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TEXTURE PROFILE ANALYSIS (TPA) OF ORGANIC SWEETPOTATO (*IPOMOEA BATATAS*) CULTIVARS AS AFFECTED BY DIFFERENT PROCESSING METHODS

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ABSTRACT

Almost one-third of the entire U.S. is buying organic produce. It is believed that organic foods taste better and are more nutritious than conventional foods. To develop successful market positioning, the characteristics desirable to consumers, for sweetpotato must be identified. Different processing methods particularly thermal treatments would impact sweetpotato textures differently and as such affect the consumer liking and eventually product acceptability. Clear understanding of the influence of different thermal treatments on the textural characteristics of sweetpotato is therefore needed. The major objective of this research work was to evaluate the impact of different thermal processing techniques such as baking, pressure cooking, and open cooking on the textural characteristics of sweetpotato cultivars. Six cultivars of sweetpotato grown on a certified organic farm were subjected into different thermal treatments. Baking was done using an air oven for 60 min. Pressure cooking was done using a pressure cooking for 15 min and open cooking was done using a vessel filled with water (500 ml) for 1 hour. In all thermal treatments, the inside product temperature was kept constant (60±2°C). The texture parameters were recorded with a texture analyzer using a 100 mm dia probe. The samples were also penetrated 5 mm from the surface using a needle probe of 2 mm dia. Maximum peak force was set in Newtons. Across the treatments, open cooked Japanese Purple was found to be the hardest although not significantly different from Hernandez open cooked cultivar. Baked Old Yellow sweetpotato was the most gummy and chewy while the softest cultivar was the pressure cooked Old Yellow; however it did not differ significantly from the other five cultivars tested.

Keywords: Sweetpotato, cooking, thermal, texture profile

INTRODUCTION

Sweetpotato is a highly nutritious vegetable and its consumption has been increased in various parts of the world in recent years (**Sato, 2016**). A USDA survey reported that sweetpotato consumption in the U.S. increased from 1.9 kg to 3.4 kg per capita annually between 2000 and 2014 (**Johnson *et al.*, 2015**). There are several cultivars of sweetpotatoes that vary in their flesh colour, sugar composition and percentage dry matter (**La Bonte *et al.*, 2000**). Although, traditionally, the fresh produce market prefers orange-fleshed roots (**Coolong *et al.*, 2012**) and in the US, orange-fleshed cultivars generally occupy over 90% of sweetpotato production area (**Carpena, 2009**). According to the **North Carolina Sweetpotato Commission (2015)**, the more consumer-recognized orange-flesh sweetpotato cultivars are Beauregard, Hernandez, Jewel, Carolina Ruby, Porto Rico, Cordner and Covington. Sweetpotatoes are known to be a good source of energy, protein, fibre, and minerals including potassium, vitamin A, carotenoids and phenolic compounds (**Sajeev *et al.*, 2012; Ellong *et al.*, 2014; Laurie *et al.*, 2012; Button, 2015**). They are rich in starch, which represents more than 50% of the carbohydrate components (**Ellong *et al.*, 2014**). Sweetpotatoes are majorly consumed cooked, baked or fried. Ovens and pressure cookers are currently present in a lot of homes. Sometimes, sweetpotatoes may be pureed or candied to improve shelf life (**Padmaja, 2012**).

Sweetpotato cultivars react differently when cooked (either a soft or firm texture or colour changes after cooking). **Degras (1998)** reported that changes may occur in the nutrient and chemical composition of sweetpotatoes while cooking. These changes can alter the starch, dextrins, sugar, carotene and anthocyanin contents (**Magness *et al.*, 1971; Messiaen, 1975; Duke, 1983; Susheelamma, 1992**). **Reddy and Sistrunk (1990)** discovered that baking or microwaved cooked sweet potatoes contained high reducing sugars, total sugars and pectins than steamed ones. **Martin (1986)** reported that the percentage of starch that is converted to maltose in moist sweetpotato cultivars was 63-69% and about 54% for dry cultivars. Starch digestion has been said to increase with cooking and cooked sweetpotato starch was more prone to enzymatic breakdown compared to uncooked starch. **Bradbury *et al.* (1985)** observed a significant rise in the amount of dietary fibre in boiled and steamed sweetpotatoes possibly due to conversion of part of the starch to resistant starch. In addition, it has been shown that by diluting anthocyanins in cooking water, it could cause a fade colour **(Ellong *et al.*, 2014).** The white to orange flesh stains more and the cream flesh may change to yellow or greenish or even grey (**Ellong *et al.*, 2014**). This change was reportedly caused by the carotenoids degradation (**Ellong *et al.*, 2014**). Furthermore, enzymatic browning can occur through polyphenol oxidase (PPO) reactions. PPO catalyzes the process of oxidation of mono, di, and poly phenols to o-quinones (**Lourenco *et al.*, 1992**). It is highly likely that the method of cooking the sweetpotato could alter the dry matter content (**Leighton *et al.*, 2010**). It has been previously shown that water loss due to evaporation during steaming process can increase the dry matter content of cooked samples (**Truong *et al.*, 1997**).

Sweetpotato offers great possibility for usage in the food industry for the production of commercial products owing to the fact that sweetpotato is highly rich in starch content (**Woolfe, 1992**). It becomes imperative to have comprehensive understanding of the functional properties of the different sweetpotato cultivars in order to identify the most appropriate use for food processing (**Agnes *et al.*, 2012**). Texture (dry matter content) is one of the most crucial parameters directly linked to product quality **(Bhattiprolu, 2004)**. Texture analysis is a measure of food properties relating to how food sample feels in the mouth (**Bhattiprolu, 2004**). Textural quality can be assessed by use of instruments or by analysis of important constituents (**Bach, 2012**). According to **Truong *et al.* (1997)**, parameters provided by an instrument can be good predictors of cooked sweetpotato texture. These parameters include certain characteristics such as mechanical (e.g. mealiness), geometrical (e.g. graininess), compositional (e,g. wateriness) (**Szczesniak, 1963**), adhesiveness (work required to overcome the force of attraction holding food samples) and chewiness (length of time required to chew a sample) (**Bhattiprolu, 2004**). 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 baked samples, 44% for pressure cooked and 96% for open cooked specimens when compared with raw samples (**Bernad, 2013**). Generally, sweetpotato is mostly cooked at home; however, since home preparation is usually lengthy (80-90 min at 204ºC for baked sweetpotato), many interested consumers may not use the product due to the length of time required for cooking (**Truong and Walter, 1994**). Sometimes, it is more reliable to adopt

instrumental methods for assessing food texture rather than sensory methods. This is because they can be carried out under more controlled conditions. It also offers advantage of saving time and reducing costs, as well as providing more consistent results that are not subjective (**Bhattiprolu, 2004**).
The major marketable form of sweetpotato is fresh root (**Truong and Walter, 1994**). The quality of fresh market sweetpotato can vary due to differences in cultivar, conditions of cultivation, and post-harvest handling (**Walter, 1987**). Several studies have examined the reasons for textural distinction among cultivars and sweetpotato products and to decipher the effect on buyer preference and acceptance (**Truong *et al.*, 1997**; **Tomlins *et al.*, 2004**). Sensory characteristics of boiled or baked sweetpotato and preferences of consumers on different types of sweetpotato cultivars have been investigated (**Laurie *et al.*, 2013; Leksrisompong, 2012**). Nevertheless, to the best of our knowledge, no study has been done to evaluate instrumentally the effect of different cooking methods on the textural properties of sweetpotato cultivars produced in an organic management system. The main goal of this study was to determine textural differences among six cultivars (Hernandez, Japanese Purple, Murasaki, Orleans, Old Yellow and O'Henry) prepared using open cooking, baking and pressure cooking methods. At the end of this study we will come to know the cultivars with the most desirable texture characteristics that can be grown locally which will be valuable for agricultural producers.

MATERIALS AND METHODS

Cultivar field production and harvest

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. The cultivars include Orleans, Old Yellow, Murasaki, O'Henry and Japanese Purple which have been grown in limited amounts for fresh root markets and processing industry and Hernandez, a moist type sweetpotato and major commercial cultivar well liked in the southern part of the U.S. Sweetpotato slips were purchased in June from Jones Family Farms, Bailey, N.C., Slade Farms, Surrey, V.A., Barefoot farms, TN, USA and planted immediately. It took four months for the slips to mature to vines and the sweetpotato was harvested. 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 sweetpotatoes differ in size, only samples that had similar magnitude and shape were chosen for the examination. For each cultivar, three sweetpotato roots were selected randomly, sorted, washed, peeled, and diced into cubes. Roots of average diameter measurement of 1.96 inches, length of 5.06 inches and weight of 5.12 oz. were selected for experimental use.

Sweetpotato cooking methods and experimental design

The open/non-conventional cooking technique, pressure cooking and baking were the three cooking techniques applied in this 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.*, 2010)**. No top cover was utilized for pots in the open cooking technique. A fixed time of 20 minutes cooking 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.*, 2010)**. 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**).

Instrumental texture profile analysis

After cooking, all sweetpotato were left to cool at room temperature (30±2°C), then peeled, diced into one-inch cube square samples and put away in independently sealed and labeled polythene bags to prevent loss of moisture before completing instrumental examination. Texture Profile Analysis (TPA) was done utilizing a texture analyzer TA HD Plus (Texture Technologies) with a level plate of 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 (one each squared sweetpotato cube) from the calibrated height (50 mm) with the pre-test speed; packed 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. Three samples for each treatment were tested. Care was taken to guarantee the removal of the specimen from the plate when the plate finished the second compression cycle and came back to its original position. The sample was compressed twice in order to mimic the mastication process. Six test parameters resulted from the analysis of a force versus time curve (Figure 1) was obtained during the compression test.

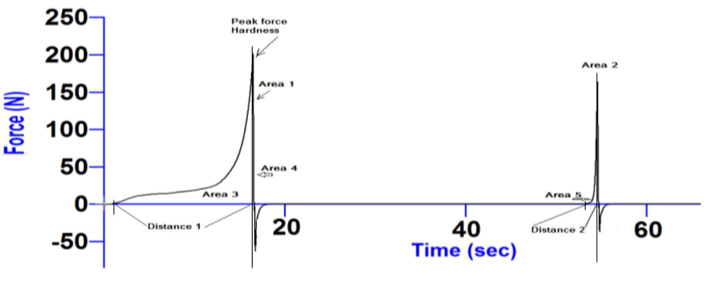

Figure 1 Typical texture (TPA) profile curve showing measurement of texture parameters

As described by **Bourne (1978),** we assessed the hardness, chewiness, springiness, cohesiveness, gumminess, and resilience. These terms were defined as follows **(Szczesniak, 1975)**: Hardness: force required to cause a deformation, Chewiness: time required to chew a food sample to a state suitable for swallowing, Springiness: the rate at which a deformed material goes back to its intact state after deformation, Cohesiveness: extent to which a sample can be deformed before rupturing, Adhesiveness: work necessary to overcome the force of attraction between the food surface and other materials in contact with the food, Gumminess: energy required to breakdown a semi-solid food to a suitable state for swallowing, Resilience: a product of a low degree of hardness and a high degree of cohesiveness.

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. 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 (hardness, springiness, cohesiveness, gumminess, chewiness, and resilience). If interactions of cultivar and cooking methods were significant, they were used to explain the results. When the main effect was significant, Fisher's least significant difference (LSD) test was used for multiple comparisons between mean values of the variables (cultivar and cooking methods).

RESULTS AND DISCUSSION

The ANOVA results indicated that the texture profile parameters were significantly affected by the thermal treatments. Cultivar and cooking method affected the instrumental texture parameters of the sweetpotatoes (Table 1).

Table 1 ANOVA results (F values) showing effects of cultivar, cooking methods and their interactions on instrumental texture parameters.

Sources		Degree of Freedom	F-Value	P-Value
Hardness	Model	17	222.31	<0.0001
	Cultivar	5	51.20	<0.0001
	Cooking method	2	284.72	<0.0001
	Cultivar * Cooking method	10	295.39	<0.0001
Springiness	Model	17	39.46	< 0.0001
	Cultivar	5	46.22	< 0.0001
	Cooking method	2	31.19	< 0.0001
	Cultivar * Cooking method	10	37.74	< 0.0001
Cohesiveness	Model	17	13.98	< 0.0001
	Cultivar	5	23.75	< 0.0001
	Cooking method	2	28.18	< 0.0001
	Cultivar * Cooking method	10	6.25	< 0.0001
Gumminess	Model	17	77.88	< 0.0001
	Cultivar	5	26.67	<0.0001
	Cooking method	2	62.68	<0.0001
	Cultivar * Cooking method	10	106.52	< 0.0001
Chewiness	Model	17	68.05	< 0.0001
	Cultivar	5	34.07	<0.0001
	Cooking method	2	58.50	<0.0001
	Cultivar * Cooking method	10	86.96	< 0.0001
Resilience	Model	17	24.35	< 0.0001
	Cultivar	5	16.00	<0.0001
	Cooking method	2	85.06	<0.0001
	Cultivar * Cooking method	10	16.38	< 0.0001

Effect of Cultivars on textural characteristics of sweetpotato

Old Yellow differed from other cultivars, having the highest values for cohesion, gumminess and chewiness (Table 2). In the chewing process, the cell wall experiences twisting or breaking based on the characteristics of the cell wall **(Waldron *et al.*, 1997).** As for springiness, Old Yellow also held the highest value and did not present significant difference with the Japanese Purple cultivar. Hernandez held the highest value for hardness although it did not differ significantly from Japanese Purple (Table 2). 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)**. According to **Truong *et al.* (2011**), such sweetpotato cultivars with high dry matter content have firm and mealy texture after cooking while those with low dry matter content have soggy texture after cooking. As for resilience, Hernandez also held the highest value, however, it did not vary significantly from Japanese Purple and Old yellow cultivars (Table 2). O'Henry produced the lowest values for gumminess and hardness. O' Henry also produced the lowest values for chewiness and resilience, however, it was not significantly different from Murasaki and Orleans. **Walter *et al.* (1997)** reported that the product processed from soft-sweet type sweetpotato was softer, moister, had fewer particles, more mass cohesion, was easier to swallow, and had an oily mouthfeel. Orleans produced the lowest parameters for springiness and cohesiveness, however, it did not vary significantly from Murasaki (and O' Henry in the case of cohesiveness) (Table 2).

Table 2 Sweetpotato cultivars and their instrumental texture parameters

	Cultivars					
Parameters	Hernandez	Japanese Purple	Murasaki	Orleans	Old Yellow	O'Henry
Texture	2.47 dc	2.43 d	2.62 bcd	2.66 bcd	263 bcd	2.61 bcd
Rank	5	6	3	1	2	4
Hardness (N)	231.50 a	221.76 ab	197.56 bc	197.71 bc	182.02 c	89.39 d
Rank	1	2	4	3	5	6
Springiness	0.64 c	0.73 ab	0.55 d	0.53 d	0.75 a	0.69 bc
Rank	4	2	5	6	1	3
Cohesiveness	0.10 bc	0.10 b	0.08 bcd	0.07 d	0.13 a	0.08 cd
Rank	2	2	3	4	1	3
Gumminess	19.30 b	17.83 b	16.95 b	15.07 b	28.54 a	7.97 c
Rank	2	3	4	5	1	6
Chewiness	12.58 b	12.33 b	10.40 bc	9.28 bc	26.54 a	5.30 c
Rank	2	3	4	5	1	6
Resilience	0.44 a	0.33 a	0.04 b	0.07 b	0.32 a	0.03 b
Rank	1	2	5	4	3	6

[*] Mean values in a row with different letters differ significantly at P<0.05 by LSD. Ranking by high to low values among the cultivars.

Texture, or mouth-feel, is a major attribute in deciding overall consumer acceptance of sweetpotato cultivars. A mixture of sensory attributes of the sweetpotato root can impact consumer taste and overall acceptability. According to a sensory study by **Nwosisi *et al.* (2017)** using a semi-trained sensory panel, the least favored cultivars (Japanese Purple) had watery [due to a somewhat lesser dry matter/ moisture content of the white fleshed sweetpotato as reported by **Leighton *et al.* (2010)],** sweet, fibrous, vanilla, and dense textural traits. Among other things, the lower acceptance of hardness or dense textural traits can be confirmed from our TPA results. Japanese Purple and Hernandez with the least liked textural traits from their study also showed the greatest hardness and resilience. However, they did not differ significantly from each other and from some of the other cultivars (Put those cultivars in this bracket). **Walter *et al.* (2002)** discovered that sensory hardness and density were highly correlated with the value of instrumental measurements while cohesiveness, oiliness and moistness were negatively correlated with the value of instrumental measurements. In an experiment conducted on sweetpotato French fries, consumers preferred the caramel flavor and disliked starch flavor, and first-bite moistness and cohesiveness of mass in texture. On the other hand, there have been other reports 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 which were neither starchy nor sticky **(Tomlins *et al.*, 2004; Nwosisi *et al.*, 2017).** Following the use of instruments, a fully-trained sensory panel should thus be set up to confirm the results of our present study as the process of determining the acceptance of a food product is measured from different dimensions (**Costell *et al.*, 2010).**

Effect of cooking methods on textural characteristics of sweetpotatoes

Springiness, cohesiveness, gumminess and chewiness were highest in the baked treatments (Table 3). While hardness and resilience were observed to be highest in the open cooked treatments, cohesiveness was found to be greatest in the pressure-cooked treatments although it was not significantly different from the baked treatment. Hardness, gumminess, chewiness and resilience were significantly reduced in pressure-cooked sweetpotatoes when compared to the rest of the cooking methods. Springiness was least among the open-cooked treated sweetpotato cultivars.

Table 3 Effect of cooking methods on textural properties of sweetpotato cultivars

	Cooking methods					
	Baking	Rank	Open cooking	Rank	Pressure cooking	Rank
Hardness (N)	188.11 b	(2)	270.84 a	(1)	101.02 c	(3)
Springiness (%)	0.70 a	(1)	0.60 c	(3)	0.65 b	(2)
Cohesiveness (%)	0.10 a	(2)	0.07 b	(3)	0.11 a	(1)
Gumminess	23.86 a	(1)	19.27 b	(2)	9.70 c	(3)
Chewiness	19.80 a	(1)	12.02 b	(2)	6.40 c	(3)
Resilience (%)	0.05 b	(3)	0.54 a	(1)	0.20 b	(2)

Mean values in a row with different letters indicate significantly different at P<0.05. Values in parenthesis in a row indicate the ranking among the cooking methods with respect to that parameter.

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).** 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).** As water flows down during osmosis into the cell vacuole to fill the cell wall compartment, turgor pressure helps to keep the cells rigid **(Bach, 2012).** Flaccidity sets in when turgor pressure is lost **(Bach, 2012).** Cells with high turgor pressure are usually stiff and hard, whereas flaccid cells are rubber-like **(Bach, 2012).** The sweetpotato flesh is composed mainly of starch, which only swells up by water absorption and then breaks down due to the hydrolysis of the weak bonds **(Sugri *et al.*, 2012)**. Starch granules in the raw state on the other hand are hard, tightly packed, tiny aggregation of starch molecules, which give a chalky feels when chewed out of the cells **(Leighton *et al.*, 2010).** During cooking of the sweetpotao, the starch granules begin to soften at about 66 ºC (this temperature varies in plants), and moisture is absorbed, which impairs their compact structure and the granules swell up to many times their original size and weight **(McGee, 2004).**

Comparison of the effect of thermal treatments on sweetpotato cultivars

Of all the treatments tested, baked Old Yellow cultivars were the most gummy and chewy (Table 4). Baked Old Yellow sweetpotato was also the springiest, however it di did not vary significantly from baked Japanese Purple sweetpotato cultivar. The maximum viscosity attained during the heating cycle, peak viscosity, shows the swelling ability of the starch granules before they are physically broken down **(Ikegwu and Okechukwu, 2010)**. **Truong and Walter (1994)** observed in their study that although in baked roots, the microstructure of the cell wall was destroyed completely, many gelatinized starch granules still retained integrity and shape. This finding contradicts with what was reported on Egyptian sweetpotato cultivar **(Damir, 1989)**. There was a complete shape deformation of starch granules baked at 175 ˚C for 60 min. The extent of deformation of starch granules and other contents associated with the structure of baked sweetpotato likely varies among cultivars and may contribute to textural variability **(Truong and Walter, 1994**). The proportion of amylopectin and amylose in starch may thus account for the texture attributes in food products, including, stickiness, and resistance against shear stress, swelling of starch granules due to heat, solubility, tackiness, stability of gel, cold swelling, and retrogradation**.** Japanese Purple cultivar prepared using the open cooking method was the hardest, however, they were not different from open-cooked Hernandez sweetpotato cultivar (Table 4). 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**.** When heat is applied however, the cell membrane structure is disturbed, and there is loss of turgor pressure wherein water filters from the cells **(Bach, 2012).** First, the cell tissues loose solidness quickly, a turgor pressure diminishes then the cell wall loses its integrity as a result of a loss of pectic compounds**.** The open-cooked Hernandez cultivars were also the most resilient, however, they did not vary significantly from the Japanese purple and Old Yellow sweetpotato also prepared using open cooking method (Table 4). Baked Old Yellow sweetpotato were also the most cohesive of all treatments and cultivars tested, however, their cohesive property was not significantly different from Japanese Purple and Old Yellow pressure-cooked sweetpotato, Old Yellow open-cooked sweetpotato and Hernandez baked Sweetpotato. Boiling at high temperatures disturbs cell cohesion and adhesion, bringing about a defect 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 and Martens, 2000**).

Table 4 Texture parameters of sweetpotato cultivars as affected by different cooking methods

	Cultivars	Hardness (N)	Rank#	Springiness (%)	Rank#	Cohesiveness (%)	Rank#	Gumminess	Rank#	Chewiness	Rank#	Resilience (%)	Rank#
Open cooking	Hernandez	532.81 ab	2	0.68 bc	7	0.07 cdef	14	39.47 b	3	26.91 b	3	1.26 a	1
	Japanese Purple	562.47 a	1	0.68 bc	8	0.07 cdef	12	42.35 b	2	28.68 b	2	0.93 a	2
	Murasaki	252.32 d	6	0.39 h	18	0.06 def	16	16.10 c	6	6.18 c	8	0.20 b	12
	Orleans	171.19 e	7	0.49 fgh	16	0.05 f	18	8.33 cd	9	4.06 c	11	0.16 b	4
	Old Yellow	49.64 gh	14	0.63 bcde	11	0.12 ab	4	5.86 cd	12	3.73 c	14	0.88 a	3
	O'Henry	56.64 gh	13	0.73 b	3	0.06 ef	17	3.52 d	15	2.58 c	15	0.02 b	11
Pressure cooking	Hernandez	58.67 gh	12	0.71 bc	6	0.10 bcd	6	6.36 cd	10	4.47 c	10	0.02 b	14
	Japanese Purple	40.03 gh	16	0.58 cdef	13	0.15 a	2	6.25 cd	11	3.75 c	13	0.02 b	13
	Murasaki	33.69 h	17	0.54 defg	14	0.10 bcde	9	3.42 d	17	1.85 c	17	0.01 b	16
	Orleans	372.75 c	4	0.66 bcd	10	0.09 bcdef	10	33.38 b	4	22.20 b	5	0.03 b	10
	Old Yellow	25.77 h	18	0.67 bc	9	0.13 ab	3	3.34 d	18	2.23 c	16	0.01 b	15
	O'Henry	75.22 fgh	10	0.72 b	4	0.07 cdef	13	5.43 cd	13	3.92 c	12	0.01 b	18
Baking	Hernandez	103.03 fg	9	0.53 efg	15	0.12 abc	5	12.08 cd	8	6.37 c	7	0.05 b	8
	Japanese Purple	62.80 gh	11	0.94 a	2	0.07 cdef	11	4.89 cd	14	4.58 c	9	0.04 b	9
	Murasaki	306.67 d	5	0.72 b	5	0.10 bcd	8	31.34 b	5	23.16 b	4	0.09 b	5
	Orleans	49.20 gh	15	0.45 gh	17	0.07 def	15	3.49 d	16	1.60 c	18	0.01 b	17
	Old Yellow	470.67 b	3	0.95 a	1	0.16 a	1	76.41 a	1	73.67 a	1	0.08 b	6
	O'Henry	136.30 ef	8	0.62 bcde	12	0.10 bcd	7	14.96 cd	2	9.41 c	6	0.07 b	7

[*] Values followed by different letters differ significantly at p<0.05 by LSD. [#]Ranking based on the values from high to low.

The softest sweetpotato were the Old Yellow cultivar type prepared using the pressure cooking method, it however did not vary significantly from many of the other cultivars (Orleans, Murasaki, O'Henry, Japanese and Hernandez) across the various treatments tested (Table 4). 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 sweetpotato. The possible reason could be because of the extent in which starch and cell wall constituents break down during cooking, which then impacts various textural properties among sweetpotato cultivars **(Leighton *et al.*, 2010).** The least springy sweetpotato was the open-cooked Murasaki cultivar, however its low springiness value was not significantly different from that observed for the open-cooked and baked Orleans sweetpotato (Table 4). The least cohesive, gummy, chewy and resilient cultivars were observed to be the open-cooked Orleans, pressure-cooked Old Yellow, baked Orleans and pressure-cooked O'Henry cultivars, respectively. **Leighton *et al.* (2010)** also reported that during boiling, take-up or adsorption of water lessens 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, and divalent cations, particularly Ca^{2+} and Mg^{2+} can decrease softening during heating, as the particles cross-interface the pectic polysaccharides associated with the cell adhesion **Leighton *et al.* (2010)**. 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**.** 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**.**

Correlations among TPA parameters

The correlation coefficients exhibited a positive relationship between the texture variables (springiness, gumminess, chewiness, resilience and hardness) of the sweetpotato roots (Table 5). Gumminess was significantly correlated with hardness and chewiness, suggesting they have a relationship. Chewiness was significantly correlated with hardness. In support of our results, experimental data examination by **Walter *et al.* (2002)** to determine the textural measurements and product quality of restructured sweetpotato French fries, indicated that hardness decreases with calcium concentrations and gel strength. Also, gumminess also appeared to be affected similarly as hardness, but the coefficient of variation was large to make this relationship uncertain **(Walter *et al.*, 2002).**

Table 5 Correlation coefficients of TPA parameters

Correlation coefficients						
TPA parameters	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience	Hardness
Springiness	1.00-					
Cohesiveness	0.27					
Gumminess	0.43	0.26				
Chewiness	0.53	0.34	0.98*			
Resilience	0.03	-0.08	0.31	0.22		
Hardness	0.23	-0.07	0.88*	0.78*	0.53	1.00-

* Values in asterisks are significant at p<0.05 by LSD

CONCLUSION

The texture profile analysis (TPA) was employed to predict the consumer acceptability of organic sweetpotato as affected by different processing methods. The mouthfeel characteristics (hardness, springiness, cohesiveness, gumminess and chewiness) can be predicted by using instruments such as texture analyzer. Chewiness was significantly correlated with hardness. Gumminess was significantly correlated with hardness and chewiness suggesting they have a relationship. Hernandez was found to be the hardest cultivar although not significantly different from Japanese Purple. Old Yellow was the most cohesive, gummy and chewy sweetpotato. The least resilient cultivar, O'Henry, was also the least hard, gummy and chewy cultivar, its chewiness and resilience was however not significantly different from Muraski and Orleans. The springiest cultivar was Old Yellow, though it did not differ significantly from the Japanese Purple cultivar. Hernandez was the most resilient cultivar, however it was not significantly different from Murasaki and Orleans. The different processing conditions such as open cooking, pressure cooking and baking affect the textural parameters differently depending upon the conditions. Springiness, gumminess and chewiness were highest under baking conditions. Hardness and resilience were greatest in open-cooked treatments. Cohesiveness was found to be greatest in the pressure-cooked treatments, although it was not significantly different from the baked treatment. In pressure-cooked sweetpotato however, hardness, gumminess, chewiness and resilience were found to be reduced significantly when compared to the rest of the cooking methods. Springiness had the lowest values among the open-cooked treated sweetpotato cultivars. Across the treatments, open-cooked Japanese Purple was found to be the hardest, although not significantly different from Hernandez open-cooked cultivar. Baked Old Yellow sweetpotato was the most gummy and chewy while the softest cultivar was the pressure-cooked Old Yellow; however it did not differ significantly from many of the other cultivars (Orleans, Murasaki, O'Henry, Japanese and Hernandez) tested. 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 sensory quality, thus setting bench marks for marketability. Although, texture stand out amongst the most essential sensory traits of root crops, it has been described as one of the most difficult attributes to gauge instrumentally. Studying the changes in texture properties of different sweetpotato cultivars prepared under different cooking methods and time would help us improve the sensory properties of each meal we consume as we would be able to determine the desirable changes in the major textural characteristics and the optimum time needed for preparation thereby reducing the time spent cooking. Although, qualitative descriptive analysis is a time-consuming process, however, when applied to promising cultivars, it can provide vital information that can predict potential preference by consumers.

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