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Effect of Variety on the Physico-Chemical, Carotenoid and Microbial Loads of Flours of Five New Varieties of Sweet Potato

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Abstract: The effect of variety on the physico-chemical, carotenoid and microbial loads of flours of 5 varieties of sweet potato: TIS2532.OP.1.13, TIS8164, TIS87/0087, CIP1999024.02 and CIP440293 were determined. Proximate composition of the flours as determined using the AOAC methods showed that TIS8164 had the highest moisture content (9.43±0.03%) among other varieties studied while TIS5325OP.1.13 had the least (7.9±0.01%). CIP440293 had the highest ash content (0.52±0.02%) while CIP1999024.02 had the least (0.22±0.08%). The%crudefiber content of CIP440293 was the highest (0.36±0.05%) among other varieties while CIP1999024.2 had the least (0.21±0.02%). The processed flours contained higher starch contents than fresh samples with TIS5325OP.1.13 having the highest starch content (36.22±0.00%) for the processed flour and TIS87/0087 having the least (30.31±0.02%) as compared with the fresh samples in which TIS5325OP.1.13 gave the highest (28.22±0.00%) while TIS87/0087 gave the least (20.78±0.02%). In terms of carotenoid content, CIP440293 had the highest for the fresh sample (6.23×10^3 μg/100 g) while TIS87/0087 gave the least (0.54×10^3 μg/100 g). These values were reduced for the processed flours where CIP440293 again gave the highest (3.99×10^3 μg/100 g) while TIS87/0087 gave the least (0.02×10^3 μg/100 g). Sensory evaluation of the fufu samples made from the stored flours indicated that their quality and mouldability were accepted at the second month of storage unlike their colors. Results indicate the acceptability of these potato varieties and their applicability in alchoholic, food and sugar industries. With good microbial loads as evidenced at the 6th month of storage and antioxidant potentials, their shelf lives could be extended if packaged well and stored.

Key words: Carotenoid, proximate composition, sweet potato, variety, microbial loads, sensory evaluation

INTRODUCTION

Sweet potato (*Ipomea batatas*) is an extremely important crop in many parts of the world and survey reports placed Nigeria as the number one producer of sweet potato in Africa with annual production output of 3.56 million metric tons, making it the second world producer with China as the number one FAO (2006).

In comparison with other tubers, sweet potato contains an average amount of proteins and carbohydrates mainly starch. They also contain some free sugars which gives the tuber its sweet taste. Vitamins A and B are also present in significant amounts and the tubers are rich in Vitamin C (Rose and Vasanthakaalam, 2011). Sweet potatoes have white, yellow or orange flesh and their skin may either be white, yellow, orange, red or purple. White colour is due to the presence of lycopene while yellow contain higher amounts of β-carotene than white types and the roots of red sweet potatoes contain anthocyanin pigment (Salunkhe and Kadam, 1998). Orange fleshed sweet potatoes are high in carotenoids and β-carotene (Takahata *et al*., 1993; Simon, 1997). Infect, consumption of orange fleshed sweet potato roots can provide sustainable vitamin A which plays a role in preventing night blindness.

Starch has a wide application possibility in many industries such as food and sugar industry. Many factors affect the starch content of sweet potato such as variety difference, long storage, etc. (Li and Liao, 1983).

The nutritional value of sweet potato (especially high levels of Vitamin A) offers an added benefit to processed products. Its processing, marketing and nutritional, could significantly contribute to alleviation of Vitamin A deficiency in parts of Africa where sweet potato is grown (Low *et al*., 1997). Sweet potato has an abundance of uses ranging from consumption of fresh roots or leaves, to processing into flour, starch, animal feed, candy and alcohol (Woolfe, 1992).

However, the bulkiness and perishability of harvested sweet potato storage is a major barrier to the

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wider utilization of the crop. A promising avenue for expanding demand is to diversify sweet potato uses. In addition, the nutritional content and microbial loads of sweet potato varies widely but depends on gene, variety, location, etc. (Woolfe, 1992). Five new sweet potato varieties planted at the field trial of National Root Crops Research Institute, Umudike, Umuahia, Abia State, Nigeria were harvested and analyzed with an aim to study the varietal effect on the physico-chemical, carotenoid and microbial loads of the fresh and flours samples of the stored sweet potato cultivars.

MATERIALS AND METHODS

Five new sweet potato varieties TIS 2532.OP.1.13 (White), TIS 8164 (Cream), TIS 87/0087 (White), CIP 1999024.2 (Light orange) and CIP 440293 (Pale orange) were harvested at maturity from field trial of National Root Crops Research Institute (NRCRI), Umudike, Umuahia, Abia State, Nigeria in November, 2009.

Production of fufu flour: Sweet potato fufu flours were produced from each of the sweet potato varieties using the processing methods described by Etudaiye *et al.* (2009).

Microbial analysis: The bacterial and fungal counts of the samples were determined using the pour plate techniques (Ezeama, 2007).

Proximate composition: The method of AOAC (1990) was used to determine the Moisture, ash, crude fiber and starch contents of the flours while the method of Rodrigueze-Amaya and Kimura (2004) was used to determine the total carotenoid contents of both the fresh and flour samples of the sweet potato varieties.

Sensory evaluation: The sensory evaluation of the sweet potato fufu flour samples was carried out using the method of Dewi *et al.* (2011).

Statistical analysis: Data was analyzed using the Mean±Standard Deviations of triplicate experiments and results were considered significant at $p<0.05$. Data was further subjected to Anova using SPSS 15.0 windows version.

RESULTS AND DISCUSSION

The microbial loads of the flours of the sweet potato varieties stored at ambient temperature (28±2°C) for six months as shown in Table 1 and 2 revealed that the microbial load increased with increase in storage time. The bacterial counts ranged from 1.5×10^{1} to 7.0×10^{5} cfu g^{-1} while the fungi counts ranged from 1.5×10^{1} to 6.5×10^{5} cfu g^{-1}. However, TIS 8164 was more susceptible to bacterial growth than any of the varieties studied at the 6th month of storage while CIP1999024.2 and TIS 87/0087 were the least susceptible to bacterial growth.

In terms of fungal growth, TIS 8164 was more susceptible than any of the varieties studied at the 6th month of storage while CIP 1999024.2 was the least susceptible to fungal growth than any of the varieties evaluated. The gradual microbial increase during storage could be attributed to contamination during packaging and storage condition of the products.

The values obtained for the bacterial and fungal counts are within the limits of 10^{6} cfu g^{-1}, being the standard set by the international commission on microbiological specification of food (ICMSF, 1978) as aerobic counts for foods.

Table 1: The bacteria average plate count (cfu g^{-1}) of stored fufu flour at ambient temperature (28±2°C)

	Months of storage						
Samples	0	1	2	3	4	5	6
CIP440293	$^{a}1.5\times10^{2}$	$^{a}2.0\times10^{2}$	$^{a}3.0\times10^{3}$	$^{a}3.5\times10^{3}$	$^{a}4.5\times10^{4}$	$^{a}5.0\times10^{4}$	$^{a}6.5\times10^{5}$
TIS2532.OP.1.13	$^{b}2.0\times10^{2}$	$^{b}2.5\times10^{2}$	$^{b}3.5\times10^{2}$	$^{b}4.0\times10^{3}$	$^{b}5.5\times10^{3}$	$^{b}6.0\times10^{3}$	$^{b}6.5\times10^{4}$
CIP1999024.2	$^{c}1.5\times10^{1}$	$^{c}2.5\times10^{1}$	$^{b}3.5\times10^{2}$	$^{c}4.5\times10^{3}$	$^{c}5.0\times10^{3}$	$^{a}5.0\times10^{4}$	$^{c}6.0\times10^{4}$
TIS 87/0087	$^{d}2.5\times10^{2}$	$^{d}3.0\times10^{2}$	$^{c}4.0\times10^{2}$	$^{d}4.5\times10^{2}$	$^{d}5.5\times10^{2}$	$^{c}5.0\times10^{3}$	$^{c}6.0\times10^{4}$
TIS 8164	$^{e}2.5\times10^{1}$	$^{e}3.5\times10^{1}$	$^{c}4.0\times10^{2}$	$^{e}5.0\times10^{3}$	$^{b}5.5\times10^{3}$	$^{d}5.5\times10^{4}$	$^{d}7.0\times10^{5}$

Values are means of triplicate e×periments and having different letters are significant at $p<0.05$

Table 2: The fungi average plate count (cfu g^{-1}) of stored fufu flour at ambient temperature (28±2°C)

	Months of storage						
Samples	0	1	2	3	4	5	6
CIP440293	$^{a}1.5\times10^{1}$	$^{a}1.5\times10^{1}$	$^{a}3.0\times10^{2}$	$^{a}3.5\times10^{2}$	$^{a}4.5\times10^{3}$	$^{a}4.5\times10^{3}$	$^{a}5.5\times10^{4}$
TIS2532.OP.13	$^{a}1.5\times10^{1}$	$^{b}2.5\times10^{1}$	$^{b}3.5\times10^{2}$	$^{b}4.0\times10^{3}$	$^{b}4.0\times10^{3}$	$^{b}5.0\times10^{4}$	$^{b}6.0\times10^{5}$
CIP1999024.2	$^{a}1.5\times10^{1}$	$^{b}2.5\times10^{1}$	$^{c}2.5\times10^{2}$	$^{c}3.0\times10^{2}$	$^{b}4.0\times10^{3}$	$^{a}4.5\times10^{3}$	$^{c}5.0\times10^{4}$
TIS87/0087	$^{a}1.5\times10^{1}$	$^{a}1.5\times10^{1}$	$^{a}3.0\times10^{2}$	$^{a}3.5\times10^{2}$	$^{c}3.5\times10^{3}$	$^{a}4.5\times10^{3}$	$^{a}5.5\times10^{4}$
TIS8164	$^{a}1.5\times10^{1}$	$^{c}3.5\times10^{1}$	$^{b}3.5\times10^{2}$	$^{b}4.0\times10^{3}$	$^{a}4.5\times10^{3}$	$^{c}5.5\times10^{4}$	$^{d}6.5\times10^{5}$

Values in each row with the same superscript are not significantly different from each other and are significant at $p<0.05$

Some micro-organisms produce chemicals that can color, flavor and stabilize foods thereby increasing their storage lives (Eleazu *et al*., 2011). Such types of foods are important because of their improved aroma and flavor characteristics. Some microflora isolated during the period of storage include *Rhizopus stolonifer* and *Aspergillus* sp. while the bacteria that were identified include *Lactobacillus planterum Streptococcus* sp., *Bacillus cereus* and *Staphylococcus aureus*.

The presence of *Lactobacillus* sp. in this study is thought to have prolonged the shelf life of the resulting fufu flour. Lactic acid bacteria are a group of gram positive bacteria that are of economic importance because they are applied extensively in both the production and p reservation of a wide variety of food products (Bron *et al*., 2004). They're thought to produce bacteriocin which helps to prolong the shelf lives of stored flours. This lends credence to earlier reports by Gobbetti *et al*. (2005) and De Vuyst and Vancanneyt (2007). The isolation of *Lactobacillus* sp. from the fufu flour from the first to the sixth month may be attributed to the fact that the fermenting microbes continued their activities throughout the storage period. The result reveals that fufu flour stored at ambient temperature (28±2°C) in sealed polyethylene is stable.

The total carotenoid contents of the 5 varieties of sweet potato flours as presented in Fig. 1 showed that they ranged from 0.54×10^3 to 6.23×10^3 µg/100 g for the fresh samples while the processed flours ranged from 0.02×10^3µg/100 g to 3.99×10^3 µg/100 g. TIS87/0087 showed the least carotenoid contents for both fresh and flour samples (0.54×10^3 µg/100 g fresh and 0.02×10^3 µg/100 g flour) while CIP440293 had the highest carotenoid content for both fresh and flour samples (6.23×10^3 µg/100 g fresh and 3.99×10^3 µg/100 g flour). The higher carotenoid contents of both the fresh and flours of 2 varieties of

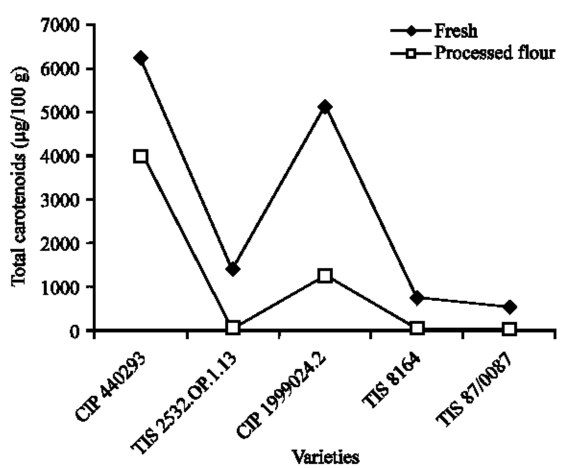

Fig. 1: Total carotenoids of fresh and flour samples of 5 sweet potato varieties

orange fleshed sweet potato (CIP440293 and CIP1999024.2) would be expected since orange fleshed sweet potato are known to contain higher carotenoid contents (Fresco and Boudion, 2002). The reduction in the carotenoid contents of the processed flours is very significant in this study as it was slightly higher than the results given by Hagenimana and Low (2000) who reported that processing of sweet potatoes results in 25-30% losses in β-carotene content. The reduction in carotenoid content of the processed flours to the extent that was observed in this study shows that the processed flours cannot meet the recommended daily intake of β-carotene (5000 to 25000 I.U/100 g) (Fresco and Boudion, 2002) while the fresh samples can. Its important to note that β-carotene serves a dual role: One as a precursor of Vitamin A where its cleaved by a di-oxygenase using molecular oxygen to form retinal in the intestine (The retinal so formed is hydrolysed to retinol which is absorbed by the intestinal mucosal cells and hence, Vitamin A deficiency could lead to night blindness): Secondly as a chain breaking antioxidant in scavenging free radical species in the body which are generated from normal oxidation of food stuffs due to leaks in the electron transport chain, normal metabolism of the body, cigarette smoking, etc. Antioxidants also help to increase the shelf life of products in food industries. There is therefore need to determine method of processing that will retain the total carotenoid content of the sweet potato flour for proper utilization of its β-carotene content.

The proximate composition of the sweet potato samples as shown in Table 3 indicated that the moisture content of the flours ranged from 7.90-9.74% with TIS5325OP.1.13 having the lowest moisture content (7.9±0.01%) which is a good attribute for storage quality while TIS8164 had the highest moisture content (9.74±0.03%).

Ash content refers to the mineral content of flour. CIP440293 had the highest quantity of minerals (0.52±0.02%) while CIP1999024.2 had the least mineral content (0.22±0.08%). This agrees with the literature value of 0.35-0.40% (Lakra and Sehgal, 2009).

Crude fibre represents that portion of food not used up by the body but mainly made up of cellulose together with a little lignin and is known to increase bulk stool. The values obtained for the fibre content in all the varieties of sweet potato studied as represented in Table 3 were within the range obtained by Lakra and Sehgal (2009). CIP440293 had the highest crude percentage fibre content (0.36±0.05%) while CIP1999024.2 had the least (0.21±0.02%).

Because of the limited supply of fossil fuels and other possible difficulties like political, technical and

Table 3: Proximate composition of 5 sweet potato varieties

	Flour (%)			Starch (%)	
Samples	Mc	Ash	Crude fibre	Fresh	Flour
1. CIP440293	8.44±0.00	0.52±0.02	0.36±0.05	22.58±0.00	31.91±0.03
2. TIS 5325OP.1.13	7.90±0.01	0.28±0.01	0.24±0.02	28.22±0.00	36.22±0.00
3.CIP1999024.2	8.90±0.01	0.22±0.08	0.21±0.02	23.05±0.05	32.52±0.04
4. TIS8I64	9.74±0.03	0.29±0.07	0.245±0.03	21.92±0.01	33.90±0.00
5. TIS87/0087	8.92±0.02	0.25±0.05	0.225±0.01	20.78±0.02	30.31±0.02

Values are Means±SD of triplicate experiments

Table 4: Sensory evaluation on fufu samples made from stored sweet potato flours

	Color		Mouldability		General acceptability	
Sample	1st month	2nd month	1st month	2nd month	1st month	2nd month
TIS 2532.OP.1.13	4.93^{a}	4.93^{ab}	4.60^{ab}	5.00^{a}	4.66^{a}	4.93^{a}
CIP1999024.2	5.06^{a}	5.40^{a}	4.46^{a}	4.86^{a}	4.86^{a}	4.60^{a}
TIS 87/0087	4.13^{a}	5.00^{a}	5.66^{a}	5.46^{a}	5.66^{a}	5.40^{a}
TIS 8164	4.93^{a}	4.20^{b}	4.86^{ab}	4.66^{a}	5.13^{a}	4.66^{a}
CIP440293	5.00^{a}	4.60^{a}	5.40^{ab}	5.13^{a}	5.60^{a}	5.06^{a}
Yam flour (control)	4.26^{a}	5.00^{ab}	4.73^{ab}	4.93^{a}	5.00^{a}	4.86^{a}
LSD (≤0.05)	1.136	1.150	1.178	1.067	1.080	1.015
	NS	SD	SD	NS	NS	NS

Scoring system: 1 = Very poor ; 2 = Poor; 3 = Fair; 4 = Average; 5 = Good; 6 = Very good; 7 = Excellent. Values with the same super script in each column are not significantly different from each other at p<0.05. NS: Not significant SD: Significant difference

secure problems, all nations in the world have been trying to explore possible energy resources. Alcohol, one of the many found substitute energy resources is especially attractive because starch or sugary biomass can easily produce it. Starch on its own also has a wide application in both food and sugar industries. The high content of starch obtained from both the fresh and processed flours of the 5varieties of sweet potato evaluated as observed in Table 3 is another significant finding in this study as it shows the wider utility of these sweet potato varieties in alcohol production on the one hand and their application in both food and sugar industries on the other hand. In addition, processing was found to increase the starch content of the sweet potato varieties studied.

Descriptive analysis is one of the most useful tests for sensory profiling and uses trained panelists to detect and rate the intensities of sensory attributes in a product (Dewi *et al*., 2011; Grosso *et al*., 2008). The determination of the culinary quality and other attributes for processing sweet potato storage roots is very important as it gives an estimate of the quantity of nutrients and anti-nutrients contained in the storage roots and to identify preferences within a collection. The quality of a flour and storage condition after milling is very important in the shelf life of the flour (Akpe *et al*., 2010). The sensory evaluation of the flours as presented in Table 4 showed that there was no significant difference (p>0.05) in the means of the colors of the flours of all sweet potato varieties evaluated in the first month of storage when compared with the control (p<0.05). However, there was significant difference in the means of the colors of CIP1999024.2, TIS87/0087, TIS8164 and CIP440293 when compared with the control (p<0.05) by the second month of storage.

In terms of mouldability of the flours, the means of CIP1999024.2 and TIS87/0087 were found to be significantly different when compared with the control in the first month of storage (p<0.05). However, there was no significant difference in the mouldability of the flours by the second month of storage when compared with the control indicating that the flours of all sweet potato varieties studied could be easily moulded by the second month of storage.

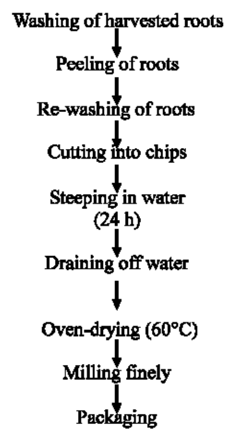

Fig. 2: Flow chart for processing of sweet potato roots into fufu flour

The flours of all sweet potato varieties evaluated were not found to be significantly different from the control in terms of acceptability in the first and second months of storage when compared with the control (p<0.05) and this is another significant finding as it indicates the general acceptability of all the flours evaluated.

The processing of sweet potato roots in fufu flour is shown in Fig. 2.

In conclusion, that variety affects the physico-chemical properties, microbial loads and carotenoid contents of both fresh and stored sweet potato flours has been demonstrated in this present study. The flours of the sweet potato varieties studied were found to have good microbial loads by the 6th month of storage indicating that their shelf lives could be extended if packaged well and stored. Both fresh and processed flours of all sweet potato varieties evaluated were found to be widely accepted and had high starch content indicating the possibility of their utilization in both alcoholic, food and sugar industries. Processing also increased the starch contents of the sweet potato varieties in addition.

In terms of carotenoid contents, all fresh samples of sweet potato varieties elucidated, were found to contain significant quantities of carotenoids indicating their antioxidant potentials. However, about 35% of this was lost during processing. Thus the development of a better processing procedure that can retain the carotenoid contents of these sweet potato varieties is recommended.

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