (P<0.05) between cultivars for individual panel preferences, using LSD test. (Figure 1).

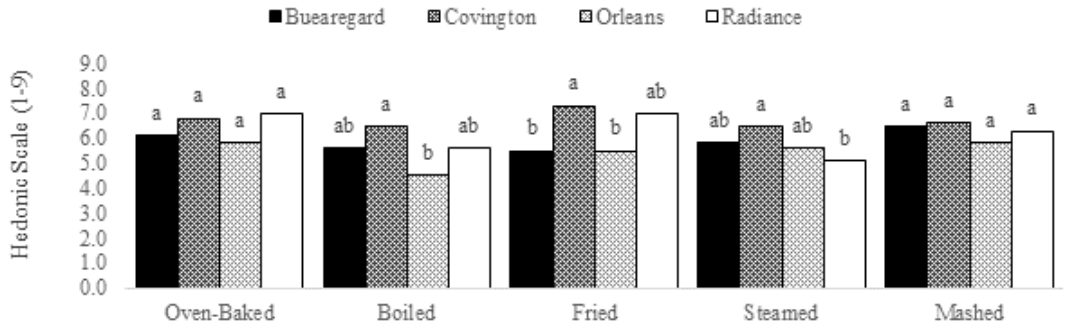

Figure 1. Panel preference on five different culinary treaments of sweet potatoes. Different letter on plot bars indicate the significant difference (P=0.05), according to LSD test

Panelists ranked sweet potato varieties for each culinary treatment according to their personal preference based on quality attributes such as appearance, texture, sensory profile and taste. Panelists preferred cultivar 'Radiance' over other cultivars in comparison for the oven-baked culinary treatment. Radiance demonstrated better mealiness, bitterness and sweetness sensory profile and ranked higher for individual preference, with a mean of 7.0 on the hedonic scale (*Like Moderately* preference indicator). 'Covington' with the second highest ranking (6.8) followed Radiance in panelists preference for oven-baked sweet potatoes. There isn't much difference, statistically non-significant, was recorded in panelist preference between cultivars for mashed culinary treatment. Covington' (6.6), 'Beauregard' (6.5) and 'Radiance' (6.3) ranked between *Like slightly* and *Like moderately* preference indicators by the panelists, whereas 'Orleans' (5.8) was just below the *Like slightly* preference indicator.

Cultivar Covington was the most preferred cultivar, by the panelist in this study, when prepared as boiled, fried

and streamed culinary treatment, on overall sensory, textural and tasted attributes of potatoes. Cultivars Beauregard and Radiance, followed Radiance, and were rated similar by panelist for their boiled culinary treatment preference for cultivars. Sweet potatoes cultivars showed significant ($P<0.05$) differences for panel presences in fried culinary treatment. Covington, followed by Radiance, was the preferred cultivar by panelist for fried sweet potatoes, whereas Beauregard and Orleans did not like much by the panelist for fried sweet potatoes. Similarly, 'Covington' preferred amongst cultivars by the panelist and recorded significantly ($P<0.05$) different from 'Radiance' in the preference test when prepared for the steamed culinary treatment. However, 'Covington' does not have a much difference in preference when compared with 'Beauregard' and 'Orleans'. Likewise, 'Radiance' preference by the panelist was comparable with 'Beauregard' and 'Orleans' when prepared as steamed culinary treatment (Figure 1).

4. Conclusion

Sweet potato cultivars prepared with different culinary treatments, in this study, were not much affected the, mealiness, bitterness, hardness, fluffiness and graininess sensory attributes, except the sweetness profile of cultivars when prepared as a fried culinary treatment. Amongst cultivar testes in this study for their sensory profile and preference test 'Covington' was well-liked by the panelist for boiled, fried, steamed and mashed culinary treatments, followed by 'Radiance'. Findings on sensory analyses and preference of sweet potato cultivars, from this study, can provide a reference for the food industry in the preparation of dishes using culinary sweet potatoes. Growers can focus on growing the cultivars that would have better marketability and consumer consumption appeal. Sweet potato breeders can also use the information for variety development for specific consumer consumption quality traits.

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