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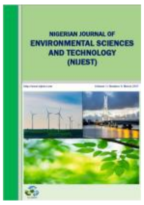

Nutritional Evaluation of Orange-fleshed Sweet Potatoes *(Ipomoea batatas*) Flour Extracted from Various Processing Techniques

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ABSTRACT

Orange flesh sweet potato (OFSP) is one of the world's most important food security-promoted root crops. Unfortunately, the crop is underutilized in Nigeria due to its poor storability technics and rapid deterioration in storage. To establish baseline data for its better storage and utilization for upgrading its value chain, an alternative approach of processing is thereby expedient to curb the menace. Thus, the nutritional evaluation of orange-fleshed sweet potato (Ipomoea batatas) flour extracted from various processing techniques was evaluated. OFSP used for the study was sourced from National Root and Tubers Research Institute, Umudike, Nigeria. The experiment was carried out in the Department of Crop Production Laboratory, University of Agriculture and Environmental Science, Owerri, Nigeria. The three different processing techniques used were peeled; scratches peeled, and puree samples. The result of the proximate composition, mineral analysis of the flours and the puree showed significant differences among the samples evaluated. However, the crude protein content for both puree and scratched OFSP was insignificantly different. The puree sample recorded the highest protein content (5.48±0.24) and moisture content (85.95±3.89), respectively, and was closely followed by scratched OFSP with (5.02±0.01) while the least was recorded in the peeled sample (4.03±0.04). The study concluded that scratched OFSP through cabinet drier processing was considered the best alternative to the puree method of storage of orange-fleshed sweet potatoes and the best method of processing in areas where electricity is erratic or not available.

Keywords: *Deterioration, Nutrient composition, Orange-fleshed Sweet Potato, Proximate composition. Puree.*

1.0. Introduction

Sweet potato (Ipomoea batatas) belongs to the morning-glory family. Despite its name, it is not related to the potato, unlike the potato- which is a tuber, or thickened stem, the sweet potato is a storage root. The plant is an important economic crop in many countries. It is ranked the fifth most important food crop in developing countries and the sixth in world food production after wheat, rice, maize, potatoes, maize, and cassava. More than 105 million metric tons are produced globally each year, 95% of which are grown in developing countries. China is the world's largest producer of sweet potatoes followed by Malawi and Nigeria (FAO, 2019). According to FAOSTAT, (2019) sweet potato production was reported to be 112.8 million tons (in 115 countries) in 2017, and China was the leading producer, followed by Nigeria and Tanzania, Indonesia, and Uganda. All the plant parts, roots, vines, and young leaves of sweet potatoes are used as foods, animal feeds, and traditional medicine around the world (Mohanraj and Sivasankar 2014). Most of the dry matter in sweet potatoes consists of carbohydrates, primarily starch and sugars, and to a lesser extent pectins, cellulose, and hemicellulose. Residues from sweet potato starch and juice processing of commercial varieties are good sources of dietary fiber.

According to Fasola, (2009), the major challenge faced by this crop is that its storage roots cannot be stored for more than a few weeks after harvest, however, he suggested that traditionally the crop could be boiled, fried, roasted, baked, or included in a wide range of tasty and famous recipes, nutritive first courses, delicious soups, main dishes, and desserts.

The crop can further be processed into purée, juice, canned, frozen, dried, and snack products. Muhammad and Mark (2018) in their findings suggested that the development of high-yielding sweet potato varieties with high nutritional values and good eating quality, coupled with improving processing technologies for the development of food products and functional ingredients are germane to meeting consumers' demand. Van'hal (2000), in his assessments conducted in developing countries, suggest that processing sweet potato roots into flour offers a unique opportunity of presenting the commodity in a more stable form. Also, Woolfe (1992) name tagged sweet potato as an "almost perfect nourishing food" as the crop contains vitamins, minerals, and many other nutrients in favorable ratios, he further revealed that promoting the utilization of sweet potato in various food preparations could provide an affordable source of nutrients that can improve malnutrition.

The orange-fleshed sweet potatoes (OFSP), one of the varieties of sweet potatoes that are considered a good source of carotenoids, Stinco *et al* (2014) reported 13.11 (µg/g db) of AC in OFSP and many researchers are recommended to use the OFSP to combat the problems of Ventricular Assist Device (VAD) in developing countries. Neela and Fanta (2019) reported that the general acceptability of OFSP is a result of its eye pleasant color and good flavor which attract different age groups to use the crop in many processed forms. OFSP contained high moisture and starch contents; however, the reverse is the case in protein and fats content ash and fiber contents are present in moderate concentrations.

The orange-fleshed sweet potato is a seasonal crop, perishable, and cannot be stored for a long period unless preserved in some way. Being rich in β-carotene, the orange-fleshed sweet potato is gaining importance as the cheapest source of antioxidants having several physiological attributes like anti-oxidation, anti-cancer, and protection against liver injury and is most suited as a biofortified crop to combat malnutrition in a small and marginal farming community. Several researchers have reported the usage of OFSP, among which is Malavi, (2022) who reported the use of one hundred grams of bread portion enriched with 40% and 50% OFSP purée provided more than 50% of vitamin A dietary requirements to children aged 4–8 years. Also, the use of puree in the substitution of flour in bread baking was reported by Bucher *et al.*, (2017) and Low *et al*., (2017). They reported that conversion of OFSP to flour has a lower conversion rate of 4.5- 5 kg to produce a kilogram of flour compared to 1.3 – 1.6kg of fresh root required to produce an equal kilogram of puree and in addition, there are significant losses of β- carotene in flour within storage beyond two months. However, the findings were upturned by Omodamiro *et al.*, (2013) who reported that some varieties of OFSP yielded as high as 21.5%. These findings according to Ginting and Yulifianti., (2015) and Alam *et al.*, (2016), necessitated alternatives and economical ways to puree formulation, especially in Nigeria where electricity has always been so erratic.

The use of OFSP puree subjected to cold-chain storage presents a challenge in terms of additional costs as the storage demands electric power and additional equipment if the long-term production is to be sustained, thus limiting the use of this puree by small-scale farmers that cannot afford the cold chain storage (Islam *et al*., 2016). These consequently, pose challenges to most agricultural products in storage houses, especially in rural areas. Information on other methods of preservation from wet (fresh) OFSP tubers to dry flour formulations on these improved sweet potato varieties is scanty. It is, therefore, quite clear that there is a need to explore other processing techniques of OFSP from wet (fresh) OFSP tubers to flour form, with caution of not compromising the nutritional constituent of the resulting products. Therefore, the objective of this study was to determine the nutritional evaluation of orange-fleshed sweet potato *(ipomoea batatas*) flour extracted from various processing techniques.

2.0. Materials and Methods

2.1 Materials

The total sum of 30kg orange-fleshed sweet potato (OFSP) (*Ipomoea batatas L*) variety used for the study was sourced from National Root Crop Research Institute, Umudike, Nigeria.

All experiments were carried out in the Department of Crop Production Laboratory, University of Agriculture and Environmental Science, Umuagwo, Imo State. The experiment was evaluated in the laboratory in a Completely Randomized Design with three replicates.

2.2 Methods of puree preparation

10kg of OFSP tubers were washed thoroughly with clean water to remove dirt and other foreign materials. The OFSP were peeled, washed with distilled water, sliced to 1.5 mm thick, and boiled at 100ºC in clean water for about 15min until tender, drained, and cooled at room temperature. Mashed and stored inside a refrigerator at (+4ºc) until usage.

2.3*. Laboratory preparation of peeled OFSP samples*

10kg each of OFSP tubers were washed thoroughly with clean water to remove dirt and other foreign materials. The Orange-fleshed sweet potatoes were peeled, washed with distilled water, and sliced to 1.5mm thickness using a slicer machine. The sliced OFSP were then parboiled for about 20 minutes, sieved, then arranged neatly in a cabinet drier at 80^{O}C for 60mins. They were then removed and immediately turned into flour using a hammer milling machine and stored until usage.

2.4 Laboratory preparation of scratched OFSP-

10kg of OFSP tubers were washed thoroughly with clean water to remove dirt and other foreign materials. The Orange-fleshed sweet potatoes were scratched with a knife, washed with distilled water, and sliced to 1.5mm thickness using a slicer machine (Plate 1). The sliced OFSP were then parboiled for about 20 minutes, sieved, then arranged neatly in a cabinet drier at 80^{O}C for 60mins. The OFSP was then removed and immediately turned into flour using a hammer milling machine and stored.

Plate 1: OFSP Slicer machine

2.5 Proximate Analysis

The moisture, ash, fat, protein, crude fibre and carbohydrate content were determined according to a procedure described by (AOAC, 2012).

2. 6 Mineral determination

The Mineral content of the samples was determined using the wet method as described by Etong *et al*., (2014). Mineral analyses in OFSP food samples were subjected to Preliminary steps of sample preparation, including a dissolution or homogenization (like blending, mixing, grinding or slurry preparation),of OFSP samples and collection of representative test portion for each macro and micro nutrient analysis and digestion in the laboratory (Plate 2).

Plate 2: Digestion block for digestion of samples

The calcium, iron, zinc, potassium, and magnesium element content were determined by atomic absorption spectrophotometer. For mass spectrophotometers (Quadrupole ICP-MS Technology) was used in order to capture samples with varying analyse concentrations and wider working range (Plate 3).

Plate 3: Atomic absorption spectrophotometer (Quadrupole ICP-MS Technology)

2.7 Data Analysis.
The mean score from each tested samples (Mineral determination and spectrophotometer) were subjected to Statistical Analysis System (SAS™, 2017) procedures for Analysis of Variance (ANOVA) and least significant difference (LSD) test which was defined at (p<0.05).

3.0. Results and Discussion

Table 1: Proximate analysis of orange-fleshed sweet potato processed with diverse technics.

Method %	Moisture%	Ash%	Fat%	Crude protein%	Crude fiber	CHO%
Puree	85.95±3.89^{b}	0.63±0.17^{b}	1.99±0.33^{c}	5.48±0.24^{b}	0.70±0.11^{cd}	71.75±3.05^{cd}
Peeled	13.71±0.57^{a}	2.32±0.12^{c}	1.40±0.01^{d}	4.03±0.04^{c}	0.63±0.02^{de}	70.98±0.65^{e}
Scratch	13.05±0.21^{c}	2.85±0.04^{ab}	1.87±0.00^{c}	5.02±0.01^{b}	0.70±0.02^{e}	72.17±0.14^{b}
LSD	4.72	0.23	0.34	0.81	0.18	3.84

Table 1 shows the proximate Composition of Orange-Fleshed Sweet Potato (OFSP) processed with different techniques. Samples recorded from all the techniques showed that moisture content ranged from (13.05-85.95) % with puree recording the highest value while the lowest value was recorded in the scratched OFSP sample. The result of the proximate composition of the flours and the puree showed that the scratch-peeled OFSP had the highest ash content ranging from (2.85±0.04), crude fiber (5.48±0.24) and carbohydrate content (72.17±0.14) with a decrease in the moisture content from 13.05±0.21. The puree had the highest moisture content and crude protein (5.48±0.24), thou not significantly different from scratched unpeeled (5.02±0.01) while the peeled had the lowest crude protein (4.03±0.04). Table 1 revealed that there was a significant ($p< 0.05$) difference in moisture content with the puree recording the highest while scratch peeled had the lowest. This is expected as the boiling process provided for the starch granules in the potato to imbibe and retain more water. This high moisture content reduced their shelf life and storability; that was why they were stored at a temperature of ±4ºC to maintain the quality, quantity, and taste of the puree. The peeled and scratched sample placed in a cabinet drier showed reduced moisture content of food materials than other processing methods, owing to the dry technique where the food samples are heat treated without immersing in water liquid. (Gouado *et al.,* 2011;Vimala *et al*., 2011) reported that dry heat dehydrates foods causing water loss while the increase in moisture of the steamed sample was due to the moist heat employed in the process. This study, therefore, makes the processing of orange-fleshed sweet potato (OFSP) into flour increase its added value and may be a promising alternative to puree substitution in food products.

Table 2: Mineral composition (mg/100g) of orange-fleshed sweet potatoes as affected by processing method

SAMPLES	Puree	Peeled	Scratched
Zn	5.59d	5.22f	5.65c
Cu	2.08f	3.29d	3.40b
Mg	478.28f	473.84c	475.49b
P	0.34f	0.28e	0.34d
K	3,288.24b	3,157.20a	3,157.20a
Ca	236.40b	177.92f	187.84e
Flour/yield/10kg	-	1.80	2.01

Results are expressed as mean ±SD, n=2. Values in the same column having different superscripts are significantly different at (P<0.05).

The results of the mineral composition of the three processing methods were presented in Table 2 above. The puree had the highest mineral composition in all the examined macro and micronutrients except for zinc, potassium, and copper. This was closely followed by a scratched peeled sample which also recorded the highest nutritional values in zinc and copper. The least nutritional values were recorded in peeled OFSP among the evaluated minerals. The convection ratio from wet to dry was highest in the scratched peeled samples with (2.01kg) as against (1.80kg) recorded in peeled OFSP.

However, four out of the six evaluated nutrients were highest in puree while two nutrients (zn and cu) were highest in scratched OFSP. This shows that scratched OFSP can be a better alternative replacement for puree, as this is void of either cold room maintenance or electricity supply. The research showed that processing OFSP tubers through the scratched processing method, not only added additional nutrients to the flour but also added to the output (0.30kg) per every 10kg of OFSP processed. This is in consonant with the research work of (Omodamiro *et al.*, 2013) who reported that some varieties of OFSP tubers yielded as high as 21.5% of flour after processing. Similarly, (Fetuga *et al*., 2014, Oloo and Rose., 2014), and (Dibi *et al*., 2017) were wet to dry conversion ratio of peeled OFSP using a flash drier produced 1.5kg/10kg,1.7kg/10kg and 1.8kg/10kg, respectively, of OFSP root tubers. The flour gotten from this process can be stored under ambient conditions in sealed moisture-proofed polyethylene nylon and stored in a storage house until needed.

4.0. Conclusions

This finding produced 2.0kg/per 10kg of wet-to-dry with the scratch peeling method adopted. The above result showed that, the three methods of processing retained the minimum required nutrients needed, either as peeled or scratched flour when compare to puree. However, analysis of flour obtained from scratched processing technics retained the highest level of nutrients in zinc, copper and the second highest in macronutrients evaluated after pureeing with the increase of 0.35% on every 10kg of OFSP processed through cabinet drier. This confirmed that there were nutrients contained in the peels of the OFSP that if, possible should be adopted as the best means of processing OFSP but caution must be observed to ensure that the diseased parts of the OFSP and spotted areas must be scrapped off before processing into flour. This study has shown that processing OFSP through scratched methods via cabinet drier not only maintained the nutritional and mineral constituency of Orange-fleshed sweet potatoes but also increases the quantity of flour production. The study, therefore, recommends that scratching OFSP tubers and processing them through dry cabinet methods can be used as an alternative replacement for puree production, especially where electricity and cold room availability might be beyond reach.

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