Performance and Acceptability of Legume-Fortified Yam Flours

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Abstract
Yam (*Dioscorea*sp.) is an annual climbing plant with edible underground tubers which is a major staple of many African and Asian countries. About 52 million tonnes of yam was produced globally in 2007, with 96% from West African (IITA, 2009). Yam has the highest calories provided per hectare when compared with other starchy tubers such as cassava and potatoes. Yam is rich in carbohydrates, dietary fibre and some minerals. Yams are usually consumed boiled, roasted, fried or pounded. The tubers are stored in-between harvests for later use which is characterized by changes in wholesomeness which may result from poor handling, wound repair, diseases, and pests infestations. Also due to its high moisture content (50- 80%), large size, and high respiration rates, it is highly perishable. Hence yam tubers are lost after 4-5 months of storage, thus causing a yearly cycle of huge post- harvest losses. In Ghana, post- harvest losses of yam have been reported to range from 10% to 50%. Although West Africa produces about 94% of the world's yam, yams have not been processed to any significant extent commercially**.** However due to similarity in composition of yam to crops like potato,yams could be processed into ready to eat foods like chips, crisps flakes and fries to increase their commercial value. They can also be processed into flours for instant foods (e.g. porridge, *fufu, mpotonpoton (*yam porridge that is spiced with palm oil added*)*). Fortifying yam flours with legumes such as soyabean and cowpeas could further enhance their commercial value as the fortified products could be used for complementary feeding. This study therefore developed legume-fortified yam flours to enhance their nutritional level as well as extend the shelf-life of yam. The results showed that the blends were acceptable to trained sensory panellists at baseline and also at six months. The products were also nutritionally enhanced, and could therefore be used for complementary feeding.
Keywords: Yams, Post-harvest Losses, Value-addition, Legume-fortified flours

1. Introduction

Yam (*Dioscorea*sp.) is an annual climbing plant with edible underground tubers (Aidoo, 2009). They are major staple tubers grown in most African and Asian countries. About 52 million tonnes of yam were produced globally in 2007, with 96% from West African (IITA, 2009). It is number one in calories provided per hectare per season when compared with other starchy tubers such as cassava and potatoes (Noamesi, 2008). Yam is rich in carbohydrates, dietary fibre and some minerals (Kouassi *et al*, 2010;Wanasundera and Ravindran, 1994). Many varieties of yam are cultivated; some of the commercially important ones in Ghana include *D. rotundata* (white yam) and *D. alata* (water yam) and *D. cayenensis* (yellow yam) (Aidoo, 2009).
Yams are usually consumed boiled, roasted, fried or pounded. The tubers are stored in- between harvests for later use which is characterized by changes in wholesomeness. These changes result from poor handling, wound repair, diseases, and pests infestations. Also due to its high moisture content (50- 80%), large size, and high respiration rates, it is highly perishable. (FAO,1998) Hence yam tubers are lost after 4-5 months of storage, thus causing a yearly cycle of huge post- harvest losses. In Ghana, post- harvest losses of yam have been reported to range from 10 to 50% (Muck, 1974; Alhassan, 1994).
Although West Africa produces about 94% of the world's yam, yams have not been processed to any significant extent commercially. However due to similarity in composition of yam to crops like potato, yams can be processed into ready to eat foods like chips, crisps, flakes and fries to increase their commercial value. They can also be processed into flours for porridge, *fufu,* pastries and bread etc. Yam is relatively low in protein (2.1%) and other essential nutrients. Other crops like cowpea (25% protein), soybean (40% protein) and groundnut (25% protein) richer in protein and minerals can be added to yam to improve its nutritional value and improve versatility of its flour. In addition, flours could be stored over longer periods and thus reduce the post-harvest losses in yam production.
This research therefore sought to explore other uses of yam by making composite flours from soybean and cowpea for instant foods, and to study the shelf-life of the flours.

2. Materials and Methods

2.1 Materials

Yam (*Dioscoreasp*), cowpea (*Vignaunguiculata*), soybean (*Glycine max*), hammer mill, dryer and knives.

2.2 Methods

2.2.1 Production of yam flour

White yam was bought from Agbogbloshie yam market in Accra, Ghana. The yam was washed, truncated at the extreme ends, peeled, sliced and boiled for 30 minutes. It was then drained and mashed. The mashed yam was dried in a mechanical (electric) dryer at 55˚C for 12 hours. The dried yam was milled into flour with a hardened steel hammer mill.

2.2.2 Production of soy flour

Soybeans were bought from Nima market in Accra, Ghana. They were sorted to remove bad grains, stones, chaff and other foreign materials. The sorted soybeans were then soaked in water at room temperature for 30 minutes and drained. The beans were boiled for 90 minutes with minimal water and then dried in a mechanical dryer at 55˚C for 12 hours. After drying, the soybeans were dehulled by crushing and winnowed to remove the chaff. The dehulled soybeans were milled into flour using a hardened steel hammer mill.

2.2.3 Production of cowpea flour

Cowpea was bought from Nima market in Accra, Ghana. It was sorted to remove bad grains, stones, chaff and other foreign materials, then washed with water and boiled for 90 minutes. The water was drained and the cowpea dried in a mechanical dryer at 55˚C for 12 hours. The cowpea was dehulled by crushing and winnowed to remove the chaff. It wasthen milled into flour using a hardened steel hammer mill.

2.2.4 Flour formulation and data analysis

The Minitab mixture design was used to generate ten different formulations for the yam composite flour consisting of yam (70% – 80%), soybean (20% - 30 %) and cowpea (20% - 30 %) flour. The minitab software was used to generate the order of sample presentation during the sensory evaluation. Instant porridge was prepared from the flours by mixing with freshly boiled water, and adding sugar to taste

Sixty (60) panelists were used to evaluate the ten different yam porridge samples for acceptability using a 7 point hedonic scale. Each panelist was presented with four samples and the following attributes and their level of intensity evaluated: colour, uniformity, texture, aroma, taste and acceptability.

Two of the most preferred yam samples by the panelists were analyzed for their nutritional value.

2.2.5 Proximate analysis

The moisture content of the yam samples was determined using AOAC (1990). The ash content was determined using AOAC (2000). Crude protein content of the samples was determined using Khedahl method (AOAC, 1990)). Fat content was determined using AOAC (2000). Carbohydrate was determined by difference (100-summation of protein, moisture, ash and fat). Energy was measured by the Atwater factor. Ash content was determined using AOAC method (2000).

2.2.6 Free fatty acid and peroxide value determination

Free fatty acid was measured using ISO 660 (1996-05-05). Peroxide value was measured using a method by Cocks and Van Rede (1966)

2.2.7 Water Activity

Water activity was measured using Multichannel Humidity Water Activity Analyser

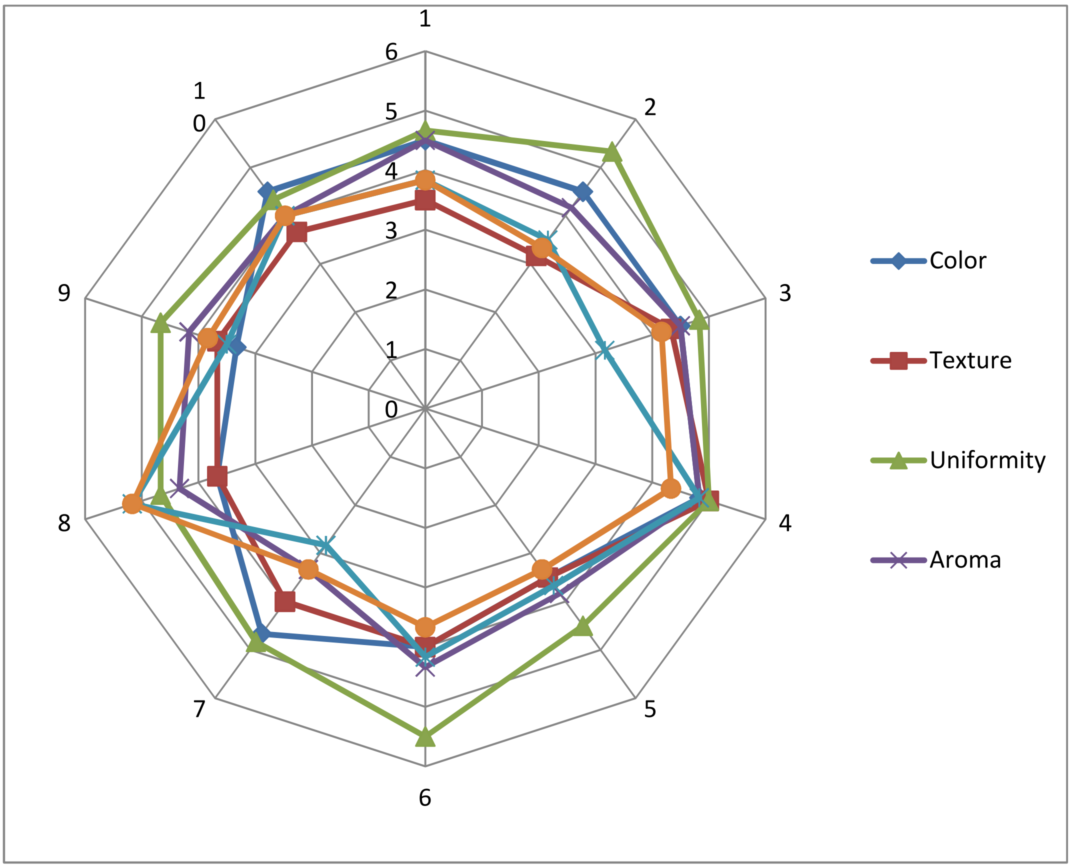
2.2.8 Statistical Analysis

The Statistical Analysis Software (SAS) version 9.1.3 (Carey, NC, USA) was used for all statistical analysis. The effects of various constituents on the sensory attributes of the porridge were determined using analysis of variance (ANOVA). Where there were significant effects ($p \leq 0.05$) of a factor, Duncan's multiple range tests was used to determine the differences.

3. Results and Discussion

The sensory evaluation results of the composite flours are shown in Figure 1

Figure 1: Acceptability of yam porridge by panelists



It was observed that the yam samples made into porridge was generally accepted by the consumers although it is not the usual starch component used in making porridge. Samples low in cowpea were most preferred (taste and overall acceptability). This observation could be attributed to the beany flavour characteristic of cowpea. Where the lines representing the various attributes are closer, it shows an almost equal level of acceptance. The nearer the lines are to the edge, the more the attributes they represent are preferred. Thus uniformity was the attribute that was most preferred.

Table 1: Chemical and Microbial analytical values of yam composite flours

Parameter	Sample A		
Time/months	0	3	6
Moisture (g/100g)	3.86±0.08	4.01±0.14	4.20±0.00
Ash (g/100g)*	2.99±0.16	2.61±0.14	2.54±0.05
Fat (g/100g)	1.86±0.16	2.0±0.01	2.14±0.05
Protein (g/100g)*	8.99±0.01	8.96±0.03	8.43±0.14
Carbohydrate {g/100g (including fibre)}*	82.22±0.01	82.34±0.01	82.73±0.00
Energy (Kcal/100g)*	381.90±0.00	382.30±0.06	383.50±0.03
Peroxide (Meg of O2/kg fat)	11.76±0.05	13.90±1.23	21.61±0.12
Free Fatty Acid (as oleic acid) g/100g	1.87±0.39	1.5±0.02	1.20±0.01
Aflatoxin (ng/g)	0	0	0
Water Activity*	0.329/29.0°C	0.336/27.8°C	0.444/27.2°C
pH	6.19±0.00	6.10±0.03	5.99±0.01
Mould and Yeast Count (cfu/g)	15	21	17

Sample A 8:1:1 of yam : soybean : cowpea

Asteriks (*) indicate significant differences between values

Table 2: Chemical and Microbial analytical values of yam composite flours

Parameter	Sample B		
Time/months	0	3	6
Moisture (g/100g)*	4.10±0.11	4.31±0.06	4.51±0.06
Ash (g/100g)	3.21±0.01	3.05±0.01	2.95±0.03
Fat (g/100g)*	4.52±0.33	4.60±0.03	4.95±0.13
Protein (g/100g)*	14.74±0.00	14.71±0.01	13.88±0.00
Carbohydrate {g/100g (including fibre)}	73.45±0.08	73.47±0.02	73.57±0.02
Energy (Kcal/100g*	383.31±0.01	393.20±0.01	393.91±0.01
Peroxide (Meg of O2/kg fat)*	15.33±0.16	16.10±0.01	17.56±0.83
Free Fatty Acid (as oleic acid) g/100g	1.09±0.18	0.92±0.04	0.81±0.01
Aflatoxinng/g	0	0	0
Water Activity	0.385/29.0˚C	0.393/27.8˚C	0.451/27.2˚C
pH	6.29±0.00	6.15±0.05	6.01±0.02
Mould and Yeast Count (cfu/g)	45	37	43

Sample B 6.33:2.33:1.34 yam : soybean : cowpea

Asteriks (*) indicate significant differences between values

It was observed that there was an increase in the nutritional value of the yam samples when soybean and cowpea were added. Yam has protein content of about 2.1g (FAO, 1990), therefore increase in protein content to over 8g/100g due to the addition of soybean and cowpea which are high protein foods is very encouraging. This may increase the usage of yam composite flour.

The energy value of sample B was higher than sample A. This can be due to high fat content of sample B due to its higher proportion of soybean, which is richer in fat (18%)as compared to cowpea (1.9%) (Karr-Lolienthal*et al*, 2005; Davis *et al*, 1991); the fat has contributed to the energy value. These increases in the nutritional value of yam samples make them suitable for other food uses like complementary foods especially for children.

The flours were packaged in polythene and left on the shelf for six months. Though significant differences were observed between some of the chemical parameters at baseline and at six months, such as the peroxide value in sample B, this was not reflected in the sensory results as the samples were acceptable to the panelists. There was no complaint of rancidity in the samples. Furthermore, the significant increases in moisture and water activity could not adversely affect the products because the moisture levels were far below the level of 7.5% acceptable for many flours. The water activity values were also well below one (1) at six months and are therefore acceptable. Significant differences in protein could be due to changes in the moisture level over time as it has an inverse relationship with changes in moisture content.The results thus showed that the production of yam flours could be a very good tool for preventing post-harvest losses of yams, and could thus improve the income levels of both farmers and marketers.

Malomo *et al*, (2012) also substituted different levels of soybean flour into yam flour and obtained nutritionally-enriched dough with improved rheological and functional properties. They concluded that the flour could help in the reduction of malnutrition in sub-Saharan Africa**.** Ukpabi (2010) found out that even a lesser used yam specie (*Dioscorea esculenta*) when combined with wheat flour at the ratio of 80:20 w/w (wheat- yam) could be used for the production of bread that is comparable to those made with solely wheat flour in Nigeria.

Kadam *et a*l., (2012) developed and evaluated composite flours from yam, soybean and chickpeas and found that the soybean and chickpea increased the protein content of the flours; they also reported that the flours could be packaged in polythene or boxes and stored for three months without deterioration in quality. Eke-Ejiofor and Owuno (2012) studied the functional and pasting properties of **wheat- three-leaved yam** ***(Dioscorea dumentorum*****) composite flour blend.** Their study showed that compositing the popular wheat flour with a locally available under-utilized root crop like three-leaved yam flour is desirable in terms of functional, pasting and chemical characteristics. De Buckle (2009) applied MEPS (methodology for assessing and programming production ‑ consumption systems,) to assess the programming systems of the five Andean Pact countries. She compared the five country programmes against a 5-year projection of the existing wheat system (based on 90% to 100% imported wheat), and indicated that the implementation of the programmes would promote the incorporation of 700,000 new hectares for the local production of grains (wheat, rice, corn, barley, and soybeans) and would generate 51,000 new jobs, US $110 million in value added, and US $100 million in foreign exchange savings.

4. Conclusion

This study indicated that it is feasible to produce wholesome composite yam flour that is nutritionally enhanced and which could stay for six months without deterioration. Adoption of the technology would improve the yam value chain and could lead to increases in yam production, utilization and income generation which could all be translated into poverty reduction and reduction in unemployment. Ghana and other African yam-producing countries could also seriously consider programmes that would increase the production of composite flours.

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