Diversification of Sweet Potato Blends and Utilization for Malnutrition and Poverty Alleviation

A. A. Ladele, N. T. Meludu, O. Ezekiel, T. F. Olaoye, O. M. Okanlawon

***Abstract*—**Value addition to agricultural produce is of possible potential in reducing poverty, improving food security and malnutrition, therefore the need to develop small and micro-enterprises of sweet potato production.

A study was carried out in Nigeria to determine the acceptability of blends sweet potato (*Ipomea batatas*) and commodities yellow maize (*Zea mays*), millet (Pennisetum glaucum), soybean (*Glycine max*), bambara groundnut (*Vigna subterranean*), guinea corn (*Sorghum vulgare*), wheat (*Triticum aestivum*), and roselle (*Hibiscus sabdariffa*) through sensory evaluation.

Sweet potato (*Ipomea batatas*) roots were processed using two methods: oven and sun drying. The blends were also assessed in terms of functional, chemical and color properties.

Most acceptable blends include BAW (80:20 of sweet potato/wheat), BBC (80:20 of sweet potato/guinea corn), AAB (60:40 of sweet potato/guinea corn), YTE (100% soybean), TYG (100% sweet potato), KTN (100% wheat flour), XGP (80:20 of sweet potato/soybean), XAX (60:40 of sweet potato/wheat), LSS (100% Roselle), CHK (100% Guinea corn), and ABC (60:40% of sweet potato/ yellow maize). In addition, carried out chemical analysis revealed that sweet potato has high percentage of vitamins A and C, potassium (K), manganese (Mn), calcium (Ca), magnesium (Mg) and iron (Fe) and fibre content. There is also an increase of vitamin A and Iron in the blended products.

***Keywords*—**Blends, diversification, sensory evaluation, sweet potato, utilization.

I. Introduction

SWEET potato (*Ipomoea batatas*) is a crop of considerable potential and widely grown in Nigeria. It is reported by [1] to be rich in carbohydrates, vitamin A and C as well as contain a significant amount of calcium and iron. Although sweet potato has not gained as much popularity as other staple crops, it is reported to be the world's seventh most important food crop after wheat, rice, maize, potato, barley and cassava [2]. Reference [3] reports major constraints to its increased production and utilization in Nigeria as including lack of industrial or village-level processing of the crop and low levels of commercialization. There appears to be a disjoint between the producers, traders and consumption by end users. A misconception for some persons is that for the crop to be so sweet, it must translate to poor health.

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The desirable nutritional value of *Ipomoea batatas* is gaining recognition, as the understanding between diet and health increases. Health fad diets recognize that sweet potato has a high satiety factor' which might be as a result of the high fibre. Various parts of the crop have been reported to contain both organic and mineral nutrients including vitamins A and C, zinc, potassium (K), sodium, manganese, calcium (Ca), magnesium (Mg) and iron (Fe) [4], [5]. Reference [6] posits that sweet potato should be considered as the future food crop which can be used to alleviate poverty and goes further to suggest that the production of sweet potato can match the consumption of rice and therefore rule out importation of rice therefore reducing food shortage and overcoming hunger. Why Sweet potato is not popular in the diet of developing countries can be seen as puzzle with the population preference for processed rice which [6] quoted, "We need to educate people that sweet potato as food is just as good or even better, as any other food sources. Materials grown in the tropics include cereals (maize, sorghum and millet), starchy tubers (cassava, sweet potato and yam), while oil seeds (soybean, bean seed/cowpea and groundnut) can be used as protein quality improvers. Reference [7] states that the diet of an average Nigerian consists of foods that are mostly carbohydrate based, there is a need for strategic use of inexpensive high protein resources that complement the amino acid profile of the staple diet in order to enhance their nutritive value. Most cereals are limited in essential amino acids such as threonine and tryptophan but rich in essential amino acid particularly the Sulphur amino acids. Thus a combination of such food stuffs will improve the nutritional value of the resulting blend that will make it better compared to the individual components alone [8].

The enrichment of bread and other cereal based confections with legume flours particularly in regions where protein utilization is inadequate has long been recognized. This is because legumes are high in minerals like protein, vitamins B and lysine, an essential limiting amino acid in most cereals [9]. Legumes can therefore complement cereals when blended at optimum ratio [10]. Supplementation of cereals with locally available legumes rich in protein although, often limiting in sulphur amino acids, increases the protein content of cereal-legume blends and their protein quality through mutual complementation of their individual amino acids [11]. These meals are usually prepared as thick porridges such as liquid gruels for adults or as pap for infants, with a drink reported by [12]. For long and easy storage, these commodities are usually processed as flours and important applications include gruels, baked foods, drinks and dough. These flours have their properties that are important in food application systems to ensure wide utilization such as functional properties. Substitution levels are determined and such blends in definite proportions increase utilization of certain crops, increase nutritional content and enable better properties of flours. The suitability of cereals, oil seed and legumes blend meals for human consumption has been extensively reviewed, Reports have studied several nutritional blends [13] but not as varied as the use of sweet potato in conjunction with several commodities yellow maize (*Zea mays*), millet (*Pennisetum glaucum*), soybean (*Glycine max*), bambara groundnut (*Vigna subterranean*), guinea corn (*Sorghum vulgare*), wheat (*Triticum aestivum*), and roselle (*Hibiscus sabdariffa*).

a. The objectives of the project were to:
- Educate local communities on the processing of sweet potato flours in order to reduce waste from unprocessed sweet potato crop.
- Develop blends of Sweet potato with yellow maize, millet, soybean, bambara groundnut, guinea corn, wheat and roselle.
- Evaluate functional properties, color properties, and carry out a sensory evaluation of gruel made from the blends.
- Determine the nutritional composition contents of blends.

b. Justification
- Value addition to the crop thereby increasing earnings for farmers.
- Increased awareness of the importance of diversification of crops as a way to solve hidden hunger and reduce food insecurity.
- The provision of nutritious cereal with higher protein content and low sugar content due to the natural sugar present in sweet potato.
- Bridging the gap between the processors and end users.

II. Materials and Methods

A. Source of Material

The main commodity sweet potato (*Ipomea batatas*) was obtained from Bodija market with other commodities yellow maize (*Zea mays*), millet (*Pennisetum glaucum*), soybean (*glycine max*), bambara groundnut (*Vigna subterranean*), guinea corn (*Sorghum vulgare*), roselle (*Hibiscus sabdariffa*) and wheat (*Triticum aestivum*).

B. Processing of Sweet Potato Flour

In processing the sweet potato flour, two methods were employed. The first method involved the use of a fabricated gas powered cabinet dryer to dry sulphited chips and the second method was the use of traditional sun drying method without the addition of chemical as shown in flow diagram 1 and 2 respectively. The flow diagram in Fig. 1 shows the flow process for production of sweet potato flour. Fresh sweet potato roots (*Ipomea batatas)* were first cleaned to remove excess dirt, after the roots were washed in clean water. The cleaned roots were then peeled by hand and placed in a container as with sufficient water to cover the roots in order to prevent enzymatic discoloration of the roots. The roots were processed into chips using manual graters. Slices were about 1.2 mm ± 0.2 in thickness and 30 ± 5 mm in diameter. A solution was made of sodium metabisuphite by dissolving 80 g of the substance in 40 L clean water. The chips were then sulphited in the solution for 10 minutes and after lay out on perforated aluminum trays to drain for removal of excess water. The gas drier was lit and allowed to equilibrate to desired temperature of 50°C. The trays were placed in the drier and left to dry for about 24 hours in total. Subsequently, the dried chips were milled and stored in air tight, high density polyethylene bags.

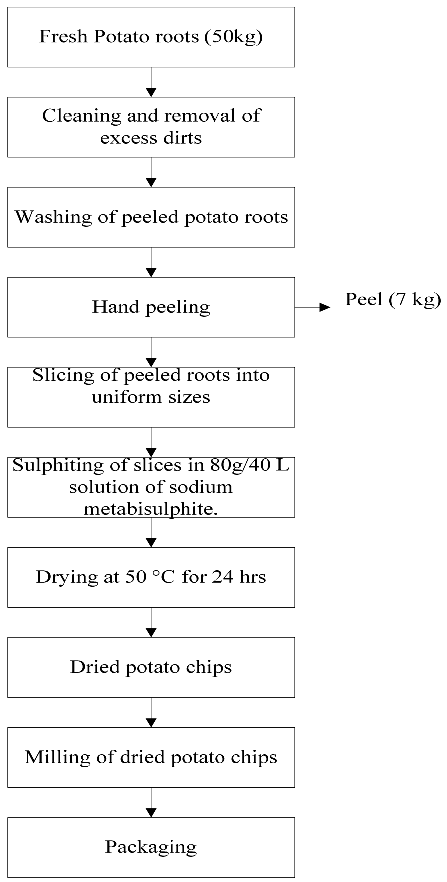

Fig. 1 Flow chart showing the processing of sweet potato flour using gas drier

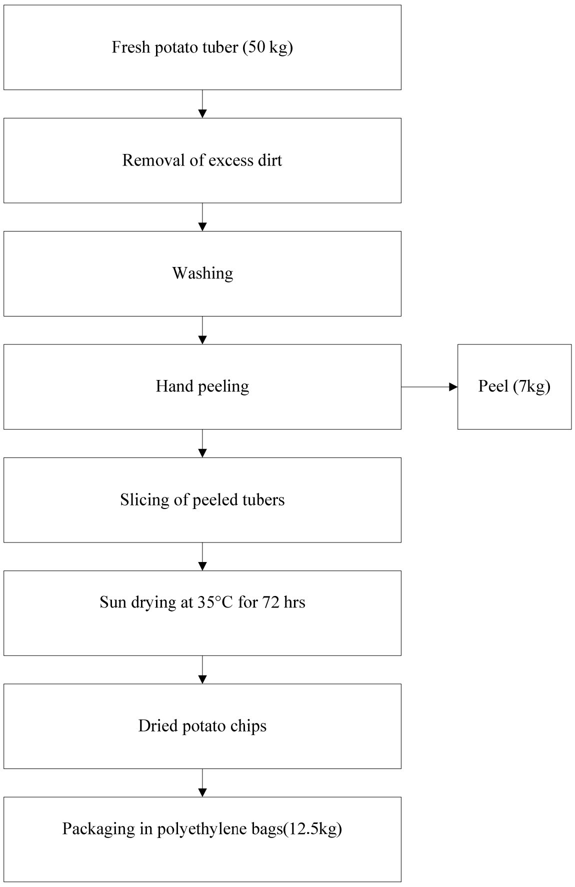

Fig. 2 Flow chart showing the processing of sweet potato flour by sun drying

Fig. 2 shows the process of production of sun dried sweet potato chips without suphiting. Sweet potato slices were placed on perforated trays to drain before drying as shown Fig. 2. Similar primary processes were used as described previously, apart from the method of drying. In addition, processing under water was used to prevent discoloration instead of the use of sulphite solution. In order to sundry the chips successfully; a high-lying ground on a northern slope was used as the drying area. Drying was done under hygienic condition with minimal contamination to product.

C. Preparation of Blends

Other commodities were cleaned, sorted, and milled. Samples were obtained: 100% each of commodities sweet potato (*Ipomea batatas*), yellow maize (*Zea mays*), millet, soybean, bambara groundnut, guinea corn and wheat. In addition mixes were prepared X: Y= 80:20 and X: Y =60:40 where X represents sweet potato flour and Y represents each commodity: yellow maize, millet, soybean, bambara groundnut, guinea corn, roselle and wheat to obtain a total of 22 samples.

D. Sensory Evaluation

Samples were prepared with hot water and a questionnaire presented to a group of panelist to assess the samples in terms of colour, taste/sweetness, mouth feel, thickness, viscosity, smoothness, appearance, and aroma. These variables were used to assess the general acceptability of the product blends by the producers (farmers) and consumers. The sensory evaluation was carried out on both the producers at Ganmo, Kwara State and Ibadan and on consumers in Kwara State and the University of Ibadan to determine the most accepted product blend.

E. Functional Properties

1) Loose and Packed Bulk Densities

The method described by [14] was used in determination of bulk density of the flours. A 100 ml measuring cylinder was filled up to the 100 ml mark. The weight of the content was determined by weighing the cylinder before filling and after filling. The cylinder was then tapped therefore making the content compact. The volume after tapping was recorded. Loose bulk density = Weight of sample (g) /100 (mL). Packed bulk density = Weight of sample (g)/ Volume after tapping (mL).

2) Water and Oil Adsorption Capacity

Water adsorption capacity (WAC) and Oil adsorption capacity (OAC) of the flours were determined following methods of [15]. One gram of starch sample was mixed with 10 ml of distilled water or refined soybean oil (sp. gravity 0.9047). The mixture was allowed to stand at 30 ± 2^0C for 30 min and then centrifuged (K241R, Benchop centrifuges, Centurion Scientific,UK.) at 2000g for 30 min. Water absorption capacity and Oil absorption capacity is expressed as gram of water or Oil bound per 100 gram of dry flour.

3) Least Gelation Concentration (LGC)

The modified method of [16] was employed. Sample suspensions of 2, 4, 6, 8, 10, 12, 14 and 20% (w/v) were prepared by accurately weighing 0.1g, 0.2g, 0.3g, 0.4g, 0.5g, 0.6g 0.7g, and 1g respectively, each in 5 ml distilled water in test tubes. The test tubes containing these suspensions were then heated for 1 h at 80^{o}C in a water bath without shaking, followed by rapid cooling under a running cold tap water. The test tubes were further cooled to 4^{o}C for 2 h. LGC (% w/v) was determined as the concentration when sample from the inverted tube did not fall down or slip.

F. Protein Content

1) Determination of Crude Protein

The crude protein content of the sample was determined by [17]. The sample (1g) was weighed into the kjedahl flask, 12ml of concentrated H_2SO_4 was added to the sample in the flask, with the addition of two tablets of catalyst. The flask was placed in the kjedahl digester and heated until its content became clear and then cooled. This was transferred to the neutralization and distillation chamber of the kjedahl apparatus, where it was neutralized and distilled with 40% NaOH solution for about four minutes. The distillate was titrated with standardized HCl (0.1N), using two to three drops of indicator until the blue grey end point was achieved. The reference used for crude protein determination was also used for the validation and laboratory quality assurance.

$$\%\ \text{Kjedahl Nitrogen} = \frac{(\text{Vs} - \text{Vb}) \times \text{C} \times 1.4007}{\text{W}}$$

$$\%\ \text{Crude Protein} = \%\ \text{KjedahlnNitrogen} \times \text{F}$$

where; Vs = titre value; Vb = titre value of the blank determination; C = Concentration of acid (0.1N HCl); W = Weight of sample (grams); F = factor to convert nitrogen to protein (6.25).

G. Vitamin C determination

Vitamin C was determined in triplicates using UV/VIS Spectrophotometer as adopted from [18].

H. Iron determination

Iron content was determined using the method of digestion and Flame Atomic Absorption of material as described by [19].

I. Color Determination (Lab)

A colorimeter was used to measure the color parameters of the samples using Hunter lab color standards, by placing at different locations, and the average determined [20]. The parameters recorded were L, a and b coordinates of the CIE scale. **L* (lightness) axis – 0 is black, while 100 is white; **a* (red-green) axis – positive values are red while negative values are green and 0 is neutral; **b* (yellow-blue) axis – positive values are yellow, while negative values are blue and 0 is neutral.

J. Statistical Analysis

One way analysis of variance (ANOVA) was conducted on each of the variables and the post hoc test (DUNCAN) test at a significance level $P<0.05$ was performed using SPSS 17 (software for windows) to compare means. Results were expressed as the means ±standard deviation

III. Result and Discussion

The study reveals that LSS (100% Roselle), TPS (80:20% of sweet potato zobo blend), KTS (60:40% of sweet potato/zobo blend), AAB (60:40% of sweet potato/guinea corn), CIO (100% yellow maize), BBC (80:20% 0f sweet potato/guinea corn), CHK (100% Guinea corn), ABD (80:20% of sweet potato/yellow maize), KTN (60;40% of sweet potato/roselle) and BAW (80:20% of sweet potato/wheat) were the most accepted samples based on colour. BBC (80:20% of sweet potato/guinea corn), ABD(80:20% of sweet potato/yellow maize), XTY(60:40% of sweet potato/millet), TYG (100% sweet potato), BAW(80:20% of sweet potato/wheat), XGP(80:20% of sweet potato/soybean) and XAX(60:40% of sweet potato/wheat) were the most accepted samples based on mouthfeel.

IV. Conclusion

The study showed that blending sweet potato flour (TYG) with other flour blends like wheat flour, soybean, millet flour, yellow maize flour, guinea corn flour, bambara nut flour, zobo flour had significant effect on the functional and nutritional properties of the flour blends. Blending TYG with the cereals with up to 60% level produced samples can be used for production of gruels for babies and adults, beverages, bakery goods with improved functional properties. This will reduce malnutrition and also enhance the income of sweet potato producer.

V. Recommendation

It is therefore recommended that:

- Value addition of Farm produce should be encouraged to improve the shelf life of such farm produce as well as increase farmers' income to improve their livelihood and at the same time develop the producing communities
- More awareness should be made for producers and consumers on the nutritional and health benefits of consuming blends of diversified products to derive additional nutrients, hence, improving healthy living

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