

## Production and evaluation of flours and crunchy snacks from sweet potato (*Ipomea batatas*) and maize flours

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### Abstract

The present study was conducted to assess the suitability of blends of two sweet potato (cream- and yellow- flesh) varieties and maize flours in the preparation of crunchy snacks. Each of the sweet potato varieties was prepared into flour and separately blended with 0, 30 and 50% of maize flour. The blends were evaluated for proximate composition, mineral content, vitamin content, anti-nutrient factors and functional properties. Baked crunchy snacks were prepared from each of the blends and evaluated for physical and organoleptic properties. The results of proximate analysis showed that crude protein (3.40 - 6.57%) was significantly different between the two varieties of sweet potato used and it increased with addition of maize flour to the two varieties. The  $\beta$ -carotene value (345 - 370  $\mu\text{g}/100\text{ g}$ ) was highest in 100 yellow-flesh sweet potato which slightly decreased with addition of maize flour. The vitamin c content (13.4-17.3 mg/100 g) was also highest for 100% yellow-flesh sweet potato. The cream-flesh sweet potato contained higher amount of phytates (16.0 mg/100 g) but lower amounts of tannins (8.66 mg/100 g) and oxalates 7.0 mg/100 g) compared with the yellow-flesh varieties. The tannins, phytates and oxalates values decreased with addition of maize flour to both varieties of the sweet potato used. The bulk density values (0.523 - 0.683  $\text{g}/\text{cm}^3$ ), water absorption capacity (123 - 143%) and oil absorption capacity (13.3 - 15.3%) were significantly ( $p < 0.05$ ) different among the samples. The specific height was highest for 100% yellow flesh sweet potato and it decreased with addition of maize flour. The sensory evaluation revealed that all the samples were scored within the acceptable attribute limits except the sample from 100 cream-flesh sweet potato which was scored lowest in all attributes.

### Keywords

Sweet potato flour

Maize flour

Crunchy snack

Chemical composition

Organoleptic properties

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### Introduction

Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant which belongs to the family of convolvulacea. Sweet potato is a minor root crop in tropical Africa despite its industrial potentials as indicated by its growth in terms of production (Tewe *et al.*, 2003). Among the root and tuber crops, it is the only one that had a positive per capita annual rate of increase in production in Sub-Saharan Africa. Sweet potato has a high yield potential that may be realized within a relatively short growing season and adaptability to a wide ecological range of 0 to 2000 meters above sea level and 30° N to 30°S (Hahn, 1984). It has been a life saver for centuries in many tropical, sub-tropical and warmer temperate areas of the world, warding off famine in times of both climatic disaster and war. Sweet potato is the world's seventh most important food crop after wheat, rice, maize, potato, barley and cassava (Tewe *et al.*, 2003). It grows under many ecological conditions, has a shorter growth period than most crops and shows no marked seasonality (Oke, 1990). Sweet potato plays a major role as a famine reserve for many rural and

urban households because of its tolerance to drought, short growth and high yield with limited inputs on relatively marginal soils (Tewe *et al.*, 2003). Sweet potato is widely grown as a staple food in many parts of the tropical and subtropics, which include developing countries where it accounts for about 107 million tonnes in production per year (Odebode, 2002). Also, it is a low input crop and it is used as a vegetable, dessert, source of starch and it is eaten as a substitute for yam due to its lower cost of production.

Sweet potato is comparatively a nutritional heavy weight; rich in complex carbohydrates, vitamins C and E, and also contains good quantities of vitamins A and B, calcium and iron (Huang *et al.*, 1999; Vimala *et al.*, 2011). The tubers can be steamed, roasted, boiled, baked, and fried. It has the potential of bridging food gap due to diversified processing and utilization technologies that have been produced but not yet fully exploited (Nungo *et al.*, 2007). There are many products that maybe made from using low priced sweet potatoes as a major ingredient (Ge *et al.*, 1992). Sweet potato skin colors come in various shades of creamy white, yellow-orange, tan, reddish-purple and red. Sweet potato has also been used in

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the production of purees and these can be used as an ingredient in various products including baby food, casseroles, puddings, pies, cakes, bread, restructured fries, patties, soups and beverages (Truong *et al.*, 1995; Walter *et al.*, 2001). Lack of industrial or village-level processing of the crop and low levels of commercialization are major constraints to increased production of sweet potatoes. The major avenue left for preservation of sweet potato is processing into secondary products.

There are wide ranges of snack items including potato chips, maize chips, puffed dough, cookies and crackers (Fazzolare *et al.*, 1997). Processing root crops especially sweet potato into convenience foods will improve their being accepted by the urban population. This will lead to expanded markets and thus encourage the increased production of root crops and also the use of processed foods based on local products to replace imported foodstuffs will also conserve foreign exchange. The objective of the study was to evaluate the suitability of two local sweet potato varieties for preparation of crunchy baked snack.

## Materials and Methods

Cream and yellow flesh coloured of sweet potato varieties were purchased from Bodija market, Ibadan as well as other materials such as baking powder, vegetable oil, nut-meg, maize flour and flavour.

### Preparation of blended flours

The two sweet potatoes varieties were processed into flours separately. The tubers were peeled and washed with clean water. The clean tubers sliced into about 5 mm thickness were blanched at 95°C for 10 min, then dried at 60°C for 8 h in a cabinet drier (Mermmet, Germany) and dry milled in a laboratory hammer mill (Apex, Germany) and screened through a sieve of 0.8 mm aperture to get the flours. The flours obtained were packaged in a low density polyethylene bag and stored in a cool place until needed. The potato flours were substituted with maize flour at 0, 30 and 50%.

### Physico-chemical analysis of the flours

#### Proximate composition

The samples were analyzed for proximate composition including moisture, crude protein, fat, ash, crude fibre, and carbohydrate according to standard methods (AOAC, 2005). The moisture content of the samples was determined by oven (Genlab) drying to a constant weight at 105°C. The fat content was extracted with petroleum ether (40-

60°C) using a soxhlet apparatus for 6 h. The micro kjeldahl procedure was adopted for determination of protein, while carbohydrate was determined by difference. All analyses were done in triplicate.

#### Mineral composition

Iron, phosphorus and calcium were determined after triple acid digestion according to standard procedures (AOAC, 2005) using atomic absorption spectrophotometer (Model 200, Germany).

#### Other analyses

Vitamin C was determined using dye-titration method, while  $\beta$ -carotene was estimated based on the official procedures (AOAC, 2005). Free fatty acid value was defined as the number of mg potassium hydroxide required to neutralize the free acid in g of the sample (Saad *et al.*, 2007). It was determined using titration and expressed as the percentage of free fatty acidity.

#### Anti-nutrient composition

Phytate was quantified using the method described by Ola and Oboh (2000). Total oxalate was determined using the method described by Krishna and Ranjhan (1980). Tannin was determined by the acidified vanillin method using a spectrophotometer (Jenway Spectronic 21D Model) as described by Chang *et al.* (1994).

#### Functional properties

Bulk density was determined according to the procedure described by Beuchat (1997). The bulk density was expressed as the weight of the sample per volume. Water and fat absorption capacities were determined by the method described by Sathe and Diphas (1981). The water/fat absorption capacity was expressed as the weight of water/fat bound by the dry flour. Emulsion capacity was determined according to the method described by Padmashree *et al.* (1987). The emulsion capacity was expressed as the ratio of emulsion layer to the height of the total content in the tube multiplied by 100%. Gelation capacity was determined according to the method described by Coffman and Gracia (1977). The least gelation concentration was determined as the concentration when the sample from the inverted tubes does not fall down or slip.

#### Baking of sweet potatoes snacks

The flour (200 g), baking fat (14 g), baking powder (2 g), flavour (1 g), were mixed together for about 10 min using a cake mixer (Kenwood, Hampshire UK) on a second speed running at 90 rev/min after which the improver and water was added to

obtain a homogenous dough in the mixing machine. The dough was rolled using a pasta roller (Crownstar, China) and cut into shapes. The pieces was placed in the greased baking trays and then baked in a pre-heated oven (Genlab) operating at 100°C for 10 min turned at intervals of every 3 min. The chips were allowed to cool and packaged in a low density polyethylene bag.

#### Physical properties of the snacks

The weight of the samples was determined on an electronic weighing balance (Mettler, Germany). The height was determined using a measuring ruler. The specific height was estimated by dividing the height with the corresponding weight.

#### Sensory evaluation

Organoleptic evaluation of the coded samples of baked sweet potato was carried out for level of acceptance and preference using a thirty member semi trained panel. The attributes evaluated for include appearance, taste, mouth feel and overall acceptability using a nine point hedonic scale, where 1 and 9 representing “extremely dislike” and “extremely like” respectively.

#### Statistical analysis

The data collected from the experiments were subjected to analysis of variance (ANOVA) and samples' means were separated using Duncan's multiple range test. Significance was accepted at 5% significance level.

### Result and Discussion

#### Proximate composition

The result of analysis of proximate composition shown in Table 1 indicates that the crude protein values of the flours ranged from 3.40 to 6.75%. Yellow flesh sweet potato (YFP) alone had significantly ( $p < 0.05$ ) higher crude protein content (4.33%) than 100% cream fleshed sweet potato (CFP) (3.40%). The values were similar to the average protein value of 4.41 g/100 g reported by Ravindran *et al.* (1995). The crude protein content increased with addition of maize flour for both varieties of sweet potato used in this study showing that maize is richer in protein than sweet potato. There were significant ( $p < 0.05$ ) differences in protein content among the blends. Similarly YFP had significantly ( $p < 0.05$ ) higher crude fat content than CFP. Addition of maize flour significantly ( $p < 0.05$ ) increased crude fat content of CFP but not for YFP, however no significant ( $p > 0.05$ ) differences were observed among the blends. Ash content values ranged from 2.17 to

Table 1. Proximate composition of the flours

Sample (Percentage of Sweet potato)	Dry Matter (%)	Crude Protein (%)	Crude Fat (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)
100%CFP	92.0±1.0 <sup>a</sup>	3.40±0.10 <sup>c</sup>	2.70±0.26 <sup>d</sup>	2.70±1.7 <sup>b</sup>	3.63±0.15 <sup>a</sup>	79.6±1.2 <sup>a</sup>
70%CFP	91.3±1.5 <sup>a</sup>	4.90±0.17 <sup>c</sup>	3.37±0.57 <sup>ab</sup>	2.60±0.10 <sup>bc</sup>	3.28±0.23 <sup>b</sup>	77.2±1.1 <sup>b</sup>
50%CFP	90.7±1.2 <sup>a</sup>	6.13±0.32 <sup>a</sup>	3.07±0.60 <sup>ab</sup>	2.17±0.06 <sup>d</sup>	3.17±0.12 <sup>b</sup>	76.1±1.7 <sup>b</sup>
100%YFP	90.7±1.5 <sup>a</sup>	4.33±0.29 <sup>d</sup>	3.73±0.12 <sup>a</sup>	3.13±0.23 <sup>a</sup>	2.43±0.15 <sup>c</sup>	77.0±1.0 <sup>b</sup>
70%YFP	91.0±1.0 <sup>a</sup>	5.60±0.36 <sup>b</sup>	3.50±0.50 <sup>ab</sup>	2.67±0.31 <sup>b</sup>	2.23±0.21 <sup>c</sup>	77.0±0.9 <sup>b</sup>
50%YFP	92.7±1.5 <sup>a</sup>	6.57±0.12 <sup>a</sup>	3.77±0.25 <sup>a</sup>	2.30±0.17 <sup>cd</sup>	2.27±0.15 <sup>c</sup>	77.8±1.5 <sup>ab</sup>
Means	91.4±1.3	5.16±1.13	3.36±0.53	2.59±0.36	2.84±0.58	77.4±1.5

CFP - Cream flesh sweet potato

YFP - Yellow flesh sweet potato

Means followed with the same superscripts along the column are not significantly ( $p > 0.05$ ) different

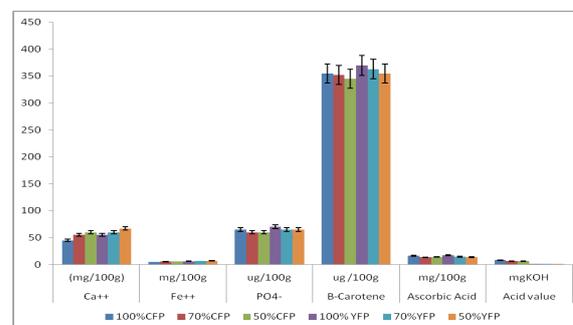


Figure 1. Minerals, vitamins and free fatty acid contents of sweet potato-maize flour blends

3.13% with 100% YFP having the highest value and 50% maize flour substitution with the least values. Substitution of sweet potato flours with maize flour caused significant ( $p < 0.05$ ) decrease in ash content of the blends. The high ash content observed would mean that the two varieties might be high in mineral content as reported by Ravindran *et al.* (1995). Crude fibre content significantly ( $p < 0.05$ ) varied between the two varieties of sweet potatoes with cream flesh variety having higher value (3.63%). No significant ( $p > 0.05$ ) differences were observed among the blends for both varieties of sweet potato. The high carbohydrate content (76.1 - 79.6%) observed in this study has been associated with high caloric value of sweet potatoes (Ravindran *et al.*, 1995; Woolfe, 1992). The moisture increased from 7.86% to 8.36% for the cream fleshed variety and decreased from 8.03% to 7.53% for the yellow fleshed variety as observed in this study. The values of moisture content observed were in close agreement with that reported by Oboh *et al.* (1989).

#### Minerals, free fatty acid and vitamin c and $\beta$ carotene

The minerals, vitamins and free fatty acid present in the flours are shown in Figure 1. The calcium (55.0 mg/100 g), iron (6.0 mg/100 g), phosphate (70  $\mu$ g/100 g),  $\beta$  carotene (370  $\mu$ g/100 g) and ascorbic acid (17.3 mg/100 g) contents of YFP were significantly ( $p < 0.05$ ) higher than the corresponding values of 45.0 mg/100 g, 5.0 mg/100 g, 65.0  $\mu$ g/100 g, 355  $\mu$ g/100 g and 16.1 mg/100 g for CFP. However, the free fatty acid content of CFP (8.00 mgKOH) was significantly ( $p < 0.05$ ) higher than the value (1.00 mgKOH)

Table 2. Functional properties of flours

Sample (Percentage of Sweet potato)	Bulk density (g/cm <sup>3</sup> )	Least gelation (%)	Water absorption (%)	Oil absorption (%)	Emulsifying capacity (%)
100%CFP	0.683 <sup>a</sup>	14.7 <sup>a</sup>	143 <sup>a</sup>	15.3 <sup>a</sup>	30.5 <sup>b</sup>
70%CFP	0.577 <sup>b</sup>	10.7 <sup>b</sup>	123 <sup>b</sup>	13.3 <sup>a</sup>	29.0 <sup>b</sup>
50%CFP	0.523 <sup>d</sup>	6.6 <sup>c</sup>	130 <sup>b</sup>	14.0 <sup>a</sup>	29.7 <sup>b</sup>
100%YFP	0.586 <sup>b</sup>	16.0 <sup>a</sup>	142 <sup>a</sup>	13.3 <sup>a</sup>	33.3 <sup>ab</sup>
70%YFP	0.556 <sup>bc</sup>	10.6 <sup>b</sup>	128 <sup>b</sup>	13.7 <sup>a</sup>	37.7 <sup>a</sup>
50%YFP	0.537 <sup>cd</sup>	8.0 <sup>c</sup>	139 <sup>a</sup>	14.7 <sup>a</sup>	27.7 <sup>b</sup>
Means	0.577	11.0	134	14.0	31.3

CFP - Cream flesh sweet potato

YFP - Yellow flesh sweet potato

Means followed with the same superscripts along the column are not significantly (p &gt; 0.05) different

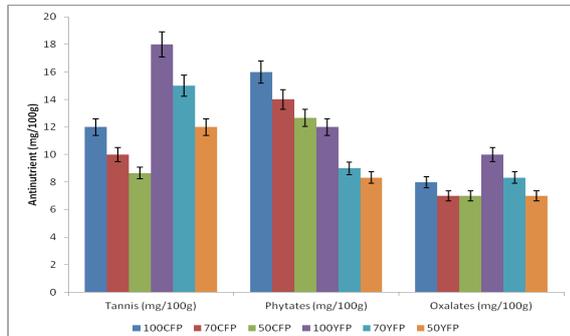


Figure 2. Anti nutritional properties of the blends of sweet potato and maize flours

for YFP. Both sweet potato varieties were high in vitamin c and  $\beta$ -carotene. The values obtained were in agreement with findings of Bittenbender and Kelly (1988). The calcium and iron contents in the blends increased with increase in amount of maize flour for both varieties of sweet potato used, while phosphate,  $\beta$  carotene and ascorbic acid contents decreased with increase in the level of substitution with maize flour.

#### Anti-nutrients

The anti-nutritional properties of the blends are presented in Figure 2. The tannin and oxalate contents of the yellow flesh sweet potatoes were significantly ( $p < 0.05$ ) higher than the values for cream flesh sweet potato. However, the phytates content (16.0 mg/100 g) of CFP was significantly ( $p < 0.05$ ) higher than 12.0 mg/100 g detected in sample YFP. The tannin, phytates and oxalate contents of both varieties of sweet potato decreased with increase in the amount of maize flour in the blends. There were significant ( $p < 0.05$ ) differences among the sample' means. Abubakar *et al.* (2010) reported values of 0.86, 167.2 and 0.68 mg/100 g for phytates, oxalates and tannins respectively for boiled sweet potato. Phytates in foods was reported to possess beneficial effects as it contains antioxidants that eliminate free radicals from the body system (Pamplona-Roger, 2006). Proper cooking before consumption was reported to significantly reduce the total oxalates and tannins in foods (Akwaowo *et al.*, 2000).

#### Functional properties of the blends

The functional properties of the sweet potato

Table 3. Organoleptic Properties of Sweet Potatoes Snacks

Sample	Appearance	Taste	Mouth feel	Overall Acceptability
100%CFP	6.13 $\pm$ 1.99 <sup>b</sup>	5.73 $\pm$ 1.99 <sup>c</sup>	5.60 $\pm$ 1.88 <sup>b</sup>	6.03 $\pm$ 1.60 <sup>b</sup>
70%CFP	7.63 $\pm$ 1.93 <sup>a</sup>	7.30 $\pm$ 2.43 <sup>a</sup>	7.63 $\pm$ 2.14 <sup>a</sup>	6.93 $\pm$ 1.92 <sup>ab</sup>
50%CFP	7.00 $\pm$ 1.62 <sup>ab</sup>	7.17 $\pm$ 1.48 <sup>ab</sup>	6.87 $\pm$ 1.32 <sup>ab</sup>	6.93 $\pm$ 1.79 <sup>ab</sup>
100%YFP	6.77 $\pm$ 2.07 <sup>ab</sup>	6.53 $\pm$ 2.04 <sup>b</sup>	6.40 $\pm$ 1.85 <sup>b</sup>	6.93 $\pm$ 1.74 <sup>ab</sup>
70%YFP	7.13 $\pm$ 1.77 <sup>ab</sup>	7.50 $\pm$ 1.87 <sup>a</sup>	7.07 $\pm$ 1.60 <sup>a</sup>	7.33 $\pm$ 1.57 <sup>a</sup>
50%YFP	7.47 $\pm$ 1.71 <sup>a</sup>	7.37 $\pm$ 1.40 <sup>a</sup>	7.80 $\pm$ 1.78 <sup>a</sup>	7.70 $\pm$ 2.05 <sup>a</sup>

CFP - Cream flesh sweet potato

YFP - Yellow flesh sweet potato

Means followed with the same letters along the column are not significantly (p &gt; 0.05) different.

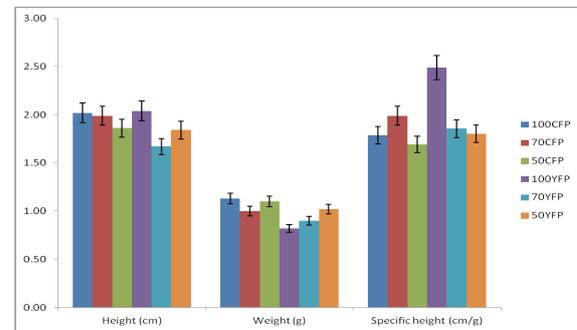


Figure 3. Physical properties of the baked snacks from blends of sweet potato and maize flours

flours and blends of sweet potato and maize flours are presented in Table 2. Bulk density (0.683 g/cm<sup>3</sup>), water absorption capacity (143%) and oil absorption capacity (15.3%) were highest for 100% CFP. Bulk density, least gelation, water absorption and emulsifying capacities were all significantly ( $p < 0.05$ ) decreased with increase in amount of maize flour in the blends. The high bulk density of sweet potato flours has been attributed to high enzyme activity of sweet potato (Manlan *et al.*, 1985). Similarly, least gelation capacity values decreased significantly ( $p < 0.05$ ) with increase in the level of substitution of sweet potato flour with maize flour. Sweet potato alone had higher water absorption capacity than the blends of sweet potato and maize flours. This observation may be attributed to higher carbohydrate and low protein contents of sweet potato compared to maize flour as reported by Iwe and Onuh (1992). Both sweet potatoes had high water absorption capacities with no significant ( $p > 0.05$ ) variation. This may be due to milling process which results in starch damage. The oil absorption and emulsion capacities were not significantly ( $p > 0.05$ ) different among the samples' means. Sathe and Diphase (1981) reported that emulsification may be due to the globular nature of the major protein. Since sweet potato flour has low protein content, it will consequently have low globular protein content.

#### Physical properties of sweet potatoes snack

The weight of the sweet potatoes snack that were made with sweet potatoes flour and maize flour (Figure 3) ranged from 0.82 g to 1.13 g while the 100% yellow fleshed variety was the lowest. The

results of the height of the snacks showed that 100% yellow fleshed variety had the highest height value of 2.04 cm. The snack's height decreased with addition of maize flour to sweet potato flour. The values for specific height of the snacks were significantly ( $p < 0.05$ ) different among the samples' means.

#### Sensory attributes

The sensory evaluation scores for the snacks in Table 3 showed that there were significant ( $P < 0.05$ ) differences in snack samples for all sensory attributes evaluated. Addition of maize flour enhanced sensory attributes of both sweet potato varieties. All the samples were scored within acceptable limits except for the 100% cream-flesh sweet potato snack that was scored lowest in all attributes. The yellow-flesh sweet potato snacks were comparatively scored better than the corresponding cream-flesh sweet potato snacks in all sensory attributes. These observations can be attributed to the prevailing yellow colour imparted by the carotenoid content of the sweet potato variety.

#### Conclusion

It could be inferred from this study that acceptable crunchy snacks can be prepared from sweet potato and maize flours. Both varieties of sweet potato are suitable for making snacks without much significant change in the organoleptic characteristics of the product. Addition of maize flour resulted in increased crude protein and better overall acceptance of the snacks. The most acceptable snack was produced from 50% maize flour substitution of yellow variety of sweet potato.

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