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Production and Evaluation of Ready-to-Eat Breakfast Cereals from Blends of Whole Maize and African Yam Bean (*Sphenostylis stenocarpa*)

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ABSTRACT

Ready-to-eat breakfast cereal (RBC) containing underutilized legume was made to improve its nutrient and reduce cost. Blends of yellow maize (*Zea mays*) and African yam bean (AYB) (*Sphenostylis stenocarpa*) at 100:0, 90:10, 80:20, and 70:30 were used to produce RBC using locally adaptable process. Products were analyzed for proximate, anti-nutritional and mineral contents, as well as sensory test. Highest protein content of 15.98% was obtained in 70:30 AYB supplemented sample. There was no significant ($p<0.05$) difference in gross energy of the samples which were liked by the panelists. Low technology for producing RBC could improve food security among the poor.

Introduction

Food insecurity remains a significant international challenge of the developing countries including Nigeria. Prevalence of underweight and stunted growth is on the increase as a result of malnutrition and micro nutrient deficiency (Smuts *et* al., 2004). Food insecurity in developing countries like Nigeria will remain, if efforts are not made towards finding alternative such as diversifying the use of underutilized indigenous plants.

There are differences in breakfast meals that are consumed in different cultures worldwide. Such includes cereals, legumes, beverages and fruits and vegetables (Rampersaud *et al*., 2005). Consumption of cereal at breakfast provides more fiber, iron, folic acid, and zinc and less fat, sodium, sugar, and cholesterol, compared with non-cereal breakfast (Albertson *et al*., 2008). Consumption of whole-grain wheat has been established to have a direct prebiotic effect on the composition of human gut microbiota (Costabile *et al*., 2007), and also reduce the prevalent occurrence of chronic diseases. The major form of consumption of cereals at medium and low income earners is with little or no protein. Drawback in the consumption of whole cereal for breakfast by these categories of people could be as a result of limitations of its diversified product.

Legumes are sources of low-cost dietary plant proteins and minerals when compared with animal products such as meat, fish and egg which are expensive and out of reach for low-income families (Obatolu *et al*., 2007). They contain essential amino acids (Iqbal *et al*., 2006). Indigenous legumes are important sources of affordable alternative protein to poor resource people in many tropical countries, especially in Africa and Asia where they are predominantly consumed. They are good sources of carbohydrates, minerals, dietary fiber, resistant starch and water soluble vitamins, which are important in human health. They are means of enhancing food security among smallholder farm families. Personal interaction with smallholder farmers was that the meal of certain hard-to-cook legumes fills and sustains them for long working hours when consumed. However, they also contain anti-nutritional factors such as lectins, saponin, haemagglutin, protease inhibitor, oxalate, goitrogen, phytates, trypsin inhibitor and tannin (Amarowicz and Pegg, 2008), which can be eliminated or reduced by processing.

African yam bean (*Sphenostylis stenocarpa*), an important legume in Africa, is a lesser-known legume of the tropical and sub-tropical areas of the world which has attracted research in recent times (Azeke *et al*., 2005). The major challenge limiting its wide consumption like most other indigenous legumes includes its hard-to-cook nature. AYB seeds have higher amino acids than those in pigeon pea, cowpea, and bambara groundnut (Uguru and Madukaife, 2001). It has amino acid profile that is comparable to whole chicken's egg and meets the daily requirement indicated by Food and Agriculture Organization (FAO) and World Health Organization (WHO) (Ekpo, 2006).

It is thus important to look into the possibilities of expanding utilization options for this important food crop to prevent further neglect and enhance its cultivation among smallholder farmers. The aim of research is to produce a high protein content ready-to-eat flake-type cereal product for low income earners. This is to be done through an innovative, low technology and locally adaptable procedure using whole maize and African yam bean, to encourage its future implementation by local stakeholders.

Materials and Methods

Materials

Yellow maize (Acr. 91 Suwani. Srci/Dia Gaga. 1 Qpm variety) was obtained from a local farm in Osogbo, while African yam bean was obtained from a local market in Iwo, Nigeria. Commercial corn flakes was obtained from a supermarket in Ogbomoso, Nigeria.

Sample preparation

The two grains in three replicates were cleaned separately by removing the bad ones and other extraneous materials and kept in plastic containers until needed for use. Whole maize after cleaning was steeped in water for 24 h at room temperature,

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sun-dried for 24 h and was finally milled into flour. African yam bean was coarse-milled to remove the hull and was further milled into flour after dehulling. The two flour samples were sieved with screen size of 250 μm and later mixed in different ratio of 100:0, 90:10, 80:20 and 70:30 of maize and African yam bean, respectively, with a food mixer (Kenwood, UK). Each flour sample was mixed with 33% (g/mL) of portable water to form slurry that was cooked for 10 min with low heat. The cooked mash was spread thinly on aluminium tray and allowed to cool down before being baked in an oven at 70°C for 4 h. Drying with simultaneous toasting of the cooked slurry was done to have a flake-type cereal product that mimics a common and acceptable commercial product that could be affordable to low and medium income earners. The maize-AYB ready-to-eat product came out as a continuous flake and was allowed to cool down. It was broken into pieces and packed in tightly closed plastic containers.

Proximate composition and anti-nutritional contents analyses

Ready-to-eat breakfast cereal was analyzed for moisture, crude protein, crude fat, crude fiber and ash contents using standard methods of AOAC (2000) while total carbohydrate content was obtained by difference. Gross energy value was estimated by multiplying the fat, protein and carbohydrate content by Atwater factors of 9, 4 and 4, respectively, and summing up (FAO, 2003). Anti-nutritional contents, i.e. phytate and tannin contents, were also determined according to the methods of AOAC (2000).

Mineral content analysis

One gram of each sample was digested with 6 ml of HNO_3 (Suprapure, Merck), 2 ml of H_2O_2 (Suprapure, Merck) in a microwave digestion system and diluted to 10 ml with deionized water. A blank digest was carried out in the same way. The concentrations of Ca, Fe, P, Mg, Cu, Na, K, Zn elements in the samples were determined in an air-acetylene flame by the AAS (A Perkin–Elmer Analyst 700 model atomic absorption spectrometer) using a deuterium background correction.

Sensory evaluation

Sensory evaluation was carried out on all samples by subjecting them to preference test using 50 panelists that are familiar and are regular consumers of corn flakes. Reconstitution of the flakes was done with milk solution that was prepared by addition of sugar and milk into water at the ratio of 3:1:24 (w/w/v). Quantity of 25 g of each sample was added to 100 mL of the milk solution to prepare for consumption. While the control sample was served immediately after soaking, other samples were allowed to soak in milk solution for 10 min before being served. Samples were served at room temperature (30 ^{o}C) to the judges to rate them on the basis of taste, aroma, softness, color and general acceptability. The rating was done using hedonic scale of 1 – 7 (where 1 = dislike extremely; 2 = dislike moderately; 3 = dislike slightly; 4 = neither like nor dislike; 5 = like slightly; 6 = like moderately; and 7 = like extremely).

Statistical analysis

All collected data were subjected to Analysis of Variance (ANOVA). Where there was significant treatment effect, least significant difference (LSD) was used to separate the means at 5% level of probability using Statistical Analysis Systems (SAS) package (version 8.2 of SAS Institute Inc, 1999).

Results and Discussion

Proximate composition and anti-nutritional contents

The proximate composition of different samples of ready-to-eat breakfast cereal is shown in Table 1. The moisture content of the control sample (10.52%) was significantly (p<0.05) higher than samples supplemented with AYB, which ranged from 5.41 – 7.54%. The least value was observed in sample with 30% AYB supplementation. Lower moisture content obtained in the developed products could probably be due to the drying condition.

Crude protein content of all samples ranged from 14.31 - 15.48% (Table 1). All samples supplemented with AYB flour had higher percentage of protein content than control sample. This observation is similar to the findings of Adelekan *et al*. (2012) who reported that shrimp flour and African yam bean flour increased the percentage of protein when fortified with maize. The protein contents observed in this study were higher than the one reported by the same authors. The obtained values are higher than value of 12% protein content recommended for a food to be considered as a protein source (FNB, 2002).

The crude fiber content increased from 2.15% in the sample without inclusion of legume to 2.31% at 30% supplementation of corn with African yam bean. The World Health Organization (WHO) recommends consumption of foods containing more than 25 grams of total dietary fiber/day because it shows protective effect against weight gain and obesity, which leads to other major diseases (WHO, 2003). Range of 3.90-5.12% was obtained for the fat content in all the samples with the least amount being recorded in sample made from 100% whole grain while the highest value was obtained in 70:30 AYB supplemented sample. The low content of fat in the samples gives an indication that they could be recommended as food for people requiring low fat diet. Highest value of ash content (2.84%) was obtained in the control sample while least value of 1.25% was recorded in the sample with 30% AYB supplement. The ash content indicates the level of inorganic materials that are present in the samples.

Carbohydrate content was highest (71.62%) in the sample made from whole maize, but with no significant difference from others. There was no significantly difference in the gross energy values obtained in all the samples. Highest value of 389.00 Kcal was obtained in the sample with 30% AYB supplementation. This implies that supplementation with AYB does not reduce the energy value of the breakfast cereal products.

Table 1: Proximate composition (%) of ready-to-eat maize-AYB-blend breakfast meal

*Sample	Moisture	Crude protein	Crude Fibre	Crude Fat	Ash	Carbo hydrate	Gross Energy (Kcal)
Control	10.52a	14.44a	2.14a	4.62a	2.84a	71.44a	385.10a
100:0	5.78c	14.76a	2.15a	3.90a	1.78a	71.62a	380.62a
90:10	7.54b	14.31a	2.22a	5.12a	1.68a	69.14a	379.88a
80:20	6.10c	15.81a	2.26a	5.04a	1.85a	68.95a	384.40a
70:30	5.41c	15.98a	2.31a	4.96a	1.25a	70.11a	389.00a

Means within the same column followed by the same letter are not significantly (p<0.05) different from one another.
*Sample was prepared with maize: African yam bean ratio

Phytate content of sample with inclusion of 10% AYB had the highest value of 7.16 mg/100 g which is significant than others that had values that ranged from 5.16-6.56 mg/100 g (Table 2). Tannin content was significantly higher in control than samples with 0-20% maize-AYB-blend. This revealed that inclusion of AYB into cereal when adequately processed reduced the amount of anti-nutritional factors in foods. Adewale *et al*. (2013) reported that food processing techniques provides alternative means of improving the quality of foods as observed in this study.

Table 2: Anti-nutritional factors of ready-to-eat maize-AYB-blend breakfast meal

*Sample	Phytate (mg/100 g)	Tannin (mg/100 g)
Control	5.16b	0.32a
100:0	6.39ab	0.17b
90:10	7.16a	0.18b
80:20	6.38ab	0.18b
70:30	6.56a	0.24ab

Means within the same column followed by the same letter are not significantly (p<0.05) different from one another.
*Sample was prepared with maize: African yam bean ratio

Mineral contents

The mineral content of maize-AYB-blend breakfast cereal is shown in Table 3. Sodium values of samples with inclusion of AYB varied from 3.75 to 5.40 ppm while control sample had 3.25 ppm. Samples with 30% AYB recorded the highest potassium content. Highest value of calcium was observed in samples treated with 20-30% AYB than other samples. Significant higher difference was observed in magnesium value of maize-AYB-blend than control. Although there was no significant difference in the mineral contents of maize-AYB-blend, higher values were recorded in these samples than their control counter parts. Mineral deficiencies are prevalent in human populations and the improvement of the mineral content in cereal products will promote human mineral intake (Ficco *et al*., 2009). Inclusion of AYB at 20 and 30% increased vital mineral contents of breakfast cereal which in turn will help in increasing human mineral intake.

Table 3: Mineral contents (ppm) of ready-to-eat maize-AYB-blend breakfast meal

*Sample	Na	K	Ca	Mg	Zn	Fe	P
Control	3.25a	4.00a	1.88a	1.32b	0.78a	0.16a	14.12a
100:0	5.20a	5.45a	1.88a	1.58a	1.56a	0.14a	13.19a
90:10	3.85a	2.65a	0.75a	1.56a	0.56a	0.14a	12.5a
80:20	3.75a	3.35a	2.25a	1.56a	1.67a	0.15a	12.70a
70:30	5.40a	7.00a	2.25a	1.58a	1.66a	0.18a	11.16a

Means within the same column followed by the same letter are not significantly (p<0.05) different from one another
*Sample was prepared with maize: African yam bean ratio

Sensory evaluation

Sensory attribute analysis revealed that the commercial sample which served as the control recorded highest preference scores and was most preferred in terms of taste, aroma, softness, color and general acceptability (Table 4). However, all the formulated samples recorded scores that were higher than 4.00 which means that they were liked, but not as much as the control. In all the sensory qualities that were evaluated, only softness had least ratings for preference. The formulated products were very hard compared to the control and this could be as a result of excessive drying time and that the drying temperature was too high. There was no significant difference in the values obtained for all the samples that had AYB inclusion. This means that formulation of sample with up to 30% can be encouraged.

Table 4: Sensory attributes of reconstituted ready-to-eat maize-AYB-blend breakfast meal

*Sample	ǂTaste	ǂAroma	ǂSoftness	ǂColor	ǂGeneral Acceptability
Control	6.34b	6.03b	6.01b	6.27b	6.43c
100:0	5.61a	5.56a	5.14a	5.12b	5.75b
90:10	5.41a	5.53a	4.94a	5.60a	5.41ab
80:20	5.41a	5.51a	4.83a	5.52a	5.30a
70:30	5.48a	5.28a	4.75a	5.41a	5.34ab

Means within the same column followed by the same letter are not significantly (p<0.05) different from one another
*Sample was prepared with maize: African yam bean ratio
ǂ1 = dislike extremely; 2 = dislike moderately; 3 = dislike slightly; 4 = neither like nor dislike; 5 = like slightly; 6 = like moderately; and 7 = like extremely

Conclusion

Inclusion of AYB into breakfast cereal increased the protein content of the breakfast cereal. Anti-nutritional factors, which are the major limitation of consumption of AYB were also reduced. The product also has the potential of being accepted by the low and income earners, especially if there is improvement in the drying process. Production of maize-AYB-blend breakfast food at 70:30 ratio using low technology process is an opportunity for value addition, most importantly, of the underutilized AYB. Production at commercial level has the potential to reduce protein-energy malnutrition and also increase food security in most developing countries. This will strengthen the innovation capabilities of African agricultural systems as a means of addressing poverty, improving food security and achieving broader economic growth and development.

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