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Textural characteristics of organic sweetpotato (*Ipomoea batatas*) cultivars as affected by different thermal processing methods

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Abstract

Different processing methods particularly thermal treatments would impact the potato texture distinctly thus understanding the influence of different thermal treatments on textural characteristics of sweetpotato is needed. Six varieties of sweetpotato were grown on the organic farm and subjected to three thermal treatments (baking, pressure cooking and open cooking). Baking was done in an oven. Pressure cooking was done with a pressure cooker and open cooking was done using a vessel of water. Textural parameters were recorded with a texture analyzer. Objectives were to evaluate the impact of different thermal processing techniques on textural properties of sweetpotatoes and to generate the texture profile analysis of cooked potatoes. Cohesiveness (0.08-0.12%), gumminess (1.96-54.71) and chewiness (0.89-45.39) were highest in baked treatments while hardness (61.24-475.55N) and resilience (0.02-0.11%) were highest in open cooked treatments. Hardness, gumminess, chewiness and resilience reduced with pressure cooking. Based on these results desirable sensory properties can be optimized to maximize consumer acceptance.

Keywords: Sweetpotato, Texture, Cooking, Hardness, Texture Profile Analysis

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Introduction

Among the important food crops produced worldwide, sweet potato (*Ipomoea batatas* L.) is ranked seventh (Button 2015) and thus it plays an important role in global food security. There are various species of sweetpotato with diverse sensory attributes, in terms of taste, mouthfeel characteristics (Sato, 2016; Nwosisi et al. 2016). Different cooking techniques (frying, baking, roasting, microwave, steaming and boiling) have a major impact on taste and the quality of the edible product in general (Sugri et al. 2012). As they result in variations in the material, chemical and sensory qualities of the end produce (Vitrac et al. 2000; Fontes et al. 2011). Thus, research on the elements influencing the quality standards of sweetpotato in terms of the sensory attributes (flavor and texture) and the consumer preference are important to generate sales profit (Sato, 2016). Van Oirschot et al. (2002) assessed the sensory qualities of various cultivars of orange fleshed sweetpotaotes and found that the primary attributes that segregated between the distinctive cultivars were fundamentally identified with the diversity in textural characteristics. Texture Profile Analysis (TPA) is a test designed to mimic food in the mouth and texture analyzer measures the characteristics of force relative to the texture of food, providing outcomes that are insightful and without bias (Liu & Li, 2010). It is thus essential to research how the textural attributes of various cultivars of sweetpotato are related (Sato, 2016). The prime objective of this present research is to investigate the TPA textural parameters of sweetpotato varieties as affected by various thermal processing methods. Six sweetpotato cultivars with different flesh colors were assessed to: 1) evaluate the impact of different thermal processing techniques such as baking, pressure cooking, open cooking on textural characteristics. 2) To generate the texture profile analysis of cooked potatoes using a texture analyzer.

Materials and Methods

Six sweetpotato cultivars of various flesh and texture attributes were gathered toward the conclusion of the 2016 cultivation season from the Tennessee State University, Nashville TN certified organic farm. Production practices applied were done following the regulations of the National Organic Program. Cultivars were Burgundy and Carolina Ruby (red skin and orange flesh); Beauregard, Ginseng and Golden Nugget (copper rose skin and orange flesh) and the non-conventional Asian kind, All Purple (purple skin with purple flesh). Sweetpotato slips were purchased from Jones Family Farms, Bailey, N.C., Slade Farms, Surrey, V.A., Barefoot farms, T.N. After harvest, root curing was done at 13-16°C and 80-90% humid conditions for 5-7 days and set aside for eight weeks before conducting the experiment. Sweetpotato roots were graded according to USDA grading standards. As sweet potatoes differ in size, only samples that

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had similar magnitude and shape were chosen for the examination. For each cultivar, three roots of U.S. no 1 petite size (greatest measurement 2.25 inches, most extreme length 7 inches) were chosen indiscriminately and washed with tap water preceding use in test.

Sweetpotato cooking methods and experimental design

The open/non-conventional cooking technique, pressure cooking and baking were the three cooking techniques applied in this research experiment. Distilled water was utilized as a part of cooking to keep ions from affecting the firm structure of the sweetpotato cultivars.

Open Cooking

Open cooking was performed specifically on high heat with a 2-L stainless steel pot containing 20 oz. to 38 oz. of bubbling water and they were cooked without peeling their skins (Leighton et al. 2008). No top cover was utilized for pots in the open cooking technique. Cooking time differed slightly among the cultivars. A fixed time of 20 minutes was employed.

Pressure cooking

Pressure cooking was done in a 2-L stainless steel pot, with 20-38 ounces of water and they were cooked without peeling their skins (Leighton et al. 2008). Cooking pots were secured with the customary top for pressure cooking. In pressure cooking the temperature used was 100 °C and with similar specific time of 20 minutes.

Baking

Baked samples were heated in aluminum container at 204°C for 90 min within an oven. Cooking duration was chosen with the assistance of sensory tests (Leksrisompong et al. 2012). And finally in order to compare the different cooking procedures, the final product temperature was kept constant. The internal product temperature was kept constant for all treatments in order to compare the different processing / heat treatments. Several experiments were conducted to fix the final internal product temperature.

Instrumental profile analysis

After cooking, all sweetpotato were left to cool at room temperature, then peeled, diced into one-inch cube square samples and put away in independently sealed and labelled polythene bags to prevent loss of moisture before completing instrumental examination. Texture Profile Analysis (TPA) was finished utilizing a texture analyzer TA-HD Plus (Texture Technologies, USA), utilizing a level plate 40 mm in breadth. The samples were packed to 75% of their unique stature by two continuous compressions. The crosshead speed was set at 1.66 mm/sec. Configured height was at 50 mm. Pre-test speed was set at 1.00 mm/sec while post-test speed was 5.00 mm/sec. Testing compression was done as follows. The plate approaches the specimen (1 inch cube) from the calibrated height (50mm) with the pre-test speed; packs it to half of the original height with test speed; plate goes back to the original position using post-test speed. Once the test is finished, the pulverized example was expelled, and the stage surface was cleaned to evacuate the extracted dampness or water. At that point, the next specimen was set underneath the plate. For each cultivar, three different treatments (open cooking, pressure cooking and baking) were applied. Three samples for each treatment was tested. Care was taken to guarantee the specimen removed from the plate when the plate finished the second compression cycle and came back to its underlying position.

Progressively, texture profile of the various sweetpotato samples prepared using different cooking strategies (Fig. 1) were examined for: (1) Hardness (N), the highest force at the primary compression (height of first peak); (2) Cohesiveness, the proportion ratio of the regions of the two resistance ridges (Area 2/Area 1); (3) Gumminess (Hardness * Cohesiveness); (4) Springiness is distance 2/ distance 1 (Springiness is the regained height of the specimen after the compressive exertion is removed (Bourne, 1978), calculated as the ratio of the compression distance regained between the primary and secondary compression (Montejano et al. 1985). (5) Resilience (Area4/ Area3) (6) Chewiness (Gumminess * Springiness).

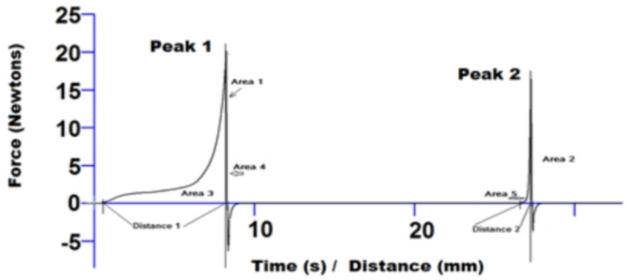

Figure 1. Typical texture profile analysis (TPA) sweet potatoes indicating texture parameters

Data analysis

Data collection and calculation were accomplished using exponent software of the texture analyzer. Instrumental texture parameters from the force versus time curves were recorded in triplicates. Three sweetpotatoes per cultivar were analyzed in each treatment. Data from the texture profile analysis were combined for analysis of variance (ANOVA) using PROC GLM in SAS (Ver. 9.4, SAS, Inc., Cary, N.C.) to determine significant influences of primary parameters-cultivar and cooking methods on the secondary parameters of hardness, and springiness. cohesiveness, gumminess, chewiness, and resilience. If interactions of cultivar and cooking methods were significant, they were used to explain the results. Fisher's least significant difference (LSD) (Fisher, 1939) test was used for multiple comparisons between mean values of the variables cultivar and cooking methods.

Results and Discussion

An analysis of variance (ANOVA) was performed to highlight the characteristics and significant texture differences observed for each sample. Regardless of flesh color, the sizes of the US. no 1 Petite sweetpotato roots employed in this study were not significantly different from each other (Table 1). The results also depicted the cultivar had no significant effect on the sizes of the sweetpotato roots (Table 2). Texture analyses were performed on cooked slices of the six sweet potato samples.

Open cooking

Hardness and resilience were observed to be highest, while cohesiveness had the lowest values among the open cooked treated sweetpotato cultivars (Table 3).

Pressure cooking

Hardness, gumminess, chewiness and resilience were found to be reduced significantly in pressure cooking when compared to other cooking methods (Table 3).

Baking

Cohesiveness, gumminess and chewiness were highest in the baked treatments (Table 3). Different methods of cooking are impacted by a blend of various factors, like temperature and time, thus when comparing various cooking techniques, care should be taken as outcomes will fluctuate due to the type of cooking treatment applied and the food product being prepared (Bernad, 2013). The deciding factor for the texture of plant substances are the cell wall's properties, magnitude and spread of vesicles within the cell's cytoplasm and the air-spaces located in-between cells (Bach, 2012). The textural characteristics of root crops are determined by the constituents of cell wall polymers and cell turgor pressure (Bach, 2012). Root crops consist mostly of thin-walled functional storage cellular tissues and cell walls that comprise of 90% polysaccharides (usually cellulose, peptic substances and hemicellulose) and 10% glycosylated proteins and phenolic constituents (Smith et al., 2003; Bach, 2012). In addition, other components such as, size and magnitude of food particles, level of heterogeneity, and the association of starch with lipids, protein and fiber would modify the characteristics that arise due to the thermal treatment (Trancoso-Reyes et al. 2016).

Cultivar

All purple (purple fleshed) sweetpotato differed significantly from other cultivars with the highest value of hardness, cohesiveness, gumminess and chewiness (Table 4). Beauregard held the highest value for springiness; however, it showed no significant differences from the Golden Nugget and All Purple cultivar (Table 4). Beauregard also was the cultivar with the most resilient texture and the least springy of all cultivars although its resilience and springy texture profile, did not vary significantly from most of the other cultivars. Ginseng produced significantly lower resilience than all the other cultivars tested. Ginseng also produced the lowest parameters for hardness, springiness, gumminess and chewiness however it did not vary significantly from many of the other cultivars. Cohesiveness, gumminess and chewiness were highest in the baked treatments while hardness and resilience were observed to be highest in the open cooked treatments (Table 4). Hardness, gumminess, chewiness and resilience were found to be reduced significantly in pressure cooked sweetpotatoes when compared to the rest of the cooking methods. Cohesiveness had the lowest values among the open cooked treated sweetpotato cultivars. Springiness had no significant effect on pressure cooked treatment sweetpotato roots. Leksrisompong et al. (2012) likewise assessed the impact of sweet potato of various flesh colors on buyer preference and discovered that the orange fleshed sweet potatoes were appeared to be moister and softer than those of other flesh colors (Leksrisompong et al. 2012). The purple shaded sweet potatoes were believed to be stringier and firmer in texture (Leksrisompong et al. 2012). Consumers generally were open to try sweetpotatoes of different flesh colors only if the flavor and textural traits were likewise very much enjoyed (Leksrisompong et al. 2012).

Dry matter content has been reported to be connected to some degree with the texture of potatoes, although this reality is not really clear (Van Marle et al. 1997). The dry weight of potatoes determines the texture of cooked and raw potatoes (Thybo & Martens 1999; Van Dijk et al. 2002; Seefeldt et al. 2011). Previous research studies have shown that, raw potatoes with lower dry matter content are soft, and potatoes with higher dry weight basis are firmer and harder (Gilsenan et al. 2010). Kruger et al. (1998) reported that the dry matter content of the white-fleshed sweetpotato at 18.2% was lower than that of the orange fleshed sweetpotato at 20%. Leighton et al. (2010) in addition observed that the white-fleshed sweetpotato had a moister appearance, a moister texture when first chewed and seemed to have reduced firmness than of orange-fleshed sweetpotato. Leighton et al. (2010), explained that the higher dry matter content of orange fleshed sweetpotato could have added to its being less moist on appearance, more denser and pastier than the white-fleshed sweetpotato. In addition, somewhat lesser dry matter of white-fleshed sweetpotato could account for the higher watery appearance (moisture content) of the cooked white-fleshed sweetpotato when assessed using a trained sensory panel (Leighton et al. 2010). Tomlins and others (2004) reported that the most essential sensory descriptors affecting consumer acceptability were starch and stickiness as they were more favored by consumers compared to the least preferred types were neither starchy nor were they sticky (Tomlins et al. 2004). Nevertheless, Afuape et al. (2014) conducted sensory assessments of fourteen sweet potato cultivars with various flesh colors and discovered that all were acceptable to consumers. Consumer acceptance of flesh color, texture and aroma of boiled sweetpotatoes was significant (Afuape et al. 2014).

Table 1. Physical properties of sweetpotato cultivars (Average sizes-weight, length and diameter, of U.S. no 1 petite size sweetpotato roots cultivated in the 2016 growing season)

Cultivars	Flesh color	Weight (oz)		Diameter (in)		Length (in)	
		Value	Rank	Value	Rank	Value	Rank
All Purple	Purple	6.7 a	1	1.88 a	6	5.34 a	3
Beauregard	Orange	5.9 a	4	1.97 a	4	5.37 a	2
Burgundy	Orange	6.3 a	3	2.11 a	1	5.72 a	1
Carolina Ruby	Orange	6.5 a	2	2.05 a	3	5.14 a	4
Ginseng	Orange	5.2 a	5	1.97 a	5	4.63 a	6
Golden Nugget	Orange	5.2 a	6	2.08 a	2	5.08 a	5

* Values followed by different letters differ significantly at $p<0.05$ by LSD.

Table 2. ANOVA results indicating effect of cultivar on U.S. no 1 petite sweetpotato root size

	Sources	Degree of Freedom	F-Value	P-Value
Weight	Model	23	1.43	0.1596
	Cultivar	5	1.12	0.3656
Length	Model	23	1.12	0.3688
	Cultivar	5	0.49	0.7834
Diameter	Model	23	0.85	0.6513
	Cultivar	5	0.54	0.7454

Table 3. Cultivar and cooking method interaction: Instrumental texture parameters

	Hardness (N)	Rank	Springiness (%)	Rank	Cohesiveness (%)	Rank	Gumminess	Rank	Chewiness	Rank	Resilience (%)	Rank
Cultivars	**Open cooking**											
All Purple	475.55 a*	1	0.60 bcde	8	0.113 ab	3	54.72 a	1	33.31 ab	2	0.08 ab	4
Beauregard	209.51 cd	5	0.72 abc	3	0.086 cdef	10	21.28 bc	5	14.55 cd	4	0.11 a	1
Burgundy	242.02 c	4	0.65 abcd	5	0.086 cdef	9	21.35 b	4	13.80 de	5	0.10 ab	3
Carolina Ruby	140.68 def	8	0.66 bcde	9	0.07 fg	16	9.46 bcd	9	5.95 def	9	0.04 c	7
Ginseng	170.39 cd	6	0.53 cde	13	0.07 fg	17	13.1 bcd	6	7.56 def	8	0.03 c	8
Golden Nugget	61.24 efgh	12	0.48 de	15	0.06 g	18	3.78 d	14	1.85 def	14	0.02 c	18
	Pressure cooking											
All Purple	143.20 de	7	0.60 bcde	7	0.09 bcdef	7	13.00 bcd	8	7.79 def	6	0.02 c	17
Beauregard	122.02 def	9	0.81 a	1	0.08 efg	13	9.48 bcd	9	7.74 def	7	0.02 c	16
Burgundy	51.18 fgh	13	0.58 cde	10	0.103 abcde	6	5.27 bcd	11	3.07 def	12	0.02 c	14
Carolina Ruby	35.79 gh	15	0.45 e	18	0.08 efg	14	2.83 d	15	1.31 ef	16	0.02 c	12
Ginseng	47.62 gh	14	0.57 cde	11	0.106 abcd	5	5.07 cd	12	2.92 def	14	0.02 c	13
Golden Nugget	64.24 efgh	11	0.64 abcde	6	0.076 fg	15	4.66 d	13	3.04 def	13	0.03 c	9
	Baking											
All Purple	333.14 b	3	0.69 abc	4	0.12 a	1	38.83 a	3	26.91 bc	3	0.04 c	6
Beauregard	31.15 h	16	0.45 de	17	0.08 efg	12	2.47 d	16	1.11 ef	16	0.02 c	15
Burgundy	23.43 h	18	0.45 de	16	0.083 defg	11	1.96 d	18	0.89 f	18	0.02 c	10
Carolina Ruby	78.20 efgh	10	0.55 cde	12	0.11 abc	3	8.61 bcd	10	4.76 def	10	0.08 b	5
Ginseng	24.76 h	17	0.49 de	14	0.086 cdef	8	2.06 d	17	1.04 f	17	0.02 c	11
Golden Nugget	426.77 a	2	0.79 ab	2	0.12 a	2	54.71 a	2	45.39 a	1	0.10 ab	2

* Values followed by different letters differ significantly at $p<0.05$ by LSD

Table 4. Main effect of cultivars on TPA parameters

Parameters	Cultivars					
	All Purple	Beauregard	Burgundy	Carolina Ruby	Ginseng	Golden Nugget
Hardness, (N)	317.30 a	120.89 c	105.54 c	84.89 c	80.92 c	184.08 b
Springiness (%)	0.63 ab	0.66 a	0.56 bc	0.53 c	0.53 c	0.63 ab
Cohesiveness (%)	0.107 a	0.082 b	0.091 b	0.086 b	0.087 b	0.085 b
Gumminess	35.52 a	11.07 c	9.53 c	6.97 c	6.74 c	21.05 b
Chewiness	22.67 a	7.80 c	5.92 c	4.01 c	3.84 c	16.76 b
Resilience (%)	0.05 a	0.05 a	0.05 a	0.04 a	0.02 b	0.05 a

* Values followed by different letters differ significantly at $p<0.05$ by LSD.

Comparison

In general, the ANOVA result of the six texture parameters evaluated were significant for the cultivar, cooking method and cultivar by cooking method interaction effect, the only exception was the effect of the cooking method on springiness was not significant (Table 5). On the properties of Jewel sweetpotatoes that had been baked partially and chilled before final cooking (Truong & Walter 1994), springiness had no significant effect on pressure cooked treatment sweetpotato roots. Of all the treatments tested, open cooked cultivars of All Purple were the hardest, with no significant variation from the baked Golden Nugget cultivars (Table 5). TPA hardness and fracturability showed comparative patterns and were highly correlated with peak force (Truong et al. 1998). It is noteworthy that the strength of the cell wall and cell tugor pressure are the reason for hardness in plant tissue (Lin & Pitt, 1986). When heat is applied however, the cell membrane structure is disturbed, and there is loss turgor pressure wherein water filters from the cells (Bach, 2012).

First the cell tissues loose solidness quickly, a turgor pressure diminishes (Greve et al. 1994b) then the cell wall loses its integrity as a result of a loss of pectic compounds (Greve et al. 1994a). Starch granules in root crops are available in undefined and crystal-like structures (Bach 2012). The starch in freshly harvested roots range from 6.9% to 30.7% (Tian et al. 1991). In addition, Bach (2012) discovered beetroots are more thermally stable when its texture was compared with that of Jerusalem artichoke tubers and softening of beetroots through boiling was just as a result of break of cell wall structure and loss of turgor pressure. As beetroots have considerable measures of ferulic acid dimers, which are engaged with cross-connecting of pectic polysaccharides between cells, prompting a solid cell adhesion even after after treatment (Waldron et al. 1997a)

Open cooked

All Purple sweetpotato cultivar were the gummiest although they did not vary significantly from baked All Purple and baked Golden Nugget sweetpotato cultivars (Table 5). Baked Golden Nugget sweetpotatoes were also the chewiest, however they did not vary significantly from open cooked All Purple sweetpotato (Table 5). During the chewing process, the cell wall experiences twisting or breaking based on the characteristics the cell wall (Waldron et al. 1997b). Beauregard sweetpotato prepared by open cooking had the highest resilience but its resilience value did not vary significantly from those in baked Golden Nugget sweetpotato and in the open cooked Burgundy and All Purple sweetpotato cultivars (Table 5). The most cohesive were the Beauregard sweetpotatoes to which pressure cooking was applied while the springiest were the baked All Purple sweetpotatoes, although both did not vary significantly from many of the other sweetpotato cultivars tested.

The softest sweetpotato was the Burgundy cultivar prepared by baking, it however did not vary significantly from many of the other cultivars across the various treatments tested (Table 5). The Burgundy sweetpotato to which the baking treatment was applied had the lowest value for both gumminess and chewiness, however not significantly different from most of the other cultivar and treatments (Table 5). Alternatively, an examination by Truong & Walter (1994), the typical texture profile analysis (TPA) curve for baked sweetpotato roots (Jewel cultivar) at 25˚C and 60˚C demonstrated a lower adhesiveness, cohesiveness and springiness. The TPA curve at the primary pressure cycle had a fracture peak, showing that the prepared sweetpotato had a level of firmness (Truong &Walter, 1994). This sort of TPA profile has been reported in cooked tubers of different Irish potato varieties (Leung et al. 1983). The Golden Nugget sweetpotato cultivar, treated with open cooking was the least cohesive and also the least resilient, though not significantly different from most of the other cultivars of same parameter across treatments (Table 5). Taherian & Ramaswam (2009) saw in their experiment that during boiling, take-up or adsorption of water lessen the cohesiveness and weakens the cell walls. Other than this, pectic polymers that play a part in cell adherence are broken down by β-elimination at higher temperatures (Keijbets & Pilnik, 1974; Ng & Waldron, 1997), and divalent cations, particularly $Ca2+$ and $Mg2+$ can decrease softening during heating, as the particles cross-interface the pectic polysaccharides associated with the cell adhesion (Favaro et al. 2008). The conduct of the above parameters is related to the sample properties and composition and essentially to the concentration of starch (Trancoso-Reyes et al. 2016). On heating, the crystalline areas are disturbed, water is taken up and the starch forms a gel (Adams, 2004). The gelatinised starch in the case of potatoes can at times occupy the whole cell, in which case the potato will be viewed as soft (Adams, 2004). The least springy cultivar was the pressure cooked treated Carolina Ruby cultivar, however its low springiness value was also not significantly different from that of many of the other sweetpotato cultivars across the various treatments (Table 5). In an investigation by Leighton et al. (2010) five sweetpotato cultivars it was discovered that sweet potatoes expanded in weight after cooking, though no noteworthy contrasts were found for the measure of weight increase between the diverse cultivars. The expansion in weight could be because of the application of moist heat cooking technique, and that the water content in the sweet potatoes increased (being starch based) amid the cooking time frame (Leighton et al. 2010). Fluctuating levels of firmness that emerge from various cooking treatment could be the motivation to measure the differences among varying cooking methods, for example, 29% diminishing in hardness for sous-vide treated samples, 44% for pressure cooked and 96% for cooked specimens when compared with raw samples (Bernad, 2013). Boiling at high temperatures disturbs cell cohesion and adhesion, bringing about a diminish in tissue rigidity (Truong et al. 1998). Asides from this, potatoes with greater dry matter content are softer in texture after they are boiled (Thybo & Martens, 2000; Kaur et al. 2002; Ukpabi et al. 2011). An investigation by Truong et al. (1998) revealed that sweetpotato samples immersed in boiling water were softer than the raw sweetpotato as shown by a less steep bend with reduced fracture strength. In a different report by Leighton et al. (2010) decrease in both shear strain and stress was seen in every single cultivar prepared with steaming technique in contrast to the qualities observed for raw sweet potatoes. The possible reason could be because of the extent in which starch and cell wall constituents break down during cooking, which then impacts on various textural properties among sweet potato cultivars (Leighton et al. 2010). Consequently, the estimation of pressure or shear constraint of raw samples may not be an exact forecast of the textural qualities of sweet potatoes (Truong et al. 1997). Wang et al. (2012) compared sweetpotatoes cooked by high steaming, and those broiled for 40 minutes, and discovered that the level of gelatinization could reach as high as 95% with just 140˚C superheated steam, while cooking in an oven or open fire requires temperatures up to 240˚C. It was likewise found that in spite of the fact that the presence of sweetpotatoes cooked utilizing superheated steam were not burned like the broiled ones, notwithstanding, sweetpotatoes baked at 240˚C for a 1h had the highest sensory score (Wang et al. 2012). The structure of starch granules are a major determinant of textural traits in tuber and root crops (Charoenkul et al. 2011). Starch consists of "amylose (a spiral polymer made up of D-glucose units) and amylopectin (a soluble polysaccharide and highly branched polymer of glucose found in plants)" (Anderson & Gugerty, 2015). The proportion of amylopectin and amylose in starch may thus account for the texture attributes in food products, including, stickiness, resistance against shear stress, swelling of starch granules due to heat, solubility, tackiness, stability of gel, cold swelling, and retrogradation (Satin, 1998).

Correlation

The ANOVA table for analyzing the correlation coefficients for the texture variables showed that the model was significant at p<0.05 (Table 6). The correlation coefficients exhibited a positive relationship between the texture variables springiness, gumminess, chewiness, resilience and hardness of the sweetpotato roots (Table 6). Springiness and resilience were not correlated with cohesiveness and with each other. Gumminess was significantly correlated with hardness and chewiness suggesting they have a relationship. Texture profile examination through instrumental texture estimations that identify with human discernment, are both imitative and empirical in nature (Bhattiprolu, 2004). Imitative tests (mimic gnawing and biting) include instrumental reproduction of conditions under which sensory properties of the specimen are surveyed by people (Bhattiprolu, 2004). Therefore, the imitative test ought to have the most reliable connection with sensory assessment (Szczesniak, 1963). The imitative test produces results for a number of instrumental parameters e.g., hardness, springiness, chewiness and so on, not at all like experimental, which measures just a single parameter. Although, texture standouts amongst the most essential quality traits of root crops, it has been described as one of the most difficult attributes to gauge instrumentally (Bach, 2012). Nevertheless, Bach (2012) in his study, did not find any direct association between the instrumentally measured texture and the sensory assessed texture properties in Jerusalem artichoke tubers. A study by Ellong et al. (2014) reported that the CAM/11/007 cultivar was beneficial for use as an edible vegetable because of its little size, uniformity in color, extraordinary flavor and texture. Although, its sporadic shape and low dietary potential can be a drawback.

Table 5. ANOVA results showing effects of cultivar, cooking methods and their interactions on instrumental texture parameters.

	Sources	Degree of Freedom	F-Value	P-Value
Hardness	Model	17	66.40	<0.0001
	Cultivar	5	84.36	<0.0001
	Cooking method	2	100.00	<0.0001
	Cultivar * Cooking method	10	50.60	<0.0001
Springiness	Model	17	8.47	< 0.0001
	Cultivar	5	6.82	0.0001
	Cooking method	2	1.29	0.2880[NS a]
	Cultivar * Cooking method	10	10.73	< 0.0001
Cohesiveness	Model	17	13.68	< 0.0001
	Cultivar	5	10.57	< 0.0001
	Cooking method	2	22.92	< 0.0001
	Cultivar * Cooking method	10	13.38	< 0.0001
Gumminess	Model	17	31.35	< 0.0001
	Cultivar	5	40.80	<0.0001
	Cooking method	2	35.23	<0.0001
	Cultivar * Cooking method	10	25.85	< 0.0001
Chewiness	Model	17	27.70	< 0.0001
	Cultivar	5	31.46	<0.0001
	Cooking method	2	26.90	<0.0001
	Cultivar * Cooking method	10	25.98	< 0.0001
Resilience	Model	17	33.44	< 0.0001
	Cultivar	5	7.83	<0.0001
	Cooking method	2	80.58	<0.0001
	Cultivar * Cooking method	10	36.81	< 0.0001

[a] NS- not significant

Table 6. Correlation coefficients of TPA parameters

Variable	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience	Hardness
Springiness	1.0					
Cohesiveness	0.38	1.0				
Gumminess	0.52	0.66	1.0			
Chewiness	0.59	0.66	0.98*	1.0		
Resilience	0.43	0.41	0.65	0.64	1.0	
Hardness	0.54	0.56	0.98*	0.95*	0.67	1.0

* Values are significant at p<0.05 by LSD

Conclusion

The results indicated the following conclusions 1. The texture profile analysis (TPA) clearly indicated the quality of organic sweetpotatoes is affected by different processing methods. 2. The mouthfeel characteristics like hardness, springiness, cohesiveness, gumminess and chewiness can be predicted by using instruments like texture analyzer. 3. Gumminess was significantly correlated with hardness and chewiness suggesting they have a relationship. 4. All purple was found to be the hardest, most cohesive, gummy and chewy sweetpotato. The least resilient cultivar, Ginseng, was the also the least hard, gummy and chewy cultivar. Beauregard was the springiest and most resilient cultivar. 5. The different processing conditions like open cooking, pressure cooking and baking affect the textual parameters differently depending upon the conditions. 6. Cohesiveness, gumminess and chewiness was highest under baking conditions. Hardness and resilience was greatest in open cooked treatments. In pressure cooked sweetpotatoes however, hardness, gumminess, chewiness and resilience were found to be reduced significantly when compared to the rest of the cooking methods. Cohesiveness had the lowest values among the open cooked treated sweetpotato cultivars. 7. In general, the hardness and other parameters reduced with processing, but the extent of decrease differed with the variety. 8. Across the treatments, open cooked, All Purple was found to be the hardest, springiest and gummiest cultivar while the baked burgundy sweetpotato were the softest, least gummy and chewy. Open cooked Beauregard were the most resilient while Beauregard prepared by pressure cooking were the most cohesive of all cultivars. Baked Golden Nugget were the chewiest while the least resilient and least cohesive cultivars were the open cooked Golden Nugget. Pressure cooked Carolina Ruby cultivars were the least springy. Results of this study indicate that the prediction of mouthfeel characteristics using instruments will reduce the time and energy to conduct sensory evaluations and helps to assess sweetpotato quality, thus setting bench marks for marketability.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

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