Chemical Composition and Sensory and Pasting Properties of Blends of Maize-African Yam Bean Seed

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Abstract

This study was designed to improve the nutritional content of maize flour by incorporating African yam bean (an underutilized crop with high nutritional value) and to evaluate its effect on the chemical, sensory and pasting properties of the flour blends. Maize and African yam bean seed were processed into flours at ratios 100:0; 80:20; 70:30; 60:40 and 0:100 and used to produce *tuwo*, a maize-based meal, its sensory attributes being evaluated. Chemical and pasting properties of the flour blends were determined. Crude protein (9.61-14.71%), crude fibre (1.34-5.81%), total ash (1.39-2.09%) and sugar (4.11-6.01%) contents increased while fat (4.53-3.94%), amylase (24.18-11.40%), starch (66.66-51.15%) contents and some of the sensory qualities decreased significantly (*p<0.05*) with increasing quantity of African Yam Bean Flour (AYBF). However, 80:20 flour blend showed no significant difference *(p>0.05)* from control sample. Among the pasting parameters, final viscosity and break down viscosity reduced while peak viscosity and trough viscosity increased with increasing quantity of AYBF.

Keywords: African yam bean seed flour, Maize flour, Proximate composition, Pasting properties, Sensory evaluation

Introduction

The problem of malnutrition due to deficiency of protein and calories is common in Nigeria. The protein –calories source of vegetable origin have been proposed as a solution to this problem. Maize *(Zea mays L.)* is commonly used as an inexpensive source of calories in Nigeria and some other countries. Maize is the third most important cereal in the world after rice and wheat and ranks fourth after millet, sorghum and rice in Nigeria [1]. Global statistics for cereal consumption indicate that the average total consumption in the African diet is 291.7g per person per day, including an average maize consumption of 106.2g per person per day [2]. Maize flour is extensively used in making tamales, tortillas, arepas, fry bread and popular Mexican drink and it is also sprinkled in trays to prevent dishes from sticking. In Nigeria, products from maize include: *ogi, tuwo, donkunnu, masa, popcorn, aadun, kokoro*, cooked or boiled maize and roasted maize. Some of these products are made from maize flour, which is rich in carbohydrate but low in protein. These products are widely consumed especially among the low income community thus necessitating its enrichment with an inexpensive quality protein.

African Yam Bean (AYB) (*Sphenostylis stenocarpa*) is a less-utilised tropical legume with high nutritional value. Its protein content is reported to range between 20.2 and 21.2 percent [3]. Amino acid analyses indicate that lysine and methionine levels in the protein are equal to or better than those of soybeans while most of the other essential amino acids correspond to WHO/FAO recommendations [4]. Moreover, AYB has been reported to also have a high crude fibre content [5]. Although it contains anti-nutritional factors such as haemagglutinins, tannins and oligosaccharides [6], processing destroys most of these factors and the processed products do not give serious health problems [7].

Anti-Nutritional Factors (ANF) in leguminous products are chemical substances present in products although non-toxic but generate adverse physiological responses in animals that consume them. In most cases, ANF interferes with the utilization of nutrients in legume products [8]. Some anti-nutritional factors such as alkaloids, flavonoids, saponins, lectin, trypsin inhibitors, phytate and oxalate have been identified in the seeds of AYB [9,10,6]. However, the levels of the various ANF in AYBS were found to be lower than those of cowpea [11]. Apata and Ologhobo [12] reported a complete destruction of trypsin inhibitor and haemaglutinins in some tropical legumes by cooking. Despite the availability and the nutritional importance of this crop, it is still underutilised. AYB has been processed into flour and paste used locally for "*moinmoin"* (cooked paste) and "*akara*" (fried bean balls). Enriching maize flour with nutrient-dense African yam bean will help to alleviate protein-energy malnutrition in Nigeria and some other African countries where maize flour are processed into different forms of food products (e.g. snack foods, cooked paste and fried products). Maize flour, like other cereals, is limiting in lysine and tryptophan, but rich in sulphur-containing amino acids, methionine and cystine, the opposite occurring for AYBF [13]. The protein of the maize flour and African yam bean flour thus complement each other's limiting amino acids. High cost of both animal protein and commonly utilized legumes contribute to protein-energy malnutrition. Therefore, the need for less-utilized legumes that are cheaper and rich in protein cannot be overemphasized in the reduction of protein energy malnutrition. This will also offer wider utilization of AYB, and

offer a better patronage to farmers and industrial producers of AYBF.

Other legumes such as groundnut, soybean, cowpea have been used to improve nutritional contents of maize-based products [14,15]. But there is sparse literature on the utilization of AYB to enrich maize flour. Therefore, the current study was carried out;

(i)   To determine the effect of AYB flour on the chemical and pasting properties of the maize-AYB flour blends with a potential industrial use

(ii)   To evaluate the use of AYB flour in the maize-based meal that is commonly consumed and its consumers' acceptability. The information would contribute to the processing of the maize-AYB flour, thereby improving the utilization of the AYB, creating a novel use for AYB and increasing the nutritional content of food products obtained from the AYB-maize flour blends.

Materials and Methods

Materials

Maize (BR-9928-DMR-SY) was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria while the seeds of two varieties of African yam bean were purchased from a retail market (Umuaiha), Abia state, Nigeria and identified as Tss-9 and Tss-30 at the IITA genetic resource centre.

Sample preparation

Preliminary analysis was carried out on two varieties of AYB and chosen based on their physical features (attachment to the seed coat) as reported by IITA Genetic Resource Centre. The choice of appropriate cultivar of AYB was made by dehulling manually. It was found that seeds having their seed coats loosely attached to the seeds were more easily dehulled than seeds having their seed coats firmly attached. Therefore, choice of appropriate variety of AYB was made based on its intended use. Loosely attached AYB is required for food products that require dehulling to facilitate easy dehulling process. The study was carried out between July-December, 2012.

Maize samples (BR-9928-DMR-SY) were sorted and milled using 750 μm mesh size and packaged in high density (100μm) polyethylene until when needed. AYB (Tss-30) seeds were sorted, weighed, washed and manually dehulled after soaking in water (1:5w/v) for about 4 hr at $29\pm2°C$, and then dried in an oven at $60°C$. The dried seeds was milled in a hammer mill (model ED-5 Thomas Wiley, England) and sieved with 500μm mesh size. Parts of the maize flour were substituted with 0, 20, 30, 40 and 100% of AYBF by weights. Each blend was properly mixed in a mixer to obtain homogenous samples and packaged separately in airtight plastic containers till needed.

Analytical methods

Crude protein, ash, crude fibre and crude fat contents were determined using the methods 920.05, 923.03, 963.09 and 920.85, respectively of AOAC [16]. For mineral analysis, atomic absorption spectrophotometer (Buck Scientific model 200A) was used at different wavelength for each mineral element (Cu-324.8, Zn-213,9, Ca-422.7, Fe-248.3, Mg-285.2, Mn-279.5, Na-589 and K-766.5nm) [17]. Amylose content was determined following the spectrophotometric method of Julianno 1971 [18] using spectrophotometer (Milton Roy Spectronic 601) at 620nm. Sugars and starch were colorimetrically quantified following the method of Abiodun and Akinoso [19].

The pasting profile of flour sample was studied using a Rapid Visco-Analyzer (RVA) (Newport Scientific Pty. Ltd.) with the aid of a thermocline for windows version 1.1software (1998). The RVA was connected to a PC where the pasting properties and curve were recorded directly. Flour suspension was prepared by addition of the equivalent weight of 3g flour to distilled water to make a total of 28g suspension in the RVA sample canister. The heating and cooling cycles were automatically programmed in the following manner. The temperature was kept within $60°C$ to $99°C$ while maintaining a rotation speed of 160rpm. The whole cycle was completed within 13 min. The viscosity was expressed in centipoises (cP). The parameters measured (RVA units) were:

Peak viscosity: highest viscosity during the heating stage

Breakdown viscosity: the difference between the peak viscosity and the minimum viscosity at the end of the heating stage

Setback viscosity: the difference between the maximum viscosity during cooling and the minimum viscosity during heating

Final viscosity: the viscosity at the end of the cooling stage

Pasting temperature ($°C$): this is the temperature at which there is a sharp increase in viscosity of flour suspension after the commencement of the heating stage.

 Peak time (min): time taken for the paste to reach the peak viscosity).

Preparation of maize –AYB meal and sensory evaluation

The flour blends obtained by varying the proportions of AYBF (0, 20, 30 and 40%) with maize flour were used to prepare *tuwo* according to the method described by Aiyeleye and Eleyinmi [20]. *Tuwo* was made from milled maize enriched with AYB flour and reconstituted into thick paste by boiling water. The thick paste, *tuwo* produced was subjected to sensory evaluation. Ten semi-trained panelists were selected from the staff and graduate students of IITA, Ibadan, and screened with respect to their interest and ability to differentiate food sensory properties as described by Iwe Iwe [21]. Sensory evaluation room was well-illuminated and the booths were well partitioned to avoid distraction or interference by other panelists. The samples were rated on the following quality attributes: color, taste, palatability, texture, aroma and overall acceptability using a nine point hedonic scale.

Statistical analysis

All analyses were carried out in triplicate. The mean and

standard deviation of the data obtained were calculated. The data were evaluated for significant differences in their means with analysis of variance (ANOVA) *(p<0.05).* Differences between the means were separated using SAS (version 9.2).

Results and Discussion

Effect of enriching maize flour with African yam bean flour on chemical composition

Table 1 showed chemical composition of flour blends obtained by varying the proportions of AYBF (0, 20, 30 and 40%) with maize flour. Significant *(p<0.05)* increase in protein content (9.61-14.71%) was obtained among the flour blends with increasing quantity of AYBF. The increase in protein content obtained is similar to the report of Alozie et al. [5] for wheat-AYB flour blends. This increase in protein content is attributed to the inclusion of AYBF. This can be due to the fact that AYB has been reported to be nutrient-dense, having high protein content [22]. Okafor and Usman [23] also reported higher protein content with increasing AYBF in the breakfast cereal produced from blend of maize, AYB and defatted coconut. The high protein content of AYBF-MF will be of great importance in reducing protein-energy malnutrition resulting from high cost of animal protein and commonly consumed legumes.

Ash content ranged between 1.39 and 2.73%. This is similar to the values obtained by Amoatey et al. [24] for nutritional composition of the African yam bean compared to some tropical legumes. Significant increase was obtained in the ash contents of the flour blends with increasing quantity of AYBF. The ash contents obtained for the varying proportion of AYBF in maize flour were comparable to the values obtained for Sorghum-AYBF by Okoye et al. [25]. Much higher values were obtained for wheat-AYB flour samples by Alozie et al. [5].

Crude fat content of the flour blends (Table 1) obtained ranged from 4.53% to 2.26%. The value reduced with increasing quantity of AYBF. This may be attributed to low fat content of AYBF reported by earlier authors [24,26]. The significant *(p<0.05)* decrease in fat contents of the flour blends may be of interest to consumers interested in consumption of low fat food products. A similar report was obtained by Ishiwu and Onyeji [27] for instant gruel made from blend of maize starch and African yam bean.

The effect of enriching maize flour with African yam bean flour on the amylose, sugar and starch contents of the MF-AYBF blends are presented in table 2. Amylase and starch contents of the MF-AYBF blend decreased while sugar contents increased significantly *(p<0.05)* with higher quantity of AYBF. Amylose is important because it affects water absorption and textural properties of the flour and the resultant products. It was indicated to affect gelatinization, retrogradation, swelling power and enzymatic susceptibility of starch [28]. The amylose content of the blends reduced significantly from 21.41% (20% AYBF: 80% MF blend) to 14.83% (40% AYBF: 60% MF blend) as the quantity of AYB flour increased. Amylose is the starch fraction which retrogrades more rapidly due to the tendency of the linear molecule to associate rapidly but amylopectin retrogrades slowly. This implies that paste produced from the 20%AYBF: 80% maize flour blend with higher amylose content might retrograde faster than that 60%MF: 40%AYBF with low amylose content. Starch retrogradation gives rise to production of resistant starch that is not very digestible; hence, it is of better functionality as it will produce maize meal with low glycemic index which prevents colon cancer [29].

The mineral compositions of MF-AYBF blends were obtained from author's previous work (Idowu, 2015). Sodium, potassium and calcium were the major minerals in the MF-AYBF

Table 1: Proximate composition (%) of maize and African yam bean blends.

Blends[1]	Crude fat	Crude protein	Crude fibre	Ash
100-MF	4.53±0.20a	9.61±0.41e	1.34±0.04a	1.39±0.01e
20-AYBF	4.17±0.08ab	12.16±0.12d	2.23±0.11b	1.79±0.01d
30-AYBF	3.94±0.11ab	13.72±0.29c	2.68±0.10bc	1.95±0.01c
40-AYBF	3.77±0.07b	14.71±0.04b	3.10±0.15c	2.09±0.03b
100-AYBF	2.26±0.57c	22.73±0.12a	5.81±0.71d	2.73±0.02a

Values with the different letters along the column are significantly different at *p*<0.05v
[1]0%AYBF+100% MF; 20%AYBF+80%MF; 30%AYBF+70%MF; 40%AYBF+60%MF; 100%AYBF+0%MF

Table 2: Amylose, sugar and starch contents (%) of maize and African yam bean blends.

Blends[1]	Amylose	Sugar	Starch
100-MF	24.18±0.16a	4.14±0.04d	66.66±0.65a
20-AYBF	21.41±0.16b	4.11±0.01d	61.97±0.02b
30-AYBF	18.47±0.38c	4.39±0.05c	58.71±0.42c
40-AYBF	14.83±0.32d	5.25±0.09b	54.42±0.38d
100-AYBF	11.40±0.11e	6.01±0.13a	51.15±0.90e

Values with the different letters along the column are significantly different at *p*<0.05
[1]0%AYBF+100% MF; 20%AYBF+80%MF; 30%AYBF+70%MF; 40%AYBF+60%MF; 100%AYBF+0%MF

Table 3: Mineral composition of maize and African yam bean blends. (Adapted from (Idowu, 2015))

	Ca	Mg	K	Na	Mn	Fe	Cu	Zn
Blends[1]	(%)	(%)	(%)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
0%AYBF	0.49c	0.12c	0.56d	8.24d	12.02d	31.84c	0.35c	9.16a
20%AYBF	0.55b	0.15b	0.84c	39.23c	16.08c	32.01c	0.88b	9.67a
30%AYBF	0.58b	0.17b	0.93b	56.40b	16.08c	32.02c	0.88b	10.12a
40%AYBF	0.62b	0.16b	0.98b	62.37b	17.34b	47.87a	0.88b	9.41a
100%AYBF	0.74a	0.21a	1.41a	144.78a	21.20a	38.07b	2.42a	8.90a

Values with the different letters along the column are significantly different at *p<0.05*
[1]0%AYBF+100% MF; 20%AYBF+80%MF; 30%AYBF+70%MF; 40%AYBF+60%MF; 100%AYBF+0%MF

Table 4: Pasting properties of maize and African yam bean blends.

Blends[1]	Peak viscosity (cP)	Trough1 viscosity (cP)	Breakdown viscosity (cP)	Final viscosity (cP)	Set back viscosity (cP)	Peak time (min)	Pasting temperature (ºC)
/100%-MF	479.50d	367.00d	112.50a	1654.50a	1287.50a	7.00a	89.80a
20-AYBF	481.00d	456.50c	104.51b	1363.50b	850.00b	7.00a	89.20a
30-AYBF	516.00c	469.00c	101.62c	1060.50c	604.00c	7.00a	82.83b
40-AYBF	580.00b	511.00b	99.00c	1052.00c	583.00c	7.00a	83.10b
100-AYBF	816.50a	720.50a	96.00e	962.00d	241.50d	5.45b	81.10c

Values with the different letters along the column are significantly different at *p<0.05*
[1]0%AYBF+100% MF; 20%AYBF+80%MF; 30%AYBF+70%MF; 40%AYBF+60%MF; 100%AYBF+0%MF

Table 5: Sensory evaluation scores of maize and African yam bean blends.

Parameter	100-MF	20- AYBF	30-AYBF	40%AYBF
Colour	7.47a	6.95a	5.81b	4.97b
Taste	7.21a	6.89a	6.71a	5.16b
Palatability	7.21a	6.96a	5.11b	4.62b
Texture	6.11b	6.56b	7.21a	7.89a
Aroma	7.11a	6.89a	5.32b	4.97c
Overall acceptability	7.81a	7.56a	5.87b	4.67b

Values with the different letters along the row are significantly different at *p<0.05*
[1]0%AYBF+100% MF; 20%AYBF+80%MF; 30%AYBF+70%MF; 40%AYBF+60%MF; 100%AYBF+0%MF

samples(Table 3). With increasing quantity of AYBF, significant *(p<0.05)* increase for potassium, iron and sodium were obtained, while no significant *(p>0.05)* difference was obtained for zinc, copper, manganese, calcium and magnesium. Similar report was obtained by Ene-Obong 1992 [30] for mineral composition of AYB flour.

Effect of enriching maize flour with African yam bean flour on pasting properties of maize flour

According to the RVA patterns, the pasting behavior of AYBF-MF blends showed significant difference among the blends (Table 4). Flour sample with 100%AYBF gave the highest peak viscosity value (816.50cp), while the 100% MF gave the least value. The peak viscosity of MF-AYBF blends was found to increase with increasing quantity of AYBF. The 100% MF gave the least trough and the trough value showed significant increase *(p<0.05)* with increase in quantity of AYBF. Flour sample with 100% MF had the highest final viscosity, and this final viscosity reduced with

increase in quantity of AYBF in the flour blend. This implies that the ability of the flour blends to form a thick paste after gelatinization reduced as the proportion of AYBF increased. This is similar to the report obtained for traditional unfortified maize dough and samples of dough fortified with raw bambara-nut especially at 10% replacement level [31].

Sensory evaluation Scores of Tuwo produced from AYBF-maize flour blends

Result from sensory evaluation shown in table 5 indicates that all *tuwo* samples produced from the various flour blends were generally accepted for all the attributes evaluated as none scored below the minimum acceptable rating of 5 on the 9 point hedonic scale. However, samples with 20% level of enrichment were generally accepted by the panelists and its sensory values were not significantly *(p>0.05)* different from those obtained at 0% level of enrichment which consumers are familiar with. This

is similar to the report obtained by Abioye 2009 [32] for Soy-plantain flour.

Conclusion

Addition of African yam bean flour to maize flour improved the nutritional content of this cereal, creating a novel use for African yam bean. This fact could be nutritionally advantageous to Nigerians, many of them could hardly afford the expensive protein foods of animal origin and highly utilized legume. Pasting properties of the AYBF-maize flour blends could be an advantage for their industrial uses.

Meal produced from the flour blends were generally accepted by the panelists, thus leading to the production of a *tuwo* with better nutritional quality as well as a high sensory acceptance which makes it a good prospect for commercial producers of *tuwo*.

Therefore incorporating African yam bean flour into maize flour is important since the nutritional quality of food products derived from these two raw materials is improved. Moreover, this fact will offer the possibility of use of underutilized legumes, which will help to create new jobs both at farm and at industrial levels.

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