NUTRITIONAL AND ANTI-OXIDANT QUALITY OF PAP FLOUR PREPARED WITH DIFFERENT MIXES OF ORANGE FLESHED SWEET POTATO, MAIZE, AND SORGHUM.

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ABSTRACT

Fermented cereal porridge, is a popular cereal in Nigeria and most West Africa. It is also called 'pap' and is usually made from corn (Zea mays) and sorghum (Sorghum vulgare). Sweet potato (Ipomea batatas) especially the orange fleshed (OFSP) can be used to fortify most cereal and starch foods. This study was carried out to analyze the nutritional quality of different traditional pap flour mixes; 50% Maize + 50% OFSP; 50% Sorghum + 50% OFSP, 50% Sorghum + 50% Maize, 100% Maize and 100% Sorghum. The grains were picked by removing the dirt, washed and dried till constant weight while fresh OFSP roots were washed, sliced and dried until constant weight was obtained. Data were collected on the pap flour mixes to analyze the proximate quality, mineral composition and selected anti-oxidants. Data collected were analyzed using SPSS while means were separated using Duncan Multiple Range Test. Result showed that addition of 50% OFSP to 50% Maize improved the potassium (261.30mg/100g) and crude protein (9.92g/100g) while 50% Sorghum + 50% OFSP had better calcium (7.69 mg/100g), lutein (12.59 µg/100g), Zeaxanthin (8.31 µg/100g) and beta-carotene (172.86 µg/g). Result also showed that there was no significant difference (p≤0.05) in the dry matter content of the different pap flour mixes. Conclusively, traditional flour mix with OFSP are higher in crude protein, lutein, zeaxanthin and beta-carotene. Therefore, 50% Maize + 50% OFSP and 50% Sorghum + 50% OFSP pap flour mix should be promoted, to enhance its potassium, crude protein, zeaxanthin, carotene and lutein content.

Keyword: Maize, Orange Fleshed Sweet Potato (OFSP), Pap, Sorghum, Anti-oxidants

INTRODUCTION

The methods and techniques for processing agricultural products are usually culturally based and most of these processing methods have been in use for many centuries. One of such unit operation in use is fermentation which is known across the globe as a household technology in plant food processing (Egwin *et al.*, 2013); and, as a means by which the nutritive value of plant products could be improved (Obadina *et al.*, 2008). Fermentation helps to detoxify the anti-nutritional factors, increase palatability and improve bioavailability of nutrients. Rice, maize, wheat, sorghum, millet, cassava yam, coco-yam, oil-bean and their derivatives are some of the crops whose products are subjected to the fermentation process at different stages of processing to a number of food products.

Pap is a traditional food product processed as a paste obtained after fermenting, milling and sieving grains like maize, millet and sorghum. Preparation of pap through fermentation of these grains is influenced by processing techniques employed and this could affect the color, taste, odour, microbial load and consumer acceptability of the product. The production of nutritionally high-quality pap, free from odour, poor taste and color and which is relished by humans have been a challenge to food processors over the years.

Sweet potato is an important staple food crop in Africa in general and Nigeria in particular (FAO, 2018; Ejechi *et al*., 2020). It has been reported that 100g, of orange fleshed sweet potato (OFSP) can provide enough beta-carotene ranging from 0 to 100 percent (Lindsay and Marjorie, 2001) of the suggested daily vitamin A requirement (350ug per day) for infants and young children. Hence, infants, young children and adults are usually encouraged to eat more of orange-fleshed sweet potato (OFSP) because it contains adequate amount of nutrients in form of Vitamins B and C as well as useful amounts of other micronutrients (Bovell, 2010). Currently, sweet potato is being utilized in various forms such as baked, cooked, oven-roasted, boiled, and fried among others (Sheryl, 2019) These uses can be adapted in the country to boost production and consumption of the crop according to Egeonu (2004).

Based on the availability of sweet potato in Nigeria and its nutritional advantages, this study seeks to investigate the potential in having pap mixed with sweet potato flour as a component to further explore other uses for sweet potato roots and also enhance the nutritional characteristics of pap as a staple meal. Hence, the objective of this study was to determine the proximate quality, mineral composition and anti-oxidants present in different pap flour mixes of OFSP, maize and sorghum.

MATERIALS AND METHODS

The study was carried out at the Agronomy Laboratory at Osun State University, Ejigbo campus, Osogbo, Nigeria. Orange fleshed sweet potato (OFSP) roots were procured from farmers in Eruwa, Oyo state while sorghum and maize were purchased at an open market in Ejigbo, Osun State. The pap mixes investigated were: 50% Maize + 50% sweet potato; 50% Sorghum + 50% sweet potato; 50% Sorghum + 50% Maize; 100% Maize; and 100% Sorghum. Fresh OFSP root was washed, sliced and dried. Sorghum and maize grains were cleaned by removing the dirt, washed and dried to 15% moisture content**.** The maize traditional flour was prepared using the method of Adesokan *et al*. (2010). The Sorghum was also prepared and milled into flour according to Nwakalor *et al.* (2014).

Preparation of flour Mixture

The prepared powdered sample (100 g) was reconstituted with 100 ml of distil water. The reconstituted powder was poured in 150ml of boiling (100ºC) distil water in a pot and stirred for 2 to 5 minutes to obtain a smooth gruel.

Data Collection

The proximate, mineral and antioxidant properties of the pap flour mixture formulated from different blends of maize, orange fleshed sweet potato and sorghum flours was carried out. The ash content was determined using a muffle furnace. 2g of the pap flour was dissolved in l0ml of conc. HC1. The mixture was heated on a steam bath to effect complete dissolution. The dissolved ash was filtered into a 100 ml volumetric flask and made up to volume with distilled water. The mineral content such as calcium, magnesium, phosphorus and potassium were determined using an atomic absorption spectrophotometer (Spectronic Unicam, UK). Sodium and potassium were determined by flame photometric method while Phosphorus was determined by Vanadate colorimetric method (AOAC, 2010).

Proximate chemical composition content of pap flour samples was performed according to AOAC International Official Methods of Analysis (AOAC, 2010). Moisture content was determined by the oven method; fat content was determined by using petroleum ether extraction; and crude protein content was determined by Kjeldahl method (nitrogen content × 6.25). Crude fiber was determined by digesting defatted samples with diluted acid (1.25% sulfuric acid solution) for 30 min at boiling point followed by digestion with 1.25% sodium hydroxide solution for the same duration. Carbohydrate concentration was obtained by the difference between 100 and the total sum of the percentage of moisture, ash, fat, fibre and protein (Akande *et al*., 2017; Tumuhimbise *et al*. 2019; Anino *et al*., 2019).

Lutein, Zeaxanthin, and β-carotene extraction and determination

About 0.25 g of homogenised pap flour samples were weighted and placed in 50 ml beakers and extracted for 2 days in dark with 30 ml 100% acetone. After the extraction, the samples were ultrasonicated for 15 minutes and then filtered through the Buchner funnel under vacuum with filter paper. The filtrate was quantitatively transferred to 50 ml flask and completed to 50 ml volume with acetone. Analyses of samples were carried out using UV-VIS spectrophotometer (Spectronic Unicam, UK). The absorbance of acetone extracts was measured at 662 nm, 645 nm and 470 nm. The total content of carotenoids was calculated from the equations (Lichtenthaler & Wellburn 1983) for 100% acetone (in µg/ml of plant extract). Lutein was determined at 448nm wavelength with ethanol as solvent and Zeaxanthin was determined at 452nm wavelength with Acetone as solvent using the atomic absorption spectrophotometer. The β-carotene was determined by soaking 1 g of the pap flour in 5 ml of methanol for 2 h at room temperature under dark condition in order to get a complete extraction. The β -carotene layer was separated using hexane through separating funnel. The volume was made up to 10 ml with hexane and then this layer was again passed through sodium sulphonate through a funnel in order to remove any moisture from the layer. The absorbance of the layer was measured at 436 nm using hexane as a blank (Ranganna, 1999). The beta carotene was calculated using the formula:

$$\boldsymbol{\beta}\text{carotene }(\mu g/100g) = \text{Absorbance }(436\text{ nm}) \times V \times D \times 100 \times {}^{100}/_{W} \times Y$$

where:

V = Total volume of extract;

D = Dilution factor;

W = Sample weight; and

Y = Percentage dry matter content of the sample.

Statistical Analysis

The proximate, mineral and anti-oxidant of the different pap flour mixes were analysed using the America Official Analytical Chemistry, AOAC and means were separated using Duncan Multiple Range Test at 5% probability.

RESULTS

Mineral analysis of Traditional pap flour prepared using different mixes

Table 1 shows the mineral contents of the different mixes of the pap produced. The results revealed that there was significant difference (P≤ 0.05) among the mixes of pap. The result also showed that the different mixes had different nutritional strengths based on the mineral contents determined. The mix of 50% Sorghum + 50% OFSP gave the highest (7.69 mg/100g) value for calcium which was not significantly different for the value obtained for pap produced from 100% sorghum. The highest magnesium content (124.75 mg/100g) was gotten from the mix of 50% Maize + 50% Sorghum while the combination of 50% maize + 50% OFSP gave the highest amount of Potassium (261 mg/100g) in the pap mix produced. Furthermore, the 50% Sorghum + 50% OFSP mix again had the largest Phosphorus content.

TABLE 1: THE MINERAL CONTENT OF THE TRADITIONAL PAP FLOUR MIXES

Custard mixes	Ca	Mg	K	P
	…………………… (mg/100g) …………………………			
100% Maize	6.45^{b}	106.64^{b}	189.39^{c}	198.46^{b}
100% Sorghum	7.23^{a}	121.23^{a}	242.17^{a}	208.86^{a}
50% Maize + 50% OFSP	6.71^{b}	118.00^{a}	261.30^{a}	180.69^{c}
50% Sorghum + 50% OFSP	7.69^{a}	118.30^{a}	224.25^{a}	219.09^{a}
50% Maize + 50% Sorghum	5.89^{c}	124.75^{a}	194.39^{b}	188.05^{b}
SD	*0.69*	*11.01*	*30.74*	*5.20*

Key: Means followed by different letters (a-e) are significantly different (P≤ 0.05) within individual column according to Duncan's multiple range test.

Proximate composition of traditional pap flour prepared using different mixes

Table 2 shows the proximate contents of the different mixes of the pap flour produced. The results revealed that there was significant difference (P≤ 0.05) among the mixes of pap flour. The result also showed that the different mixes had different nutritional strengths based on the proximate contents determined. The mix of 50% Maize + 50% OFSP gave the highest (11.19g/100g) value for moisture content followed by other pap flour mix which were not significantly different from each other. The highest dry matter content (91.78 mg/100g) and ash (1.86g/100g) was gotten from 100% Maize while the combination of 50% maize + 50% OFSP gave the least (88.81g/100g). The highest amount of fat and crude fibre (4.26g/100g and 7.32g/100g respectively) were observed in the pap flour mix of 100% sorghum. Furthermore, the 50% Maize + 50% OFSP mix again had the largest crude protein (9.16g/100g) content.

TABLE 2: THE PROXIMATE CONTENT OF THE TRADITIONAL PAP FLOUR MIXES

Proximate content (g/100g)	100% maize	100% sorghum	50% maize + 50% OFSP	50% sorghum + 50% OFSP	50% maize + 50% sorghum	*SD*
Moisture	8.24^{b}	8.75^{b}	11.19^{a}	8.70^{b}	8.87^{b}	*1.16*
Dry matter	91.78^{a}	91.25^{a}	88.81^{b}	91.30^{a}	91.31^{a}	*1.18*
Fat	1.82^{c}	4.26^{a}	2.06^{b}	2.96^{b}	2.45^{b}	*0.97*
Ash	1.86^{a}	1.22^{b}	1.04^{b}	1.61^{a}	1.16^{b}	*0.34*
Crude protein	2.78^{b}	9.16^{a}	9.92^{a}	7.49^{a}	7.26^{a}	*2.77*
Crude fiber	2.34^{c}	7.32^{a}	4.83^{b}	5.86^{a}	5.78^{a}	*1.84*
Carbohydrate	1.86^{a}	1.22^{b}	1.04^{b}	1.61^{a}	1.16^{b}	*0.34*

Key: Means followed by the same alphabets in a row are not significantly different at 5% probability level DMRT

Antioxidants of Different Mixes of Traditional pap flour

Table 3 showed that there was significant difference (P≤ 0.05) in lutein and zeaxanthin content in the different mixes of pap. For both Lutein and Zeaxanthin, the mix of 50% Maize + 50% OFSP had the highest value (12.59 µg/100g and 8.31 µg/100g, respectively) while pap made from 100% Maize had least value for the two anti-oxidants investigated

Table 4 gives the values for beta-carotene contents of the different pap flour mixes. The Table showed that the values were significantly different for the different pap flour mixes with 50% Sorghum + 50% OFSP having the highest value 172.86 µg/100g for beta-carotene content. The least values of β-carotene contents were obtained from 100% Sorghum.

TABLE 3: THE LUTEIN (µG/100G) AND ZEAXANTHIN CONTENT (µ/G) OF DIFFERENT TRADITIONAL CUSTARD MIXES.

Mixes	Lutein (**µg/100g**)	**Zeaxanthin (µg/100g)**
100% Maize	8.69^{c}	4.85^{c}
100% Sorghum	9.45^{b}	6.79^{b}
50% Maize + 50% OFSP	12.59^{a}	8.31^{a}
50% Sorghum + 50% OFSP	10.84^{b}	7.48^{a}
50% Maize + 50% Sorghum	10.53^{b}	5.39^{b}
SD	1.05	2.05

Key: Means followed by different letters (a-e) are significantly different (P≤ 0.05) within individual column according to Duncan's multiple range test.

TABLE 4: THE BETA-CAROTENE CONTENT (µG/G) OF DIFFERENT TRADITIONAL CUSTARD MIXES

Mixes	**β-Carotene (µg/g)**
100% Maize	93.41c
100% Sorghum	94.67c
50% Maize+ 50% OFSP	128.98b
50% Sorghum+ 50% OFSP	172.86a
50% Maize+ 50% Sorghum	111.45b
SD	*32.77*

Key: Means followed by the same alphabets are not significantly different at 5% probability level DMRT.

DISCUSSION

The addition of orange fleshed sweet potato (OFSP) improved some minerals and antioxidants, this was supported by Melas *et al.*, (2021). The content of all the mineral elements examined were not significantly different and are within the recommended daily allowance (RDA). This trend was also observed by Ijarotimi and Keshinro (2012) with infant formula formulation from popcorn, Bambara nut and locust bean. The recommended daily allowance (RDA) of phosphorus is 800 mg. This suggested that more than 100g of the pap need to be consumed daily.

The fortification of food with OFSP enhanced the richness of magnesium in the traditional custard. Magnesium stimulates gastric and intestinal function while phosphorus serves as the main regulator of energy metabolism in cells (Oluwatoyin *et al.*, 2017). Furthermore, it aids in the maintenance of bone growth and integrity and is involved in the regulation of the cardiac cycle and the functioning of muscles and nerves. Deficiency diseases are hypomagnesaemia and neuromuscular irritability. Toxicity symptoms are hypotension, respiratory failure, and cardiac disturbances (Allen and Sharma 2019; Gragossian and Friede 2019). This shows that the consumption of 50% Maize + 50% OFSP will improve the functioning of muscles and nerves.

Calcium (Ca) was higher in 50% Sorghum + 50% OFSP. This shows that the consumption of this traditional custard is essential for an adequate growth and bone development (Matkovic and Ilich 1993). Calcium is a common mineral found in blood (McCarron and Reusser 1999), cells require an adequate amount of calcium to perform various functions (Miller *et al.* 2001), and teeth and bones are rich in calcium (Vallet-Regí and González-Calbet, 2004). Most of the calcium is found in bones (Reid *et al.,* 2015). The daily-recommended allowance for calcium is 1 g per day (Akram *et al*., 2020),

The 50% Sorghum + 50% OFSP traditional custard is enriched with Potassium (K) content. This shows that consumption of this mix helps in maintaining osmotic balance of the body fluids (Oluwatoyin *et al.*, 2017). Potassium is needed for many enzyme reactions (Weaver, 2013); Glycogenesis requires the presence of potassium. Insulin administration causes a fall in plasma potassium level because the deposition of glycogen brought about by insulin is also accompanied by the deposition of potassium. Moreover, insulin also increases protein synthesis within the cells, which by binding potassium ions can lead to a low plasma potassium level. Potassium deficiency leads to hypokalemia, paralysis, and cardiac disturbances. Excessive potassium levels lead to hyperkalemia, paralysis and cardiac disturbances (He and MacGregor, 2008).

In addition, Moisture is one of the major components of OFSP. It accounts for up to 75% according to (Emdrias *et al*., 2016). Though roots and tubers are consumed in fresh state after boiling or minimal processing, different researchers have reported the moisture content of less than 11%, which may be due to various drying techniques for OFSP while converting into flour (Rodrigues *et al*., 2016).

Proteins are very important nutrients for the structural and functional performance of different biomolecules in the human body, and they provide the essential amino acids required for metabolism. The addition of OFSP flour to maize improved the protein content from 2.78 g/100g to 9.92 g/100g. Therefore, to combat the protein malnutrition especially in children and pregnant women, it is very important to consume the protein-rich pulses and animal foods among communities where OFSP is considered as second staple (Neumann *et al.*, 2002).

Starch is one of the major important energy sources for the consumers. High starch (1.86g/100g) concentration was reported in 100% maize pap flour while addition of OFSP to sorghum increased the carbohydrate content from 1.22g/100g to 1.61g/100g. This result is similar to other staple cereal, roots, and tubers. So, OFSP can be consumed as the staple crop because of high concentration of carbohydrates (Jobling, 2004).

Furthermore, several studies have reported that lutein bioavailability from green vegetables is higher than that of β-carotene (Gartner *et al.*, 1996; van het Hof *et al.*, 1999; Castenmiller *et al.*, 1999) although another study (Chopra *et al.*, 2000) suggests otherwise. Research involving cell cultures, animal models, and human studies has been directed to the potential role of lutein and zeaxanthin in protecting against several chronic diseases, particularly age-related macular degeneration (AMD) and cataract, cancer at various sites, heart diseases and stroke. The abundance of lutein and zeaxanthin in 50% Sorghum + 50% OFSP shows that several diseases can be reduce when such is consumed. The xanthophylls are uniquely concentrated in the macular region of the retina (Chamberlain *et al.*, 2009) with zeaxanthin being the dominant component in the central macula and lutein is distributed throughout the retina (Bone *et al.*, 1997). Meso-zeaxanthin has been identified in human macula and appears to be a conversion product derived from lutein or zeaxanthin in the retina (Krinsky *et al.*, 2003). Bernstein *et al.* (1997) and Yemelyanov *et al.*, (2001) also identified specific xanthophyll-binding proteins in human retina and macula. Lutein and zeaxanthin are the only carotenoids reported to be present in eye lens (Yeum *et al.*, 1995). Beta-carotene may possess anti-mutagenic and anti-carcinogenic properties and play a role in the health of body tissues other than the eye as suggested by research studies related to carcinogenesis and the risk for cancer (Sanjib, 2011).

CONCLUSION

In conclusion, the present study demonstrates the potential of orange fleshed sweet potato (OFSP), as a blend, to enhance the nutritional quality of pap derived from maize and sorghum. Despite other uses of the supplement, OFSP as medicinal and a condiment, it can also be used to enhance nutrition, and may therefore be used to help combat crude protein, lutein, zeaxanthin and beta-carotene deficiency in nutrition of developing and ever-increasing populated nations.

Thus, the potential of OFSP as food enhancers in local food may contribute to global initiatives for mitigating the level of food insecurity. This study suggests that orange fleshed sweet potato can be mixed with other traditional custard primary product such as Maize and Sorghum to combat beta-carotene deficiency, which is a major constraint in Africa's diet. Further studies should be conducted on improvement and acceptance of Orange fleshed sweet potato especially to the younger generation and nursing mothers.

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