ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 07, Issue, 12, pp.17578-17584, December, 2017

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

SENSORY, CHEMICAL AND NUTRITIONAL CHARACTERIZATION OF SWEET POTATO SUBMITTED TO COOKING PROCESS IN WATER IMMERSION

[1]Jaqueline Machado Soares, [1]Ana Flávia de Oliveira, [2]Érica Caroline da Silva, [2]Paulo Sergio Loubet Filho, [3]Juliano Tadeu Vilela de Resende, [1]Dalton Luiz Schiessel, [4]Kélin Schwarz, [5]Elisvânia Freitas dos Santos and *,[1]Daiana Novello

[1] Postgraduate Program Interdisciplinary in Community Development, Midwest State University, Guarapuava, Paraná, Brazil
[2]Faculty of Pharmaceutical Sciences, Food and Nutrition, Federal University of Mato Grosso do Sul, Brazil
[3]Department of Agronomy, Midwest State University, Guarapuava, Paraná, Brazil
[4]Department of Nutrition, Federal University of Triângulo Mineiro, Uberaba, Minas Gerais, Brazil
[5]Faculty of Pharmaceutical Sciences, Food and Nutrition, Nutrition Course, Postgraduate Program in Health and Development in the Midwestern Region, Federal University of Mato Grosso do Sul

ARTICLE INFO

Article History:
Received 24th September, 2017
Received in revised form
19th October, 2017
Accepted 22nd November, 2017
Published online 29th December, 2017

Key Words:
Acceptability,
Cooking,
Nutrients,
Tuberous root.

ABSTRACT

The study aim was to evaluate the sensory acceptability and the chemical and nutritional composition of different Brazilian sweet potato cultivars cooked under water immersion, in order to identify the most favorable genotypes for consumption. The cultivars varieties analysed were Amorano, Júlia, Valentina, UGA 29, UGA 34, UGA 45, UGA 49, UGA 79, UGA 80 e UGA 81. Species of sweet potatoes Júlia, UGA 45 e UGA 49 have shown higher sensory acceptability ($p<0.05$). Higher levels of, nonreducing sugars (24.11 $g.100g^{-1}$), total sugars (29.01 $g.100g^{-1}$) and total soluble solids/titratable acidity ratio (341.20) have been observed to cultivars Valentina. There were no statistical differences ($p>0.05$) between the pH levels (6.05 to 6.97) of all sweet potatoes. In addition, there was little variation in titratable acidity content (0.07 to 0.11% citric acid) ($p<0.05$). A more favorable nutritional profile (higher levels) was observed for UGA 34 (protein, carbohydrate and energetic value) and UGA 80 (ash, lipid and carbohydrate).However, higher concentrations of total carotenoid (2.06 $\mu g.g^{-1}$) and ascorbic acid (17.72 $mg.100g^{-1}$) were observed in cultivars UGA 81 and Valentina, respectively. It is concluded that there are differences in acceptability and in chemical and nutritional composition among Brazilian sweet potatoes cultivars, submitted to cooking process by immersion in water. Sweet potato varieties Valentina, UGA 34 and UGA 80 can be considered the most favorable for human consumption, although they do not present higher sensory acceptability than the others.

Copyright ©2017, Jaqueline Machado Soares et al. *This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

Citation: Jaqueline Machado Soares, Ana Flávia de Oliveira, Érica Caroline da Silva et al. 2017. "Sensory, chemical and nutritional characterization of sweet potato submitted to cooking process in water immersion", *International Journal of Development Research*, 7, (12), 17578-17584.

INTRODUCTION

Sweet potato (*Ipomea batatas* (L.) Lam) is a tuberous root belonging to botanical family *Convolvulaceae* and is among the most popular and ancient in the world. It presents irregular shape with bark and pulp that stains ranging from pure white to intense purple. It has easy climate adaptation and needs minimum conditions to develop. A single plant can produce between 40 and 50 roots. Sweet potatoes can be marketed throughout the year, but harvesting predominates in the fall and early winter (Ikanone and Oyekan, 2014; Tang *et al.*, 2015). It occupies the 5th place among the most produced foods worldwide, being cultivated 106.601.602 tons/year. In Brazil, sweet potatoes are the 17th most cultivated temporary crop in the country with production of 525.814 tons/year (FAO, 2015, 2016). Moreover, it is considered as a grassroots crop for developing countries. This is because it has a high economic potential, besides promoting food security, since it presents a good nutritional quality (Tang *et al*., 2015; Suárez *et al.*, 2016). There are several varieties of sweet potatoes known

***Corresponding author:* Daiana Novello,**
Postgraduate Program Interdisciplinary in Community Development, Midwest State University, Guarapuava, Paraná, Brazil.

and produced worldwide. In countries such as China, Japan and Korea the varieties that stand out are those with white, yellow or purple peel color and orange or purple pulp (Kim *et al.*, 2015). In Brazil, there are with more frequent ones with colorations of clear pulp and white and purple peels. Despite this, several sweet potato cultivars are constantly being produced all over the world, with the aim of favorably modifying their agronomic, technological and nutritional characteristics. Examples of these are the Beniazuma, Koganesengan and Kotobuki genotypes, which presented higher nutrient and phenolic content (Dincer *et al*., 2011). In addition, varieties such as Juhwangmi, Sinhwangmi, Sinjami and Yeonjami were evaluated for superior productivity (Kim *et al.*, 2015).

The consumption of sweet potatoes is mainly due to their sensorial characteristics, ease preparation (cooking and baking) and favorable nutritional profile. It has a considerable energy value, which comes from its high carbohydrate content. In addition, it has significant amounts of vitamins A and C, minerals such as potassium and phosphorus and dietary fiber (USDA, 2016). Other antioxidant substances such as phenolics and carotenoids are also part of sweet potatoes nutritional composition (Dincer *et al.*, 2011). Sweet potatoes are generally consumed coked and baked, as well as being widely used by the food industry in flour, jellies and alcoholic beverages preparation. To guarantee their commercialization, these products must follow a strict quality control, which ensures compliance with the specific legislation of each country (Ikanone and Oyekan, 2014; Suárez *et al.*, 2016).

Cooking process is crucial in tubers such as sweet potatoes and it helps to reduce microbiological load, improves sensory quality, digestibility and nutrients bioavailability (Ikanone and Oyekan, 2014; Dincer *et al.*, 2011). Carotenoid content in sweet potatoes, for example, can increase by up to four times after cooking (Kim *et al.*, 2015). However, Tang *et al.* (2015) observed a negative correlation between steam cooking and bioactive substances such as anthocyanins. In addition, there may be significant changes in the nutritional profile of distinct sweet potato genotypes after cooking. Dincer *et al*. (2011) observed that cooking in water increased fiber and ash content in sweet potatoes (Beniazum, Koganeseng and Kotobu). However, there was a reduction in moisture, protein and starch content. Therefore, the aim of the present study was to evaluate the sensory acceptability and chemical and nutritional composition of different Brazilian sweet potato cultivars cooked under water immersion, in order to identify the most favorable genotypes for consumption.

MATERIALS AND METHODS

Plant material

Experiment was carried out at the Cedeteg Campus of the Midwestern State University in Guarapuava, Paraná, Brazil (25º23'42 "S, 51º27'2ºO, 1.120 m altitude). The experimental design was a randomized complete block design with three replicates and 10 treatments, genotypes from the Midwestern State University sweet potato Germplasm Bank. Clones used in the research were: UGA 29 (peels and pulps white); UGA 34 (peels and pulps purple); UGA 45 (purple peel and white pulp); UGA 49 (peels and pulps white); UGA 79 (peels and pulps white color); UGA 80 (purple peel and white pulp); UGA 81 (peels and pulps white); Amorano (purple peel and white pulp); Júlia (peels and pulps white) and Valentina (peels and pulps purple). Each replicate was composed of a three tuberous roots samples, with an average weight of 500 to 700g. The experimental soil area was prepared by plowing and harrowing. The planting beds were raised side by side, spaced 80 cm apart, with the aid of a duck nozzle. The soil chemical analysis did not identify the need for liming. The branches, taken from the parent plants of the different genotypes, were planted in the spring season in 50 cell trays. The intermediate and superior portions of the vegetative structures of the sweet potato plant (three internodes) were used. After 30 days, the seedlings were transplanted to the field, in plots composed of 6 seedlings of each genotype. Plants were arranged in plots with a useful area of 2.0 m^2, spaced 30 cm apart.

Irrigation used was sprinkler type, being performed once a day for 30 minutes in the first month after planting, or when necessary, since the pluviometric regime in this period was quite intense. Planting fertilization consisted of 40 kg ha^{-1} of nitrogen, 80 kg ha^{-1} of phosphorus and 90 kg ha^{-1} of potassium (Silva *et al*., 2004) and replacement fertilization was performed 60 days after planting, with 100 g $portion^{-1}$ of fertilizer 20-00-20. Weed control was done by manual weeding until 45 days after transplanting. After this period, plants covered the beds and control was no longer necessary. No phytosanitary controls were carried out. Harvest was performed after 157 days of planting in the field, at the end of the summer, and with commercial maturation stage to consumption. After harvesting, sweet potatoes were stored in raffia bags, duly identified and stored at room temperature (22 °C) until analysis.

Sweet potatoes samples preparation

Sweet potatoes with better visual appearance were used. Those with defects and/or presenting very different size and appearance were excluded. The samples were then washed in running water, followed by sanitization in sodium hypochlorite solution (150 ppm) for 15 minutes. The tips of the tuberous roots were discarded and the medial part cut into cylinders approximately 3 cm of length. Sweet potatoes (100 g) were immersed in 1 L of boiling water (100 °C) and cooked until the material showed no resistance to drilling by stainless steel knife. They were manually peeled, cut (2 cm x 1 cm) and stored in hermetically sealed plastic containers. The samples were kept under refrigeration until analysis (8 ºC).

Consumer study

For conducting the sensory test, sweet potatoes have been cooked as previously described. All samples were evaluated by means of an acceptance test using a nine point hedonic scale, with extremes ranging from dislike extremely (1) to like extremely (9) (Meilgaard *et al.*, 1999). Were evaluated attributes related to appearance, aroma, flavour, texture and colour. The sensory acceptability index (AI) was calculated by multiplying the average score reported by consumers to the product by 100, dividing the result by the maximum average score given to the product within the hedonic scale for 9.0 points.

Participated in sensory analyses 60 untrained volunteer subjects, sweet potato usual consumers. Consumers had aged between 18 and 60 years and were recruited among students and staff of Midwestern State University, Guarapuava, Paraná, Brazil. Each sample was served to consumers in white plates coded with randomly selected 3-digit numbers in monadic

form and using balanced design (Macfie and Bratchell, 1989). Sensory evaluations were performed by consumers under fluorescence lighting. After consuming each sample, consumer was instructed to drink water for palate cleansing. Samples were evaluated in triplicate in separate session.

Chemical and nutritional characterization

Chemical determinations were performed in triplicate on sweet potatoes without peel. The results were expressed in wet weight basis. Following chemical evaluations were performed: Reducing Sugars (RS), Nonreducing Sugars (NRS) and Total Sugars (TS), evaluated by Lane-Eynon reductometric method (AOAC, 2011). Result was expressed in $g.100g^{-1}$; pH, by means of direct reading in digital pH meter (Analyser®, 300M model, Brazil); Total Soluble Solids (TSS), measured in a digital refractometer (Hanna Instruments®, Brazil, model HI 96801) and expressed in °Brix; Titratable Acidity (TA) assessed according to AOAC (2011) and expressed in citric acid percentage (%); and Total Soluble Solids/Titratable Acidity (TSS/TA) ratio.

Color analysis was performed on sweet potato cultivars pulp in five times. System of the Commission Internationale de L'éclairage (CIE) *L**, *a**, *b**, with a colorimeter reading (Konica Minolta®, Chroma Meter CR 4400model, Japan,) with illuminant D65 and 10º angle, previously calibrated, was used. The parameters analyzed were: *L** (luminosity), *a** (red-green) and *b** (yellow-blue), as well as chroma (livability-opacity) and hue angle.

The nutritional composition was evaluated in triplicate in the shelled sweet potatoes and results were expressed in wet weight basis. The values of moisture ($g.100g^{-1}$), ash ($g.100g^{-1}$), protein ($g.100g^{-1}$) (AOAC, 2011), lipid ($g.100g^{-1}$) (Bligh and Dyer, 1959); and carbohydrate ($g.100g^{-1}$), by difference: *% Carbohydrates = 100 - (% moisture +% protein +% lipid +% ashes + % fibers*) were determinate. Total energy value ($kcal.100g^{-1}$) was calculated using values recommended by Merril and Watt (1973) for lipid (8.37 kcal/g), protein (3.11 kcal/g) and carbohydrate (3.99 kcal/g).

The total carotenoid determination ($\mu g.g^{-1}$) was performed by spectrophotometric analysis (450 nm) (Rodriguez-Amaya, 2001). The ascorbic acid (vitamin C) content was evaluated by titration with 2.6 dichlorophenolindofenol (AOAC, 2011) and results expressed in $mg.100g^{-1}$.

Statistical Analysis

The results were analyzed using analysis of variance (ANOVA). The means were compared by Scott-Knott test at 5% significance level ($p \leq 0.05$). The Statistical Analysis System software (North Carolina, USA) was used to perform the statistical calculations.

RESULTS AND DISCUSSION

Consumer study

The sensory scores of consumer study for the Brazilian sweet potatoes are reported in Table 1. The highest acceptability ($p<0.05$) for all the evaluated characteristics was verified for Júlia, UGA 45 and UGA 49 pulp cultivars. These samples also presented AI>70% in all attributes, classifying them with good sensory acceptability (Meilgaard *et al*., 1999). The genotypes Valentina, UGA 79, UGA 80 and UGA 81 were the least accepted by consumers. Leksrisompong *et al*. (2012) also observed that sweet potatoes of white pulp (Japanese, Puerto Rican, O-Henry, DM02-180) were more accepted than those of purple color (NC414, NC415, Okinawa, Purple 04-069). The authors also verified that the tuberous roots of purple color had a higher fibrosity and firmness. Effect that was observed in the present study during the preparation and cooking, fact that may have reduced the acceptability. In addition, it is known that the fibers have high levels of polyphenols, which can undergo oxidation and cause a darkening in the food, damaging the acceptance by the consumers (Van Oirschot *et al*., 2003). Despite these findings, some white pulp cultivars presented similar acceptability to those of purple pulp. Thus, it is not possible to justify the results obtained only as a function of the pulp color of the sweet potatoes.

Chemical and nutritional characterization

The chemical and nutritional characterization of the different cooked Brazilian sweet potato cultivars are presented in Table 2. Samples RS values ranged from 4.79 (UGA 29) to 7.49 (UGA 34). The NRS had a variation from 9.27 (Júlia) to 24.11 (Valentina). In addition to individual characteristics of each cultivar, the amount of these sugars in sweet potatoes may be influenced by post-harvest practices. When roots are stored, mainly in low temperatures, there is an increase in enzymes activity involved at starch degradation, a fact that triggers an increase in sugar content. From a technological and sensorial point of view, RS levels have been used as limiting factors in depreciation of potatoes. This is because they can promote changes in tuberous root color caused by non-enzymatic browning (Maillard reaction) when the vegetables are submitted to thermal processing. Thus, there may be lower sweet potatoes acceptability, especially when evaluating appearance and color attributes, which may impair marketing (Shock *et al*., 1993).

Higher levels of TS ($p<0.05$) were found in cultivars Amorano, Valentina and UGA 45 and lower in Júlia. Ravindran *et al*. (1995) explain that these differences in chemical composition reflect the genetic distinction between cultivars, since the samples belong to same cultivation area. In addition, they were subjected to similar agronomic and cooking practices. Morrison *et al*. (1993) suggest that there is substantial variation in taste and sweetness of sweet potato varieties, which depends on the presence of these sugars (sucrose, glucose and fructose) and maltose formation during cooking.

This is because maltose has been reported as a primary precursor to many volatile compounds that appeared during cooking. These substances aroused consumer interest in aroma characteristics, which probably occurred with cultivars Júlia, UGA 45 and UGA 49, since they were better accepted. Reddy and Sistrunk (1980) explain that total sugars amount present in sweet potatoes affects both consistency of food and mouthfeel by the consumer. Higher contents of these compounds are associated with greater softness and softness after cooking, as observed in cultivar UGA 45 (texture).

The pH ranged from 6.05 to 6.97, but there was no significant difference ($p>0.05$) between cultivars. According to Feltran *et al*. (2004), pH above 6.0 indicates a good state of maturation and tubers conservation. Lower pH values (between 4.7 and 5.5) are more favorable to action of deteriorating enzymes.

Table 1. Sensory scores (mean±standard deviation) and acceptability index (AI) of Brazilian sweet potato cultivars boiled under water immersion

Parameter	Amorano	Júlia	Valentina	UGA 29	UGA 34	UGA 45	UGA 49	UGA 79	UGA 80	UGA 81
Appearance	6.27±1.56^{a}	6.66±1.10^{a}	5.61±1.15^{b}	6.50±1.20^{a}	5.73±1.24^{b}	7.13±1.14^{a}	6.80±1.02^{a}	5.95±1.23^{b}	5.63±1.11^{b}	5.43±1.17^{b}
AI (%)	69.66	74.00	62.33	72.22	63.66	79.22	75.55	66.11	62.55	60.33
Aroma	6.13±1.22	6.66±0.90^{a}	6.15±1.13^{b}	6.13±1.15^{b}	6.12±1.20^{b}	6.70±0.95^{a}	6.55±1.07^{a}	6.12±1.13^{b}	6.17±1.09^{b}	6.03±1.22^{b}
AI (%)	68.11	74.00	68.33	68.11	68.00	74.44	72.77	68.00	68.55	67.00
Flavour	6.73±1.23^{a}	6.75±0.88^{a}	6.18±1.29^{b}	5.62±1.18^{b}	6.38±1.08^{b}	7.08±0.99^{a}	6.87±1.18^{a}	6.33±1.11^{b}	6.25±1.05^{b}	6.22±1.14^{b}
AI (%)	74.77	75.00	68.66	62.44	70.88	78.66	76.33	70.33	69.44	69.11
Texture	6.45±1.23^{b}	7.17±1.17^{a}	6.28±1.25^{b}	5.57±1.13^{b}	6.68±1.52^{a}	6.90±1.18^{a}	7.07±1.02^{a}	6.28±1.08^{b}	6.03±1.13^{b}	6.30±1.16^{b}
AI (%)	71.66	79.66	69.77	61.88	74.22	76.66	78.55	69.77	67.00	70.00
Colour	5.93±1.12^{b}	6.30±1.21^{a}	5.63±1.28^{b}	6.07±1.23^{b}	5.60±1.10^{b}	6.82±1.14^{a}	6.58±1.04^{a}	5.80±0.22^{b}	5.52±1.12^{b}	5.35±1.26^{b}
AI (%)	65.88	70.00	62.55	67.44	62.22	75.77	73.11	64.44	61.33	59.44

Different letters in row indicate significant differences by Scott-Knott test ($p<0.05$). Values are mean of three replicates.

Table 2. Chemical and nutritional characterization of Brazilian sweet potato cultivars boiled under water immersion

Parameter	Amorano	Júlia	Valentina	UGA 29	UGA 34	UGA 45	UGA 49	UGA 79	UGA 80	UGA 81
Chemical characterization										
RS (g.100g^{-1})	7.13±0.07^{b}	5.07±0.08^{f}	4.90±0.08^{g}	4.79±0.06^{h}	7.49±0.05^{a}	6.12±0.06^{d}	7.00±0.09^{c}	5.39±0.08^{e}	4.93±0.08^{g}	5.29±0.09^{e}
NRS (g.100g^{-1})	21.74±0.07^{c}	9.27±0.07^{j}	24.11±0.09^{a}	12.78±0.06^{g}	16.60±0.08^{f}	22.79±0.08^{b}	17.59±0.04^{e}	10.06±0.09^{i}	21.49±0.07^{d}	12.48±0.07^{h}
TS (g.100g^{-1})	28.88±0.09^{a}	14.34±0.09^{h}	29.01±0.08^{a}	17.57±0.06^{f}	24.09±0.07^{d}	28.91±0.08^{a}	24.59±0.05^{c}	15.46±0.06^{g}	26.42±0.07^{b}	17.77±0.04^{e}
pH	6.67±0.01^{a}	6.05±0.01^{a}	6.97±0.06^{a}	6.33±0.07^{a}	6.54±0.04^{a}	6.38±0.06^{a}	6.35±0.05^{a}	6.47±0.08^{a}	6.54±0.07^{a}	6.30±0.06^{a}
TSS (ºBrix)	21.40±0.56^{c}	16.50±0.24^{e}	23.50±0.15^{b}	15.60±0.47^{e}	29.10±0.22^{a}	19.60±0.32^{d}	21.50±0.33^{c}	16.00±0.28^{e}	22.80±0.25^{b}	18.10±0.29^{d}
TA (% citric acid)	0.07±0.01^{b}	0.11±0.01^{a}	0.07±0.01^{b}	0.10±0.02^{a}	0.10±0.01^{a}	0.10±0.02^{a}	0.11±0.01^{a}	0.09±0.01^{a}	0.11±0.01^{a}	0.11±0.01^{a}
TSS/TA ratio	294.90±0.37^{b}	146.61±0.18^{d}	341.20±0.11^{a}	153.82±0.32^{d}	285.66±0.17^{b}	192.97±0.22^{c}	194.38±0.21^{c}	174.69±0.20^{d}	209.88±0.19^{c}	166.78±0.21^{d}
Nutritional characterization										
Moisture (g.100g^{-1})	66.28±0.03^{e}	75.97±0.06^{a}	63.92±0.07^{f}	76.07±0.05^{a}	62.88±0.04^{g}	67.12±0.05^{d}	72.62±0.09^{c}	73.00±0.03^{b}	63.50±0.09^{f}	73.38±0.08^{b}
Ash (g.100g^{-1})	0.76±0.02^{c}	0.77±0.01^{c}	0.71±0.03^{c}	0.78±0.02^{c}	0.82±0.04^{b}	0.88±0.04^{a}	0.83±0.03^{b}	0.73±0.02^{c}	0.90±0.03^{a}	0.76±0.02^{c}
Protein (g.100g^{-1})	1.15±0.02^{c}	0.80±0.03^{h}	0.85±0.01^{g}	0.89±0.01^{f}	1.63±0.02^{a}	1.30±0.02^{b}	1.12±0.03^{d}	0.79±0.01^{h}	0.94±0.02^{e}	0.89±0.01^{f}
Lipid (g.100g^{-1})	0.06±0.01^{c}	0.06±0.02^{c}	0.07±0.01^{c}	0.07±0.01^{c}	0.06±0.02^{c}	0.11±0.01^{b}	0.05±0.01^{c}	0.07±0.01^{c}	0.16±0.02^{a}	0.06±0.01^{c}
Carbohydrate (g.100g^{-1})	31.76±0.14^{b}	22.40±0.21^{g}	34.46±0.18^{a}	23.01±0.13^{f}	34.61±0.22^{a}	30.58±0.15^{c}	25.37±0.21^{d}	25.40±0.23^{d}	34.50±0.12^{a}	24.91±0.13^{e}
Total energy value (kcal.100g^{-1})	130.76±0.44^{c}	92.39±0.56^{g}	140.69±0.89^{b}	92.60±0.97^{g}	143.69±0.65^{a}	127.02±0.67^{d}	105.14±0.96^{e}	104.45±0.88^{e}	141.93±0.78^{b}	102.66±0.94^{f}
Total carotenoid (µg.g^{-1})	0.94±0.04^{c}	0.77±0.01^{c}	0.59±0.00^{d}	0.66±0.03^{d}	1.33±0.00^{b}	0.92±0.05^{c}	0.54±0.01^{d}	1.48±0.05^{b}	1.49±0.01^{b}	2.06±2.29^{a}
Ascorbic acid (mg.100g^{-1})	3.53±0.08^{g}	4.20±0.07^{g}	17.72±0.04^{a}	9.00±0.05^{e}	6.60±0.05^{f}	14.35±0.06^{b}	13.38±0.02^{c}	12.12±0.05^{d}	9.09±0.05^{e}	4.58±0.04^{g}

Different letters in row indicate significant differences by Scott-Knott test ($p<0.05$). Values are mean of three replicates. Results reported in wet weight basis. Reducing Sugars (RS); Nonreducing Sugars (NRS); Total Sugars (TS); Total Soluble Solids (TSS); Titratable Acidity (TA); Total Soluble Solids/Titratable Acidity (TSS/TA).

Table 3. Colour parameters *L, *a** e *b** (mean±standard deviation), chroma and hue of Brazilian sweet potato cultivars boiled under water immersion**

Cultivar	*L**	*a**	*b**	Chroma	Hue
Amorano	47.61±0.26^{g}	-4.80±0.07^{f}	9.59±0.30^{c}	11.32±0.24^{c}	116.56±0.35^{c}
Júlia	44.60±0.20^{h}	-3.58±0.13^{e}	4.79±0.18^{g}	5.81±0.09^{g}	127.52±0.45^{a}
Valentina	58.07±0.16^{a}	-1.75±0.04^{b}	7.41±0.31^{e}	7.60±0.46^{f}	102.17±0.35^{f}
UGA 29	42.40±0.36^{i}	-4.55±0.19^{f}	8.47±0.28^{d}	9.56±0.29^{d}	118.42±0.28^{b}
UGA 34	36.21±0.21^{j}	6.46±0.35^{a}	5.64±0.29^{f}	8.43±0.39^{e}	41.35±0.16^{g}
UGA 45	50.58±0.40^{d}	-2.48±0.36^{c}	5.37±0.20^{f}	5.77±0.18^{g}	114.01±0.80^{d}
UGA 49	57.05±0.22^{b}	-3.28±0.23^{e}	13.54±0.36^{a}	16.43±0.23^{a}	102.49±0.37^{f}
UGA 79	49.52±0.12^{e}	-3.42±0.14^{e}	7.57±0.25^{e}	8.44±0.20^{e}	114.46±0.36^{d}
UGA 80	56.61±0.19^{c}	-2.83±0.07^{d}	9.71±0.24^{c}	9.89±0.10^{d}	106.37±0.10^{e}
UGA 81	48.63±0.32^{f}	-5.33±0.25^{g}	10.62±0.39^{b}	12.30±0.27^{b}	114.71±0.35^{d}

Different letters in column indicate significant differences by Scott-Knott test ($p<0.05$). Values are mean of replicates measures on sweet potato pulp. Results reported in wet weight basis.

Higher TSS genotypes Júlia, UGA 29 and UGA 79 had lowest concentrations ($p<0.05$). Factors among that may influence TSS content of sweet potatoes it is, genetics, soil mineral content, pre and post-harvest conditions, and storage (Kader, 1986). According to Woolfe (1992), high levels of TSS are indicative a higher sucrose contents, which may confer better taste and acceptance by consumers. This effect was not confirmed in the present study. Thus, it is possible that other aspects related to food may have a direct influence on sensory acceptability.

There was a small variation ($p<0.05$) between TA values (0.07 to 0.11% citric acid) for different sweet potato cultivars. Less acidity was observed to Amorano and Valentina genotypes and others presented higher values, but statistical difference between them ($p>0.05$). Results that corroborate with literature (Suárez *et al*., 2016). Total acid content quantifies the organic acids concentration in the food. In general, it depends on factors such as the proteins and minerals amount, the buffering capacity of these components and, especially, the soluble solids content (Mccarthy *et al*., 1991). Acidity can influence food taste and aroma, since it is related to organic acids presence. Thus, lower acidity may make the flavour of food more palatable (Bartholomew and Sinclair, 1943; Verma and Joshi, 2002). In the present study, TA was very similar in all sweet potato cultivars. This demonstrates that this variable, possibly, did not influence the acceptability.

The TSS/TA ratio ranged in sweet potatoes. Higher results to TSS/TA ratio were present in cultivar Valentina, whit variation from 146.61 (Julia) to 341.20 (Valentina). Sweet potatoes Júlia, UGA 29, UGA 79 and UGA 81 had a lower TSS/TA ratio, with no statistical difference between them ($p>0.05$). Results lower TSS/TA ratio (85.4 and 101.2) were observed by Fawzia *et al*. (1999) on sweet potatoes from Kenya. Higher values of TSS/TA ratio are indicative a more pleasant taste, as they consider a balance between sugars and acids present in food (Bartholomew and Sinclair, 1943; Verma and Joshi, 2002). This effect was also not confirmed in present study, similarly to isolated evaluations of TSS and TA.

The moisture content ($g.100g^{-1}$) ranged from 62.88 to 76.07, being higher for cultivars Júlia and UGA 29 and lower for UGA 34, agreeing with the literature (Dincer *et al*., 2011). Verma and Joshi (2002) explain that variations in moisture depend on water retention power of each tuber during cooking. Besides the influence of different characteristics inherent to food, as, for example, the fiber content. In this regard, cooking promotes a slowing of fibers increasing their hygroscopic capacity and, consequently, the moisture content in the product. There was little variation in ash content (0.71 to 0.90 $g.100g^{-1}$), corroborating with other studies (Smith, 1977; Suárez *et al*., 2016). Lower ash content was found for cultivars Amorano, Júlia, Valentina, UGA 29, UGA 79 and UGA 81, while UGA 45 and UGA 80 had the highest values.

Higher protein and energy content ($p<0.05$) were observed to UGA 34 cultivar. Sweet potatoes Valentina, UGA 34 and UGA 80 showed higher carbohydrate content than other samples. Yields were lower for Júlia and UGA 29. Júlia also had lower carbohydrate content ($p<0.05$), while the energy content was lower for Júlia and UGA 29 samples. Although there was a significant difference between lipid content level of sweet potatoes and variation was very small (0.06 to 0.16 $g.100g-^{1}$), which agrees with literature (Smith, 1977). Carotenoid content ranged from 0.54 µg/g to 2.06 µg/g ($p<0.05$), being higher for cultivar UGA 81 and lower for Valentina, UGA 29 and UGA 49. Similar results were observed by Kotíková *et al*. (2016) by analyzing boiled sweet potatoes from the Czech Republic. Carotenoid contents are influenced by a variety of factors during and after thermal processing. Among them, technique used, experimental conditions, nature of the food matrix, exposure time to heat and, especially, the type of carotenoid evaluated (Kotíková *et al*., 2016). However, research has shown that immersion cooking increases carotenoids levels in sweet potatoes. This, when compared to other methods such as methods such as braising, frying and cooking under pressure (Kim *et al*., 2015, Kotíková *et al*., 2016).

There was a statistical difference ($p<0.05$) between ascorbic acid values of cultivars, varying from 3.53 to 17.72 $mg.100g^{-1}$. Valentina presented the highest values, while Amorano, Júlia and UGA 81 had the lowest concentrations. Similar results were reported by Huang *et al*. (2006), when studying sweet potato cultivars (TNG57, TNG66, TNG68, TYY1, RP and WP) from Taiwan. The vitamin C is thermolabile, in this aspect, can be degraded with great ease, depending also on other factors present in cooking process, such as contact with water, the presence of oxygen, time and temperature (Ikanone and Oyekan, 2014).

Chemical and nutritional considerations about composition of sweet potatoes evaluated at the present study, it is possible to infer that differences observed depend mainly on characteristics of each cultivar. Similar effect was reported by Dincer *et al*. (2011), which studied three sweet potatoes varieties (Beniazum, Koganeseng and Kotobu) from Turkey. Other factors that may interfere with these evaluations, such as cultivation conditions, product maturity and storage type, have little influence on our work since all cultivars received the same treatment. In this way, UGA 34, UGA 80 and Valentina samples can be considered with better nutritional profile, since they presented higher amounts of protein, carbohydrate and energy; ash, lipid and carbohydrate and; carbohydrate and vitamin C, respectively. The cultivars Júlia and UGA 29 can be classified with a less favorable nutritional profile. This is because they presented, respectively, smaller nutrients amount in general.

Color parameters differed between sweet potatoes (Table 3), with higher variations for cultivars Júlia, Valentina, UGA 34, UGA 45, UGA 49 and UGA 81. Greater luminosity (L^*) was verified towards cultivar Valentina and smaller to UGA 34 genotype. Cultivar UGA 34 also had the highest red content (a^*) and, consequently, lower hue. The yellow (b^*) content was lower for Júlia cultivar, but higher at UGA 49. Greater vivacity (chroma) was observed in cultivar UGA 49, contrary to Júlia and UGA 45 genotypes. Higher hue values (greenish color) were found in cultivar Júlia.

Different colorations between sweet potato pulps have been previously reported in literature (Tang *et al*., 2015). Anthocyanins are responsible for purplish color of sweet potato cultivars, a fact that raises the a^* content. This effect was observed at the present research for Valentina and UGA 34 cultivars, both with purple pulp. Most of the tuberous roots evaluated had a darker coloration (low L^* values), with yellow tone (values of b^* positive) and sub-tonality green (values of a^* negative). Exception was verified for genotype UGA 34,

which presented higher red tone (*a** positive value) and yellow sub-tonality.

Conclusion

There are differences in acceptability, chemical and nutritional composition among cultivars of Brazilian sweet potatoes submitted to cooking process by immersion in water. Samples of sweet potatoes with a more favorable chemical profile (Valentina) and nutritional profile (UGA 34; UGA 80) do not present superior sensory acceptability to others. The cultivars Júlia, UGA 45 and UGA 49 are better accepted by consumers. It is not possible say that there are acceptance differences between sweet potatoes with white and purple flesh color. Although some cultivars with white pulp are more accepted than those with purple pulp. This demonstrates that there may be other intrinsic and extrinsic factors that influence the tuberous roots acceptance.

Acknowledgements

The authors thank the Araucaria Foundation of Supports Scientific and Technological Development in the State of Paraná, Brazil for financial support.

REFERENCES

Association of Official Analytical Chemistry (AOAC). 2011. *Official Methods of Analysis of AOAC International.*18ª ed. Gaithersburg (MD): AOAC.

Bartholomew, E. T. and Sinclair, W. B. 1943. Soluble constituints and buffer properties of orange juice. *Plant Pshysiology,* 18(2): 185-206.

Bligh, E. G. and Dyer, W. J. 1959. A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology*, 37(8): 911-917.

Dincer, C., Karaoglan, M., Erden, F., Tetik, N., Topuz, A. and Ozdemir, F. 2011. Effects of baking and boiling on the nutritional and antioxidant properties of sweet potato [Ipomoea batatas (L.) Lam.] cultivars. *Plant Foods for Human Nutrition,* 66(4): 341-347.

Fawzia, A., Karuri, E. G. and Hagenimana, V. 1999. Sweet potato ketchup: feasibility, acceptability, and production costs in Kenya. *African Crop Science Journal*, 7(1): 81-89.

Feltran, J. C., Lemos, L. B. and Vieites, R. L. 2004. Technological quality and utilization of potato tubers. *Scientia Agricola,* 61(6): 598-603.

Food and Agriculture Organization of the United Nations (FAO). 2015. *Statistical. Pocketbook 2015: World Food and Agriculture*. Rome: FAO.

Food and Agriculture Organization of the United Nations (FAO). 2016. *Statistics Databases.* Accessed on July 21, from Website: http://faostat3.fao.org.

Huang, Y. C., Chang, Y. H. and Shao, Y. Y. 2006. Effects of genotype and treatment on the antioxidant activity of sweet potato in Taiwan. *Food Chemistry*, 98(3): 529-538.

Ikanone, C. E. O. and Oyekan, O. O. 2014. Effect of Boiling and Frying on the Total Carbohydrate, Vitamin C and Mineral Contents of Irish (Solanun tuberosum) and Sweet (Ipomeabatatas) Potato Tubers. *Nigerian Food Journal*, 32(2): 33-39.

Kader, A. A. 1986. Effects of postharvest handling procedures on tomato quality. *Acta Horticulturae*, 190(1): 209-221.

Kim, H. J., Park, W. S., Bae, J. Y., Kang, S. Y., Yang, M. H., Lee, S. Lee, H. S., Kwak, S. S. and Ahn M. J. 2015. Variations in the carotenoid and anthocyanin contents of Korean cultural varieties and home-processed sweet potatoes. *Journal of Food Composition and Analysis,* 41(1): 188-193.

Kotíková, Z., Šulc, M., Lachman, J., Pivec, V., Orsák, M. and Hamouz, K. 2016. Carotenoid profile and retention in yellow, purple and red fleshed potatoes after thermal processing. *Food Chemistry*, 197(Part A): 992-1001.

Leksrisompong, P. P., Whitson, M. E., Truong, V. D. and Drake, M. A. 2012. Sensory attributes and consumer acceptance of sweet potato cultivars with varying flesh colors. *Journal of Sensory Studies*, 27(1): 59-69.

Macfie, H. and Bratchell, N. 1989. Designs to balance the effect of order of presentation and first-order carryover effects in hall tests. *Journal of Sensory Studies*, 4(2): 129-148.

McCarthy, M. J., Heil, J. R., Kruegermann, C. and Desvignes, D. 1991. Acid requirement for pH modification of processed foods. *Journal of Food Science*, 56(4): 973-976.

Meilgaard, M., Civille, G.V. and Carr, B.T. 1999. *Sensory evaluation techniques.* 3rd ed. Florida: CRC Press.

Merril, A. L. and Watt, B. K. 1973. *Energy values of foods: basis and derivation.* Washington: United States Department of Agriculture Handbook.

Morrison, T. A., Pressey, R. and Kays, S. J. 1993. Changes in α-and ß-amylase during Storage of Sweetpotato Lines with Varying Starch Hydrolysis Potential. *Journal of the American Society for Horticultural Science*, 118(2): 236-242.

Ravindran, V., Ravindran, G., Sivakanesan, R. and Rajaguru, S. B. 1995. Biochemical and nutritional assessment of tubers from 16 cultivars of sweet potato (Ipomoea batatas L.). *Journal of Agricultural and Food Chemistry*, 43(10): 2646-2651.

Reddy, N. N. and Sistrunk, W. A. 1980. Effect of cultivar, size, storage, and cooking method on carbohydrates and some nutrients of sweet potatoes. *Journal of Food Science*, 45(3): 682-684.

Rodriguez-Amaya, D. B. 2001. *A guide to carotenoid analysis in foods.* Washington: *International Life Sciences Institute Press*.

Shock, C. C., Holmes, Z. A., Stieber, T. D., Eldredge, E. P. and Zhang, P. 1993. The effect of timed water stress on quality, total solids and reducing sugar content of potatoes. *American Journal of Potato Research*, 70(3):227-241.

Silva, J. B. C., Lopes, C. A., Magalhães J. S. 2004. *Cultura da batata-doce (Ipomoea batatas L.)*. Brasília: EMBRAPA.

Smith, O. 1977. *Potatoes: production, storing, processing.* 2. ed. Westport: The Publishing.

Suárez, M. H., Hernández, A. I. M., Galdón, B. R., Rodríguez, L. H., Cabrera, C. E. M., Mesa, D. R., Rodríguez-Rodríguez, E. M. and Romero, C. D. 2016. Application of multidimensional scaling technique to differentiate sweet potato (Ipomoea batatas (L.) Lam) cultivars according to their chemical composition. *Journal of Food Composition and Analysis,* 46: 43-49.

Tang, Y., Cai, W. and Xu, B. 2015. Profiles of phenolics, carotenoids and antioxidative capacities of thermal processed white, yellow, orange and purple sweet potatoes grown in Guilin, China. *Food Science and Human Wellness,* 4(3): 123-132.

United States Department of Agriculture (USDA). 2016. *Agricultural Research Service. National Nutrient Database for Standard Reference, Release 28.* Accessed on July 21,

2016 from Website: https://ndb.nal.usda.gov/ndb/foods/show/3209?manu=&fgcd=&ds=.

Van Oirschot, Q. E. A., Rees, D. and Aked J. 2003. Sensory characteristics of five sweet potato cultivars and their changes during storage under tropical conditions. *Food Quality and Preference*, 14(8): 678-680.

Verma, L. R. and Joshi, V. K. 2002. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management.* New Delhi: Indus Publishing Company.

Woolfe, J. A. 1992. *Sweet potato: an untapped food resource.* New York: Cambridge University Press.

****