Original Research Article

Production and Evaluation of Breakfast Cereals from Rice, African yam-bean and Orange-Fleshed Sweet Potato

Abstract

Aims: The aim was to produce and evaluate the nutritional properties, microbiological quality and sensory attribute properties (proximate and functional) of ready-to-eat breakfast cereals from blends of local rice (*Oryza sativa*), malted African yam-bean and orange- fleshed sweet potato [*Ipomoea batatas* (L) Lam.] (umusco/3 variety) flours as well as to evaluate the nutritional properties, microbiological quality and sensory attribute of the formulated breakfast cereals.

Study Design: The experimental design that was used is Completely Randomized Design.

Place and Duration of Study: The study took place at the Department of Food Science and Technology, University of Nigeria, Nsukka between December 2016 and September 2017.

Methodology: The study investigated the application of local rice, malted African yam bean and orange-fleshed sweet potato flour to develop ready-to-eat breakfast cereals rich in proteins and pro-vitamin A. The local rice and malted African yam bean flours were blended in the ratio of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 to produce ready-to eat breakfast cereals which was subjected to sensory evaluation to isolate the best blend (90:10). From the preliminary study, composite flour was formulated by mixing rice flour and African yam bean flour from the best blend in different percentages. Samples of ready-to-eat breakfast cereals were formulated by mixing composite flour (rice and African yam bean best flour blend) with graded levels of orange fleshed sweet potato in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 for samples RAYBF1+OPF1(90% rice +African yam bean best blend: 10% orange-fleshed sweet potato flour) , RAYBF2+OPF2 (80% rice +African yam bean best blend: 20% orange-fleshed sweet potato flour), RAYBF3+OPF3 (70% rice +African yam bean best blend: 30% orange-fleshed sweet potato flour), RAYBF4+OPF4 (60% rice +African yam bean best blend: 40% orange-fleshed sweet potato flour), and RAYBF5+OPF5(50% rice +African yam bean best blend: 50% orange-fleshed sweet potato flour) respectively with 100% rice flour as the control. The breakfast cereal products were subjected to proximate, pro-vitamin A, microbiological and sensory analysis using standard methods.

Results: The protein, ash, fiber and moisture contents of the blends were significantly ($p<0.05$) higher than the control but their carbohydrate content were lower than the control. The protein content, fat, ash, crude fiber, moisture, and carbohydrate contents ranged from 6.82 to 11.21%, 0.20 to 1.21%, 4.03 to 15.81%, 1.31 to 2.80%, 6.61 to 10.92% and 63.07 to 80.22% respectively. The pro-vitamin content of the samples ranged from 0.13 to 2.55 mg/100 g. There was an increase in the pro-vitamin A content as the ratio of orange-fleshed sweet potato increased in the blend. The total viable count ranged from 3.0×10^3 to 6.7×10^3cfu/g while mould was not detected in any of the samples. The microbial content of the samples were satisfactory and not high when assessed using the guideline for microbiological quality of cereal products. The sensory evaluation conducted showed that among the six ready-to-eat breakfast cereals, 100 % adani rice breakfast cereals, samples RAYBF1+OPF1 and RAYBF5+OPF5 were highly accepted.

Conclusion: The study has shown that acceptable ready-to-eat breakfast cereals could be produced from blends of Adani rice, malted African yam bean and orange flesh sweet potato flour. Among the different noodles, 100 % adani rice and sample RAYBF1+OPF1 (90 % best blend + 10 % orange flesh sweet potato flour) were highly accepted.

Keywords: Rice; Ready-to-eat Breakfast cereal; Malted African yam beans; Orange-fleshed sweet potato.

1. INTRODUCTION

The word “breakfast” is a compound of “break” and “fast” which literally means “breaking the fast” of the long night usually 10-12 hours. Nutritional experts have referred to breakfast as the most important meal of the day, citing studies that found people who skip breakfast to be disproportionately likely to have problems with concentration, metabolism and weight [1]. Breakfast meals vary widely in different cultures around the world. It often includes a carbohydrate source such as cereal, fruit and or vegetable, protein, sometimes dairy and beverage. (please add reference)

Breakfast cereals are foods obtained by swelling, grinding, rolling or flaking of any cereal [2]. Ready-to-eat (RTE) cereals ranks as one of the best choices available as part of a nutritious breakfast. Ready-to-eat cereals (It) facilitate independence because of their ease of preparation which means that children and adolescents can be responsible for their own breakfast or snacks [3]. Such foods may need to be reconstituted, pre-heated in a vessel or allowed to thaw if frozen before consumption, or they may be eaten directly without further treatment [4]. Almost all over the world, breakfast cereals have become firmly established on breakfast tables. In addition to a wide variety of forms, taste and colours, they are expected today to also meet a stringent nutritional requirement. Breakfast cereals are basically produced from cereals which are the dry seeds of the members of the grain family. Cereal is typically a low-fat, nutrient-dense food with many essential vitamins and minerals such as zinc, phosphorus, and calcium (Please rephrase). The consumption of cereal based food product is very common and popular especially in developing African countries where they constitute a major source of their staple food [5]. Cereals are generally low in protein quality and are limiting in some essential amino acids in particular, lysine and tryptophan. The amount of cereal grown in Nigeria is high compared to its utilization. This is due to post harvest losses incurred from cereals, thus there is need to diversify the use of cereals into producing some products which can be made available all year. Rice is the seed of monocot plant of the genus *Oryza* and of the grass family poaceae (formally *Graminae*) [6]. They are about twenty wild species and two cultivated ones, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). *Oryza sativa* is the most commonly grown species throughout the world today. Rice is rich in many nutrient components including carbohydrate, proteins, certain fatty acids and micronutrients (vitamins and trace minerals). They are also sources of many bioactive non-nutrient compounds, known as an antioxidant, including phenolic compounds [7]. Adani rice is a local rice grown in Adani community. It is known for its good nutritive, physical and cooking properties and needs to be supplemented with a legume for higher nutrient-dense product. The average daily protein consumed by Nigerians is well below the recommended value of protein intake[8]. In recent times, food product developers have incorporated legumes into traditional cereal formulations as a nutrient diversification strategy as well as an effort to reduce the incidence of malnutrition among vulnerable groups. African yam bean is an under-utilized indigenous African legume and one of the most important crops in the continent. There are seven species of the genus *sphenostylis* [9]. African yam bean has attracted research attention in recent times [10]. Protein content is up to 19% in the tubers and 29% in the seed grain. The seeds form a valuable and prominent source of plant proteins in the diet of Nigerians. The seeds may be boiled and eaten with local seasoning, starchy roots and tubers. The seeds can also be roasted and eaten with coconut or palm kernels [11]. Orange fleshed sweet potato is a breed of sweet potato that is bio-fortified with vitamin A. It has a great potential to be used in food-based intervention programs to address vitamin A deficiency a major micronutrient required for health in both children and adults. The crop is a promising solution to vitamin A deficiency because it is rich in β-carotene and substantially better absorbed than leaves and vegetables. Sweet potato is generally recognized as being an underutilized nutritious food [12]. Beyond 'boil' and 'eat', orange fleshed sweet potato can be processed into various commercial products and can be used to enrich indigenous foods. The study is useful in the improvement of the nutritional quality of cereals by complementing their limiting amino acid with legumes. This study would also provide avenue for the utilization of Adani rice, African yam bean and orange fleshed sweet potato, which are presently underutilized as raw materials for industrial production of breakfast cereals. Coupled with the recent economic recession, the disposable income of most Nigerians has reduced, hence the increase in demand for breakfast cereals produced via locally available cereals; this is cheaper than imported ones as high cost of importation is evaded. The product from this study would go a long way in addressing macro and micro-nutrient deficiencies among consumers especially children. The data obtained from this study could play an important role as reference material or baseline for researchers, health and nutrition policy makers, dietary counselors as well as households [8].

Therefore, the broad objective of this study was to produce and evaluate ready-to-eat breakfast cereal from blends of rice, malted African yam bean and orange-fleshed sweet potato.

2. MATERIALS AND METHODS

2.1 Raw Materials

Parboiled seeds of Rice (*Oryza sativa*) were obtained from Adani Rice Mill in Uzouwani Local Government Area, Enugu State. The seeds of African yam bean were obtained from Orie Oba market in Udenu Local Government Area, Enugu State, while mature orange-fleshed sweet potato (*Ipomeo batatas* L.) (umusco/3) was obtained from National Root Crop Research Institute, Umudike, Abia state. Other ingredients such as sugar and salt were purchased from Ogige market, Nsukka.

2.2 Production of Raw Materials

Rice, African yam bean and orange-fleshed sweet potato were processed into flour using different methods

2.2.1 Production of rice flour

Rice flour was processed by modifying the method [13] as shown in Fig. 1. Parboiled rice grains were cleaned, sorted and washed, then steeped in water for 12h, drained and dried in a hot air laboratory oven (LABE 1201, Divine International, Dehi. Milling of the dried rice grain was done (re-write) using hammer mill (I.G. Jurgens, Bremmer, Germany) and the milled grains were sieved using a 300 μm mesh size sieve to obtain fine flour and packaged in an air tight container.

Parboiled rice grains
↓
Sorting & cleaning/weighing
↓
Steeping in water for 12h
↓
Draining
↓
Drying using hot laboratory oven
↓
Milling using hammer mill
↓
Sieving with 300 μm mesh sieve
↓
Rice flour

Fig. 1 Production of rice flour

2.2 Production of malted African yam bean

Malted African yam bean flour was produced by modifying the method described by [14] as shown in Fig.2. Healthy and clean seeds of African yam bean was weighed into perforated polyvinyl chloride bag and steeped in water. The 2-step wet steep method for African yam bean had 6 hours wet steep, 3 hours air rest and 6 hours wet steep (6-3-6) as described by Anon, [14]. The grains were then germinated for 72 hours under dark conditions. They were turned once in 24 hours. The seeds were moistened on alternate days by dipping the jute bags containing the germinating grains in water for 30 seconds. The germinated grains were removed after 72 hours and dried at 50°C for 12 hours in a convectional Gallenkamp oven (Model IH-150, Gallenkamp, England). They were cleaned by dehulling and winnowing before milling into flour using an attrition mill (Bentall Plate Mill, Model 200L 090, E. H. Bentall, England).

African yam bean seeds
↓

Cleaning

Weighing

2-step wet steep in water at room temperature (28±2^{o}c) (African yam bean: 6-3-6)

Germination for 72h (28±2^{o}c)

Drying (50^{o}c)

Cleaning

Milling

Malted African yam bean flour (please re-arrange)

Figure 2: Flow chart for the production of malted African yam bean flour.

2.2.3 Production of orange-fleshed sweet potato (*Ipomoea batatas* L.) flour

Orange fleshed sweet potato was processed in to flour using the procedure described by [15]. Orange fleshed sweet potatoes were sorted, peeled, chipped and dried. The dried sweet potato chips were then milled in a hammer mill (Thomas Wiley mill Model ED-5) into flour and packaged in an air tight container for further use. The flow diagram for the processing of orange fleshed sweet potato to flour is shown in Figure 3.

Sweet potato storage roots

Cleaning and trimming → Waste

Water → Washing Used water →

Slicing

Drying

Dried chips

Milling

Packaging

Orange flesh sweet potatoes (not clear, or remove all the flow chart)

Figure 3: Flow chart for the production of orange fleshed sweet potato flour.

Source: [15].

2.3 Preparation of the Flour Blends

Adani rice flour (RCF) and African yam bean flour (AYBF) were blended in the ratio 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 and breakfast cereals produced from the blend. The resultant breakfast cereals were subjected to sensory evaluation in order to obtain the best blend (90:10). Composite flour was formulated by mixing Adani rice flour (RCF) and African yam bean flour (AYBF) best blend (90:10) in different percentages. Samples of breakfast cereals were generated by mixing the composite flour (Adani rice and African yam bean flour) with graded levels of Orange fleshed sweet potato flour (OP) with 100% rice as the control as shown in Table 1 and 2.

Table 1: Blending ratios of local rice and malted African yam bean flour

Sample code	Local rice	Malted African yam bean
RCF+ AYBF (100:0)	100	0
RCF+ AYBF (90:10)	90	10
RCF+ AYBF (80:20)	80	20
RCF+AYBF(70:30)	70	30
RCF+ AYBF (60:40)	60	40
RCF+ AYBF (50:50)	50	50

Key: RCF + AYBF (100:0) = 100% Local rice flour and 0% African yam bean flour; RCF + AYBF (90:10) = 90% of local rice flour and 10% malted African yam bean flour; RCF + AYBF (80:20) = 80% Local rice flour and 20% malted African yam bean flour; RCF + AYBF (70:30) = 70% Local rice flour and 30% malted African yam bean flour; RCF +AYBF (60:40) = 60% Local rice flour and 40% malted African yam bean flour; while RCF + AYBF (50:50) = 50% Local rice flour and 50% malted African yam bean flour

Table 2: Blending ratios of local rice + African yam bean best blend and orange-fleshed sweet potato composite flour for the production of ready-to-eat breakfast cereals

Sample code	Rice+ African yam bean best blend	Orange-fleshed sweet potato
RC (CONTROL 100% RICE)	100	0
RAYBF1+OPF1(90:10)	90	10
RAYBF2+OPF2(80:20)	80	20
RAYBF3+OPF3(70:30)	70	30
RAYBF4+OPF4(60:40)	60	40
RAYBF5+OPF550:50)	50	50

Key: RC= Control 100% rice, RAYBF1+OPF1(90:10)= 90%rice/African yam bean best blend flour+ 10% orange-fleshed sweet potato flour, RFAYB2+OPF2(80:20)= 80%rice/African yam bean best blend flour+ 20% orange-fleshed sweet potato flour RAYBF3+OPF3(70:30) = 70%rice/African yam bean best blend flour+ 30% orange-fleshed sweet potato flour, RAYBF4+OPF4(60:40)= 60%rice/African yam bean best blend flour+ 40% orange-fleshed sweet potato flour, while RAYBF5+OPF5(50:50)= 50%rice/African yam bean best blend flour+ 50%

orange-fleshed sweet potato flour

2.3.1 Production of breakfast cereals

The stepwise process involved in the formulation of the ready-to-eat breakfast cereal is explained thus; The Adani rice, malted African yam bean and orange flesh sweet potato composite flour was mixed together. Small quantity of water was added to the flour mixtures as to have a binding effect; sugar and salt was added to give it taste. The mixtures was precooked(heat treated) by steaming for 10 minutes and then allowed to age at a temperature of 4°C for about six hours. After ageing, the product was shaped by cutting into flakes using stainless steel knives and put in baking pans and toasted in an oven at a temperature of 120°C for 1 hour after which the ready-to-eat breakfast cereal was allowed to cool under room temperature and packaged in packaging materials for use.

Blending of composite flour

↓

Conditioning (water, sugar and salt)

↓

Partial heat treating of the blends for 10 minutes(to gelatinize the starch)

↓

Ageing (4°C for six hours)

↓

Cutting

↓

Toasting

↓

Cooling

↓

Packaging

Figure 4: Flow diagram for the production of ready-to-eat breakfast cereal.

2.4 Analysis of Raw Materials and Ready-to-eat Breakfast Cereals from Blends of Local Rice, Malted African Yam Bean and Orange-Fleshed Sweet Potato (delete)

The flour blends were analyzed for their proximate composition, beta-carotene content and functional properties, while the ready-to-eat breakfast cereals were analyzed for their proximate composition, micronutrient content, sensory properties and microbial content.

2.4.1 Determination of bulk density and water absorption capacity of flour samples

2.4.4.1 Determination of water absorption capacities

Water absorption capacity was determined by modifying the method [16]. One gram (dry weight basis) of the sample was dispersed in 10 ml distilled water, vortexed intermittently for 10 minutes and centrifuged at 4500 rpm for 20 minutes. The aqueous supernatant obtained after centrifuging was decanted and the test tubes inserted and allowed to drain for 5 minutes on a towel. By weighing the residue, water absorption capacity was calculated as a percentage of a gram of water absorbed per gram of sample.

2.4.4.2 Determination of bulk density

The bulk density was determined according to the method [17]. A graduated measuring cylinder of 10 ml capacity was weighed and gently filled with the sample, followed by gently tapping the bottom until there was no further diminution of the sample level after filling to the 10 cm3 mark. The bulk density was calculated as:

Bulk density (g / cm3) = Weight of sample (g)/ The weight of sample after tapping (cm3)

2.4.2 Proximate composition

2.4.2.1 Determination of moisture content

Moisture content was determined according to the methods of Association of Official Analytical Chemists [18]. The Samples were dried at 105°C for 3 h using the preset oven mechanized convection air oven (Phoenix furnace, model 534, SN: 524-85, Chapel town, Sheffield).

2.4.2.2 Determination of crude protein

The protein content (% nitrogen x 6.25) of the sample was determined using the Kjeldahl method [18].

2.4.2.3 Determination of crude ash

The crucible containing the pre-weighed samples were placed in a heated furnace mechanized convection air oven (Phoenix furnace, model 534, SN: 524-85, Chapel town, Shefffield). At 600°C for 6 h after which they were cooled to room temperature in desiccators and weighed.

2.4.2.4 Determination of crude fiber content

The crude fiber content of the samples was determined using the standard method [19]. NHexane was used to de-fat 2 g of sample, added in oiled 200 ml of 1.25% H2SO4 and boiled for 30 minutes, filtered, washed with 1% HCI and boiling water. The residues were returned into 200 ml boiling NaOH and allowed for 30 minutes. The final residues were drained and transferred to the silica ash crucible (porcelain crucible), dried in an oven at 100°C for 2 hours and cooled until a constant weight obtained. and incinerated (ashed) in a muffle furnace at 600°C for 5 hours, cooled in a desiccator and weighed.

2.4.2.5 Determination of fat content

The fat content of the samples content (1g was extracted for ether extract determination using petroleum ether as solvent) was determined using the standard Soxhlet method [18].

2.4.2.6 Determination of carbohydrate content

The carbohydrate content of the sample was determined as nitrogen free extraction calculation by difference [18].using the formula below:

% Carbohydrate = 100 – (% moisture + % protein + % ash + % crude fiber + % fat)

2.4.3 Determination of micronutrient

2.4.3.1 Determination of β-carotene content

The β – carotene content of the samples was determined using the method [20]. The samples were weighed, W1 and homogenized in methanol in the ratio of 1:10 (%) using a laboratory blender. The homogenate was filtered using a filter paper of measured weight, W2 to obtain the initial crude extract, washed with 20 ml of distilled water in separating funnel. The other layer was recovered and evaporated to dryness at a low temperature (35 – 50°C) in vacuum desiccator. The dry extract was saponified with 20 ml of ethanoic potassium hydroxide and was left overnight in a dark cupboard. After a day, the β – carotene was taken up in 20 ml of ether and then washed with two portions of 20 ml distilled water. The β – carotene content extract (ether layer) was dried in a desiccator and treated with petroleum (petroleum spurt) and allowed to stand overnight in a freezer. The next day, the precipitated steroid was removed by centrifugation and β – carotene extract was evaporated to dryness in a desiccator and weighed, W3. The weight of the β – carotene was determined and expressed as a percentage of the sample weight.

β – Carotene content (%) = W3 – W2 × 100

W1 1

Where W1 = Weight of sample; W2 = Weight of empty filter paper and W3 = Weight of filter paper + Weight of precipitate.

2.4.4 Total Viable and Mould Count (TVC)

The total viable count was determined according to the method [21]. The samples were inoculated using nutrient agar after the serial dilution of the sample had been obtained. Pour plate method was used. The colony count was done after 24 hours of incubation at 37 °C using a colony counter (Gallenkamp colony counter, CNW 330 – 010X) and the number of colonies calculated using the following formula:

TVC (CFU / g) = (Number of colonies × Original concentration) / (Dilution factor × Volume of inoculums) CFU = Colony Forming Unit

For the mould count, after the serial dilution of the samples, they were inoculated using Sabauroud dextrose agar (SDA). Pour plate method was used. The colony count was done after 72 hours on incubation at 37 oC,using a colony counter (Gallenkamp colony counter, CNW 330 – 010X) and the number of colonies calculated using the following method:

Mould count (CFU / g) = (Number of colonies ×Original concentration)/ (Dilution factor × Volume of inoculums) CFU = colony forming unit

2.4.5 Sensory evaluation of the ready-to-eat breakfast cereals

Sensory evaluation of the samples was evaluated by 20 semi-trained panelists from the Department of Food Science and Technology for various sensory attributes (appearance, taste, colour, texture, after taste and overall acceptability). A 9-point Hedonic scale was used where ‘’9’’ represents extremely like and ‘’1’’ represents extremely dislike [22]. The samples were presented in coded plastic plates. The order of presentation of samples to the judges was randomised. Clean water was presented for the panelists to rinse their mouth in between evaluation.

2.5 Data Analysis and Experimental Design

The experiment was conducted in a Completely Randomized Design (CRD). Data obtained were subjected to one-way Analysis of Variance (ANOVA) and mean separation was done by Duncan multiple range test, using Statistical Product for Service Solution (SPSS) version 20 and significance difference was accepted at ($p<0.05$).

3. RESULTS AND DISCUSSION

Plates 1 to 3 shows the processed flours from rice (plate 1), malted African yam bean (plate 2) and orange-fleshed sweet potato (Plate 3).

 

Plate 1: Adani rice flour Plate 2: malted African yam bean flour

Plate 3: orange-fleshed sweet potato flour

3.1 Proximate Composition (%), β-carotene (mg/100g), Water Absorption Capacity and Bulk Density(%) Content of Rice, African yam Bean and Orange Fleshed Sweet Potato Flour

Table 3 shows the proximate composition (%), β-carotene (mg/100 g), water absorption capacity (%) and bulk density (g/cm3) contents of rice, African yam bean and orange fleshed sweet potato flour.

The moisture content of the flour samples ranged from 6.60% (sample RCF) to 7.60% (sample OPF). The moisture contents of local rice (6.60%), malted African yam bean (7.00%) and orange-fleshed sweet potato(7.60%) flour was within the 10% stipulated standard for storage stability of flours [23].The high moisture content of food is an index of spoilage since the moisture enhances chemical and biochemical reactions that could lead to spoilage. In general, the lower, the lower the moisture contents of a product, the longer the storage life.

The protein content (%) of the malted African yam bean flour (26.92%) was higher than that of local rice flour (7.88%) and orange-fleshed sweet potato flour (3.31%) which makes it a good protein supplement. The protein content of the African yam bean was higher than that reported by[13], who reported 18.63% as the protein content. This could be as a result of the processing method used in processing the African yam bean seeds into flour.

Malted African yam bean flour had the highest fat content (2.20%) which was higher than that of local rice flour(0.70%) and orange-fleshed sweet potato flour(0.49%). The low fat content of the flour samples in particular, orange-fleshed sweet potato indicates that it would not be easily susceptible to rancidity. Fat have been known to impart on the sensory attributes of food products, however, high fat content of food may reduce its keeping quality.

Orange-fleshed sweet potato flour has the highest ash content (4.60%) which is higher than that of local rice flour (2.45%) and malted African yam bean flour (2.14%). The value of ash for African yam bean flour is in line with that reported by [13]. The presence of the high ash content in orange-fleshed sweet potato flour shows that the mineral content is higher than others which could be as a result of the bio-fortification of the sweet potato. This would probably increase the mineral and vitamin content of the blend since ash is an index of mineral content [24].The ash content of the orange-fleshed sweet potato flour also conformed with that obtained by [24].

The crude fiber ranged from 1.86% (sample RCF) to 3.00% (sample OPF). It was observed that orange-fleshed sweet potato flour had the highest crude fiber which was higher than that of malted African yam bean flour (2.11%) and local rice (1.86%). The crude fiber content was similar to 3.0% reported by [25]. There were significant ($p<0.05$) differences among the samples. The fiber content would be effective in the delay of gastric emptying [25] and a reduction in serum cholesterol [26].

The carbohydrate content of the flours was 80.51,59.63 and 81.00% for local rice, African yam bean and orange-fleshed sweet potato flours respectively. Orange-fleshed sweet potato flour had the highest carbohydrate content while African yam bean had the lowest. The solar drying technique employed during the processing of the flour helped in the retention of the nutrients present in the flour. .

The Vitamin A content of the flour samples are shown in Table 3. The pro-vitamin A content (mg/100g) of the flour samples varied from 0.11 to 7.86 mg/100g with sample AYBF having the least pro-vitamin A content while sample OPF had the highest pro-vitamin A content. Sample RCF was found to contain no amount of pro-vitamin A. The use of solar dryer in the drying of the orange-fleshed sweet potato flour prevented the loss of the pro-vitamin A component of the flour. The values obtained for the pro-vitamin A content compared favourably well with the values reported by [25]. using different varieties of orange-fleshed sweet potato. The ß-carotene in the orange-fleshed sweet potato flour would help to solve the problem of poor sight in developing countries like Nigeria.

Water absorption capacity of the flour samples varied from 134.20 to 24.52%. The water absorption capacity is the ability of a product (such as flour) to absorb water. Orange-fleshed sweet potato flour had the highest water absorption capacity (264.52%) and was followed by malted Africa yam bean flour (213.20%). Local rice flour had the least water absorption capacity (134.20%) among the flour samples. Water absorption capacities of flours depend on several factors such as the size of granules, amylose/amylopectin ratio, and intra and inter molecular forces [27]. Water absorption capacity gives the indication of the amount of water available for gelatinization. The relatively high water absorption capacity of orange-fleshed sweet potato flour could be attributed to its high amylose to amylopectin ratio (21:79) which gives it a higher affinity for water. The relatively low water absorption capacity of rice and African yam bean flour could be attributed to the presence of low amount of hydrophilic constituents in these flours [27].

The bulk density of the flour samples varied from 0.65 to 0.90 g/cm$^{3.}$ .The bulk densities of local rice, African yam bean and orange-fleshed sweet potato flours were 0.90, 0.81 and 0.65 g/cm3 respectively. Bulk density is the weight per unit volume of a material. Bulk density is important for determining packaging food requirements, material handling and application in the food industry [28]. The differences in the bulk densities of the flours may probably be due to their different particle sizes. According to [29], bulk density depends on the particle size and initial moisture content of the flours. It was observed that the bulk density of local rice flour was the highest. The local rice may require more packing space than the other flour samples. The more the bulk density, the more the packing space and careful stacking required. There were significant ($p<0.05$) differences among the samples.

Table 3: Proximate composition (%), functional properties and β-carotene (mg/100 g) content of rice, African yam bean and orange fleshed sweet potato flour.

	Sample code		
Parameters	**RF**	**AYBF**	**OPF**
Moisture (%)	6.60^{c}±0.01	7.00^{b}±0.04	7.60^{a}±0.01
Protein (%)	7.88^{b}±0.01	26.92^{a}±0.01	3.31^{c}±0.01
Ash (%)	2.45^{b}±0.01	2.14^{c}±0.01	4.60^{a}±0.01

Fat (%)	0.70^{b}±0.01	2.20^{a}±0.00	0.49^{c}±0.01
Fiber (%)	1.86^{c}±0.01	2.11^{a}±0.01	3.00^{b}±0.00
CHO (%)	80.51^{a}±0.01	59.63^{c}±0.32	81.00^{a}±0.01
β-carotene (mg/100g)	ND	0.11^{b}±0.04	7.86^{a}±0.05
WAC (%)	134.20^{c} ± 0.00	213.20^{b} ± 0.00	264.52^{a} ± 0.01
Bulk density (g/cm^{3})	0.90^{a} ± 0.5	0.81^{b} ± 0.01	0.65^{c} ± 0.01

Values are means ± Standard Deviation (SD) of duplicate determinations. Values having the same superscript (a,b and c) within the same column are not significantly ($p<0.05$) *different. RF: Rice Flour; AYBF: African yam bean flour; OPF: Orange fleshed sweet potato flour; CHO: Carbohydrate; WAC:Water Absorption Capacity*

3.2 Sensory Scores of Breakfast Cereal Produced from Rice and African Yam Bean Flour.

The sensory scores of breakfast cereal formulated from rice and African yam bean flour is shown in Table 4.

The scores for colour of the breakfast cereal ranged from 5.13 (RF+AYBF5) to 7.18 (RF+AYBF1). There was no significant ($p<0.05$) difference between the samples and control (RF+AYBF0) except for sample RF+AYBF5. Sample RF+AYBF1 ranked highest followed by sample RF+AYBF0 (control). From Table 4, it was observed that the judges preferred the colour of sample RF+AYBF1 although it was not significantly($p<0.05$) different from sample RF+AYBF0 (control). The scores for colour decreased with increased substitution with African yam bean flour. It was also observed that the preference for the samples in terms of colour decreased with increased addition of African yam bean flour. Taste of the formulated breakfast cereal ranged from 3.85 (RF+AYBF5) to 7.55 (RF+AYBF1). Sample RF+AYBF1 was highly rated compared to other formulated samples. This showed that it was preferred to other samples and could be attributed to improvement in the taste of the breakfast cereal by the malted African yam bean flour. There was no significant ($p<0.05$) difference between the taste of sample RF+AYBF1 and RF+AYBF0 (control). This could imply that blending rice and African yam bean in the ratio of 90:10 (RF+AYBF1) for breakfast cereal production would not affect its acceptability in terms of taste. Table 4 shows that texture of the formulated breakfast cereal ranged from 4.50 (RF+AYBF5) to 7.25 (RF+AYBF1). There was no significant($p<0.05$) difference between the texture of sample RF+AYBF1 and that of the control (RF+AYBF0). The scores for texture of sample (RF+AYBF1) was highest as shown in Table 4. This showed that it was highly preferred relative to other samples. Texture of a sample usually determine whether a food product could be swallowed or chewed . From Table 4, it was observed that the mean values for the texture decreased as the addition of African yam bean exceed 10% but its addition at this level improved the texture of the breakfast cereal. This is in agreement with the findings of [30] as well as [31]. The scores for the aftertaste of the breakfast cereals ranged from 4.16 (RF+AYBF5) to 7.55 (RF+AYBF1). Sample RF+AYBF1 was mostly preferred by the panelists although no significant ($p>0.05$) different exist between the aftertaste of the sample (RF+AYBF1) and sample RF+AYBF0 (control). The preference for the breakfast cereal in terms of aftertaste decreased as the quantity of rice in the blend decreased. The sensory scores for the appearance of the breakfast cereal ranged from 4.78 (RF+AYBF5) to 7.30 (RF+AYBF1). The appearance of sample RF+AYBF1 was highly preferred by the judges compared to other samples although no significant ($p<0.05$) difference exist between the sample (RF+AYBF1) and sample RF+AYBF0 (control). The appearance of the all the breakfast cereal were generally acceptable by the panelists.

The mean score for the overall acceptability of the formulated breakfast cereals ranged from 4.05 (sample RF+AYBF5) to 7.75 (sample RF+AYBF1). There was a general decrease in the overall acceptability of the breakfast cereal with a decrease in rice flour and increase in African yam bean flour. This is similar to the findings of [32] who has it that the overall acceptability of biscuit produced from acha flour, bambara groundnut flour and unripe plantain flour decreased with increased addition of bambara groundnut flour and unripe plantain. Sample RF+AYBF1 had the highest mean score (7.75) in overall acceptability which made the breakfast cereal most acceptable to the judges although it was not significantly ($p<0.05$) different from the control (RF+AYBF0).

Generally, sample RF+AYBF1 (90% rice+10% African yam bean) had the highest mean score in all parameters assessed which indicates that the sample (RF+AYBF1) was most preferred by the judges and was selected as the best blend for further substitution with orange fleshed sweet potato.

Table 4 : Sensory scores of breakfast cereal formulated from rice and African yam bean flour.

Sample code	Colour	Taste	Texture	After taste	Appearance	Overallaceptability
RF+AYBF$_0$	$6.70^{a} \pm 0.40$	$7.15^{ab} \pm 0.22$	$6.75^{ab} \pm 0.32$	$7.00^{a} \pm 0.32$	$6.15^{ab} \pm 0.43$	$6.90^{ab} \pm 0.32$
RF+AYBF$_1$	$7.18^{a} \pm 0.31$	$7.55^{a} \pm 0.31$	$7.25^{a} \pm 0.25$	$7.55^{a} \pm 0.29$	$7.30^{a} \pm 0.40$	$7.75^{a} \pm 0.29$
RF+AYBF	6.60^{a}	6.15^{b}	$6.35^{abc} \pm 0.3$	$5.95^{b} \pm 0.3$	$5.80^{bc} \pm 0.35$	$6.35^{bc} \pm 0.32$

2	± o.26	^{c} ± 0.30	5	3		
RF+AYBF3	6.40^{a} ± 0.37	5.75^{c} ± 0.43	5.90^{bc}±0.45	5.95^{b}±0.33	6.15^{ab}±0.37	5.7^{cd}±0.38
RF+AYBF4	6.10^{ab} ± 0.42	5.00^{cd} ± 0.40	5.40^{cd}±0.43	4.80^{c}±0.35	5.30^{bc}±0.44	5.05^{de}±0.41
RF+AYBF5	5.13^{b} ± 0.46	3.85^{d} ± 0.59	4.50^{d}±0.51	4.16^{c}±0.48	4.78^{c}±0.47	4.05^{e}±0.53

Values are means ± Standard Error of Means (SEM) of 20 panelists. Values having the same superscript within the same column are not significantly ($p<0.05$) *different (a,b,c and d) Key: RF+AYBF0=100% rice+0% African yam bean; RF+AYBF1=90%rice flour+10% African yam bean flour; RF+AYBF2=80% ricea flour+20% African yam bean flour; RF+AYBF3=70% rice flour*+30% African yam bean flour; RF+AYBF4=60% rice flour+ 40% African yam bean flour; RF+AYBF5=50 % rice flour+*50% African yam bean flour.*

3.3 Proximate Composition and β-carotene Content of the Breakfast Cereal

Table 5 shows the proximate composition (%) and β-carotene (mg/100 g) content of breakfast cereals formulated from rice, African yam bean and orange fleshed sweet potato flour blends.

The moisture content of the formulated breakfast cereal ranged from 6.61% (sample RF) to 10.92% (sample RAYBF5+OPF5). There was a significant ($p<0.05$) difference in the moisture content of the samples. The moisture content of the formulated breakfast cereal samples increased as blending level of OPF increased. This is in agreement with [33] who stated that increased addition of orange fleshed sweet potato flour increased the moisture content of the bread produced from wheat and orange fleshed sweet potato flour. This could be attributed to the ability of the total high fiber in orange fleshed sweet potato to interact with large amount of water through the hydroxyl group existing in the fiber structure.

The protein content (%) of the samples ranged from 11.21% (sample RAYBF1+OPF1) to 6.82% (sample RF). There was a significant ($p<0.05$) difference in the protein content of the samples. The protein content of the sample decreased with increasing blend of orange fleshed sweet potato flour. The samples that contain African yam bean had higher protein contents than the control sample. Several researchers have reported increase in protein contents of food supplemented with African yam bean [34,35,36]. However, the protein values obtained where much lower, this could be as a result of the low protein ratio used in formulating the product which was gotten from the 90:10 best blend ratio. The control (sample RF) had the lowest protein content while among the blended samples, RAYBF1+OPF1 (11.21%) had the highest protein content with a decrease through to sampleRAYBF5+OPF5 (6.82%) which had the lowest. This was in agreement with the findings of[33] who produced bread from orange fleshed sweet potato and wheat and [37] who also produced bread from wheat, maize and orange fleshed sweet potato . The decrease in protein content could be attributed to the low protein content of the orange fleshed sweet potato flour [33].

The ash content (%) of the formulated breakfast cereal showed significant ($p<0.05$) differences with values ranging from 4.03% (sample RF) to 15.81% (sample RAYBF5+OPF5). The ash content is an index of the mineral content of a food sample which is necessary for growth and development [38]. Lower value of 5.29% to 7.36% was reported by [39] who formulated breakfast cereal from African yam bean, maize and defatted coconut. This variation could be attributed to the use of different raw materials in formulation of the product. As the graded levels of orange fleshed sweet potato increased in the composite flour, the ash content of the blend increased. This was in agreement with the findings of [40] who blended orange fleshed sweet potato and wheat flours for cookies production. This result showed that sample RAYBF5+OPF5(50:50) contained highest mineral element than other samples including the control (100% rice) due to the increase in the ratio of the orange-fleshed sweet potato flour in the blend.

Table 5 shows that the fat content (%) of the breakfast cereal ranged from 0.20% (sample RAYBF5+OPF5) to 1.21% (sample RAYBF1+OPF1). There were significant ($p<0.05$) differences among samples RF, RAYBF1+OPF1, RAYBF2+OPF2 and RAYBF5+OPF5 but there was no significant ($p<0.05$) difference between samples RAYBF3+OPF3 and RAYBF4+OPF4. This result was not in agreement with the findings of [41],using sorghum and pigeon pea blends flour blends. The results of the fat content obtained by [41], showed relative high-fat content of the products (8.70-14.2%). The fat contents of all the samples were found to be generally low. The relatively low-fat content of the food blends could contribute to the extension of the shelf-life of ready-to-eat breakfast cereals by retarding the onset of rancidity. The low-fat content of all the blends could also make the product an excellent food for diabetic and obese patients [38]. The presence of graded levels of orange fleshed sweet potato in the formulation could be responsible for the generally low fat content of the resulting products.

Table 5 shows that the fiber content (%) of the breakfast cereal ranged from 1.31% (sample RF) to 2.80% (sample RAYBF5+OPF5). There were significant (($p<0.05$) differences among the samples. The fiber contents of the blends were observed to be higher than that of the control (100% rice). The crude fiber content increased with increase addition of orange fleshed sweet potato in the blend. This was similar to the findings of [40] who incorporated orange fleshed sweet potato in his blends. This could be attributed to the increased fiber content of orange fleshed sweet potato in the blend.

The carbohydrate content ranged from 80.22% (RF) to 63.07% (RAYBF5+OPF5) where sample RF (80.22%) being the control had highest value and the least RAYBF5+OPF5 (63.07%). The samples had higher values of carbohydrate due to the presence of rice (cereal) and orange fleshed sweet potato.
Table 5 shows the β-carotene content of the formulated breakfast cereal. The β-carotene content of the breakfast cereals formulated with orange fleshed sweet potato ranged from 0.41 mg/100 g (sample RAYBF1+OPF1) to 2.55 mg/100 g (sample RAYBF5+OPF5) and in control sample RF it was relatively low 0.13mg/100 g . The β-carotene increased with increased addition of orange fleshed sweet potato flour to the blend. This could be attributed to the high β-carotene content of orange fleshed sweet potato[40].

Table 5: Proximate (%) composition and β- carotene content of the breakfast cereals

Sample code	**Moisture** (%)	**Protein** (%)	**Ash** (%)	**Fat** (%)	**Fibre** (%)	**CHO** (%)	**β Carotene** (mg/100g)
RF	$6.61^{f}\pm0.1$	$6.82^{f}\pm0.1$	$4.03^{f}\pm0.1$	$1.01^{b}\pm0.01$	$1.31^{f}\pm0.0$	$80.22^{a}\pm0.1$	$0.13^{f}\pm0.01$
RAYBF1+OPF1	$8.73^{e}\pm0.01$	$11.21^{a}\pm0.02$	$5.80^{e}\pm0.02$	$1.21^{a}\pm0.01$	$1.70^{d}\pm0.01$	$71.35^{b}\pm0.05$	$0.41^{e}\pm0.01$
RAYBF2+OPF2	$10.44^{d}\pm0.01$	$9.53^{b}\pm0.01$	$10.72^{d}\pm0.01$	$0.72^{c}\pm0.01$	$1.71^{d}\pm0.01$	$66.88^{c}\pm0.02$	$1.02^{d}\pm0.01$
RAYBF3+OPF3	$10.60^{c}\pm0.01$	$8.24^{c}\pm0.1$	$11.71^{c}\pm0.01$	$0.60^{d}\pm0.01$	$2.72^{cd}\pm0.01$	$66.13^{d}\pm0$	$1.80^{c}\pm0.03$

						.1	
RAYBF4+OPF4	$10.82^{b}\pm0.02$	$7.56^{d}\pm0.01$	$13.03^{b}\pm0.02$	$0.60^{d}\pm0.01$	$2.74^{b}\pm0.01$	$65.25^{e}\pm0.01$	$2.50^{b}\pm0.01$
RAYBF5+OPF5	$10.92^{a}\pm0.10$	$7.20^{e}\pm0.01$	$15.81^{a}\pm0.01$	$0.20^{e}\pm0.01$	$2.80^{a}\pm0.01$	$63.07^{f}\pm0.1$	$2.55^{a}\pm0.01$

Values are means ± Standard Deviation (SD) of duplicate determinations. Values having the same superscript (a,b and c) within the same column are not significantly (p>0.05) different. Key: RF:100% Rice Flour , RAYBF1+OPF1(90:10) =90%rice/African yam best blend flour + 10% orange-fleshed sweet potato flour; RAYBF2+OPF2(80:20) = 80%rice/African yam bean best blend flour + 20% orange-fleshed sweet potato flour; RAYBF3+ OPF3(70:30) = 70% rice/African yam bean best blend flour + 30% orange-fleshed sweet potato flour, RAYBF4+OPF4(60:40) = 60% rice/African yam bean best blend flour+ 40% orange-fleshed sweet potato flour and RAYBF5+OPF5(50:50) = 50% rice/African yam bean best blend flour + 50% orange-fleshed sweet potato flour. CHO: Carbohydrate

3.4. Microbial Count (cfu/g) of the Breakfast Cereals Formulated from Rice, African Yam Bean and Orange Fleshed Sweet Potato Flour

Table 6 shows the total viable and mould count of the formulated breakfast cereal from rice, African yam bean and orange fleshed potato flour.

The total viable count of the formulated samples ranged from $3.0x10^{3}$ (sample RAYBF1+OPF1) to $6.7 x10^{3}$ (sample RAYBF5+OPF5) cfu/g. The microbial loads of the sample were generally low. However, there were variations in the microbial load of the samples, this may be attributed to handling of the product after processing. There was no mould growth in all the formulated breakfast cereals which could be attributed to the low moisture content of the formulated samples. This implies that product could be kept for a very long time.

Table 6: Microbial count (cfu/g) of the breakfast cereals

Sample	TVC (cfu/g)	Mould (cfu/g)
RF	4.5×10^3	ND
RAYBF1+OPF1	3.0×10^3	ND
RAYBF2+OPF2	4.7×10^3	ND
RAYBF3+OPF3	4.5×10^3	ND
RAYBF4+OPF4	5.3×10^3	ND
RAYBF5+OPF5	6.7×10^3	ND

Values are means of duplicate determinations. Key: R: Rice flour; AYB: African yam bean flour; OPF: Orange fleshed sweet potato flour **;** *ND: Not detected; TVC: Total viable count; RF: 100% Rice flour; RAYBF1+OPF1***:** *90% of best blend+10% orange fleshed sweet potato; RAYBF2+OPF2: 80% best blend+20% orange fleshed sweet potato; RAYBF3+OP3=70% best blend+30% orange fleshed sweet potato; RAYBF4+OP4=60% best blend+40% orange fleshed sweet potato; AYBF5+OP5=50% best blend+50% orange fleshed sweet potato.*

3.5 Sensory Scores of Ready-to-eat Breakfast Cereals Formulated from Local Rice, Malted African Yam Beans and Orange-fleshed Sweet Potato Flour Blends

The sensory scores of the ready-to-eat breakfast cereals formulated from local rice, malted African yam beans and orange-fleshed sweet potato flour blends are shown in Table 7 and Plate 4, 5,6,7, 8 and 9.

From the Table, the mean scores for colour ranged from 7.60 to 5.95 with sample RF (100 % Adani rice flour) having the highest value and sample RAYBF4+OPF4(60:40) having the lowest value. Sample RF was preferred probably because of its unique cream colour, however, there was only a slight significant difference ($p<0.05$) between the samples, there was no significant difference ($p>0.05$) between samples RF, RAYBF1+OPF1 and RAYBF2+OPF2, no significant difference ($p>0.05$) between samples RAYBF3+OPF3, RAYBF4+OPF4 and RAYBF5+OPF5 and no significant difference ($p>0.05$) between RAYBF1+OPF1, RAYBF2+OPF2 and RAYBF3+OPF3 and this could be because the panelists liked the products in terms of colour. The colour of the ready-to-eat breakfast cereals became darker (from light brown to dark brown) with increasing level of orange-fleshed sweet potato in the blend. This could probably be because potatoes are more apt to scotch or discolour during dehydration or darken during product storage when they have high reducing sugar content. This discolouration could be due to the reactions involving amino acids and reducing sugars [42]. The sensory score for flavour ranged from 6.20 to 7.70 with sample RF(100%) having the least score and sample RAYBF5+OPF5 (50:50) having the highest score. There were no significant ($p<0.05$) different in flavour among the samples. It was observed that malted African yam bean as well as the orange flesh sweet potato improved the flavor of the product. The sensory scores for taste ranged from 6.20 to 7.70 with sample RAYBF2+OPF2 (80:20) having the lowest score and sample RAYBF5+OPF5 having the highest score. There was no significant ($p<0.05$) difference in the taste of the blends and the control (100% rice). The samples were found to have a good taste which could be attributed to the sweetness of the orange-fleshed potato flour as a result of its high reducing sugar content. A similar result was obtained by [43]. The sensory scores for texture ranged from 5.95 to 7.20 with sample RAYBF5+OPF5 (50:50) having the least score and sample RF (100%) and RAYBF1+OPF1(90:10) having the highest scores. The low texture score of sample RAYBF5+OPF5(50:50) could be attributed to the increase in the amount of orange-fleshed sweet potato flour in the blend. This was because, the orange-fleshed sweet potato had a coarse particle size (300 μm). There were no significant ($p<0.05$) difference among the samples and the control (100% rice) except for sample RAYBF4+OPF4 which showed significant ($p<0.05$) difference with the control. Based on the overall acceptability, sample RAYBF1+OPF1 and RAYBF5+OPF5 had the highest score (7.30), followed by the control (100% rice) 7.10. Sample RAYBF4+OPF4 had the least score (6.60). There were no significant ($p<0.05$) difference among the samples and the control. All the samples had a good rating for all the sensory attributes since their scores were higher than the mean 4.5 for a 9 – point Hedonic scale used for the sensory. There was much acceptance of the newly formulated samples by the panelists. This shows that breakfast cereals formulated with local raw materials are highly acceptable in Nigeria.

Table 7: Sensory scores for ready-to-eat breakfast cereals formulated from rice, African yam bean and orange-fleshed sweet potato flour blends .

Sample	Colour	Appearance	Flavor	Texture	Mouth feel	Taste	Aftertaste	Overall acceptability
RF	$7.60^{a}\pm0.94$	$7.40^{a}\pm1.23$	$6.20^{b}\pm2.07$	$7.20^{a}\pm1.40$	$6.95^{ab}\pm1.67$	$6.70^{ab}\pm1.53$	$6.60^{ab}\pm1.50$	$7.10^{a}\pm1.60$

RAYBF1+OPF1	7.30^{ab}±1.40	7.20^{ab}±1.43	7.20^{ab}±1.01	7.20^{a}±1.80	7.10^{ab}±1.60	6.90^{ab}±1.80	6.60^{ab}±1.50	7.30^{a}±1.60
RAYBF2+OPF2	7.10^{ab}±1.21	6.95^{ab}±0.82	6.70^{b}±1.04	6.80^{ab}±1.61	6.60^{b}±1.40	6.20^{b}±1.74	6.00^{b}±1.30	6.60^{a}±1.20
RAYBF3+OPF3	6.30^{bc}±1.74	6.80^{ab}±1.40	7.10^{ab}±1.61	7.10^{a}±1.16	7.10^{ab}±1.61	6.90^{ab}±1.63	6.50^{ab}±1.40	6.90^{a}±1.41
RAYBF4+OPF4	5.95^{c}±1.90	6.50^{b}±1.43	6.80^{b}±1.62	5.95^{b}±1.70	6.10^{b}±2.13	6.20^{b}±1.70	6.10^{b}±1.83	6.60^{a}±1.85
RAYBF5+OPF5	6.90^{bc}±1.62	7.20^{ab}±1.50	7.70^{b}±1.40	7.30^{a}±1.70	7.50^{a}±1.80	7.70^{b}±1.63	7.20^{a}±1.98	7.30^{a}±1.84

Values are means ± Standard Deviation (SD) of duplicate determinations. Values having the same superscript (a,b and c) within the same column are not significantly (p>0.05) different. Key: RF:100% Rice Flour , RAYBF1+OPF1(90:10) =90%rice/African yam best blend fl [...] weet potato flour; RAYBF2+OPF2(80:20) = 80%rice/African [...] 20% orange-fleshed sweet potato flour; RAYBF3+ OPF3 [...] am bean best blend flour + 30% orange-fleshed sweet po [...] 0:40) = 60% rice/African yam bean best blend flour+ 40% orange-fleshed sweet potato flour and RAYBF5+OPF5(50:50) = 50%

rice/African yam bean best blend flour + 50% orange-fleshed sweet potato flour. CHO: Carbohydrate

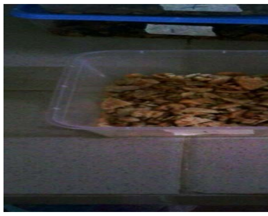

Plate 4: 100% rice

Plate 5: 90%best blend + 10% Orange-flesh sweet potato flour

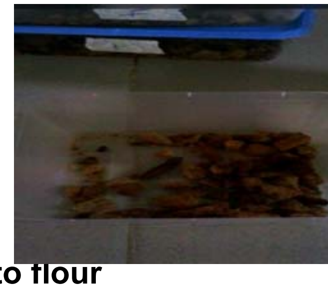

Plate 6: 80%best blend + 20% Orange-flesh sweet potato flour

Plate 7: 70%best blend + 30% Orange-flesh sweet potato flour

Plate 8: 60% best blend + 40% orange-flesh potato flour Plate 9: 50% best blend + 50% orange-flesh sweet potato flour

4. CONCLUSION AND RECOMMENDATION

The study showed that ready-to-eat breakfast cereals could be formulated from rice, African yam bean and orange fleshed sweet potato which are presently underutilized. From the study, it was observed that among the breakfast cereals formulated from rice and African yam bean flour, the judges preferred sample RF +AYBF1 which was selected as the best blend. The breakfast cereals formulated from rice, African yam bean and orange fleshed sweet potato flour were highly rated and acceptable to the panelists in all the attributes assessed. Thus, blending of rice, African yam bean and orange fleshed sweet potato flour improved the acceptability and nutritional value of the resultant breakfast cereal. It was also observed that malting of the African yam bean increased the nutritional composition and functional properties and reduced the anti-nutrients present in the legume during processing. The resulting product from the study contained appreciable amount of carbohydrate which provides energy to the body when consumed. The inclusion of orange fleshed sweet potato to the blend improved the mineral (ash, fibre and β-carotene) content of the breakfast cereal. The formulated breakfast cereals had very low microbial load while no mould was detected. The production of breakfast cereal from the raw materials used in this study would contribute to the nutritional needs of individuals who are protein and vitamin A deficient. The high nutrient density and low bulk of the flours could serve as good base ingredients to be used especially in breakfast cereals so as to enhance dietary diversification.

It is recommended that further studies be carried out on the breakfast cereals to determine their health benefits and storage stability, further studies should also be carried out to determine the storage life and stability (please)of the product. Consumers should also be enlightened on nutrient bioavailability of the genetically modified orange flesh sweet potato. The production of breakfast cereal from the blends used in the study should be encouraged as this would help alleviate to a reasonable extent protein and vitamin A deficiency and promote diversification of their utilization.

Reference

1. MayoClinic, (2009). Why is breakfast the most important meal of the day ?.http://www.mayoclinic.com/health/food-and-nutrition/AN01119. [Accessed 16 December 2010].

2. Sharma, JI. Caralli, S. . A Dictionary of Food and Nutrition. CBS Pub. New Delhi. 2004

3. Jones, MP., Dingkuhn, M., Aluko, GK., Semon, M. Interspecific oryza sativa L. x O. glaberrimasteud progenies in upland rice improvement. Euphytica, 1997 92, 237-246.

4. Okaka, JC. Handling, Storage and Processing of Plant Foods. OJC Academic Publishers, Enugu. 2005 not complete please check the source

5. Gernah, DI., Ariahu, CC. and Ingbian, EK. (2011).Effect of malting and lactic fermentation on some chemical and functional propertoes of maize. American Journal of Food Technology,11:432-435.

6. Oko, AO. Ugwu, SI. The proximate and mineral compositions of five major rice varieties in Abakaliki, South-Eastern Nigeria. International Journal of Plant Physiology and Boichemistry,2011; 3(2) :25-27.

7. Frei M, Becker K. Agro-biodiversity in subsistence-oriented farming systems in a Philippine upland region: Nutritional considerations. Biodiversity and Conversion. 2004;13:1591-1610.

8. Usman, GO. Production and evaluation of breakfast cereals from blends of African yam bean (*Shenostylisstenocarpa*), maize (*Zea mays*) and defetted coconut (*Cocusnucifera*). M.Sc. Dissertation, University of Nigeria, Nsukka. 2012

9. Porter, D. Economy Botany of *Sphenostylis* (Leguminosae). Economic Botany1992; 46: 262 -275. Same check the source

10. Azeke, MA., Frettzdorf, B., Buening-pfane, H., Holzapfel, W. Betsche, T. Nutritional Value of African yam bean (*Sphenostylisstenocapa L)*: Improvement by Lactic Acid Fermentation. Journal of Food Science and Agriculture, 2005;85(2): 963 – 970.

11. Enwere, JN. Foods of Plant Origin: Processing and Utilization with Recipes and Technology Profiles. 1st Edition. Afro-orbis Publications Ltd,1998; pp: 50 – 60.

12. Bovell-Benjamin AC . Sweet Potato: A review of its past, present, and future role in human nutrition. Adv. Food. Nutr. Res.2007; 52(1): 1 - 59.

13. Iwe MO, Onyeukwu U, Agiriga AN. Proximate, functional and pasting properties of FARO44 rice, African yam bean and brown cowpea seeds composite flour. Journal of Food and Agriculture; 2016. Available:http:dxdoi.org/10.1080/23311932 .2016.1143409.

14. Anon (2009). The free Encycopedia. http:// www.wikepedia.com. [Accessed on September, 2010].

15. Laryea D. Formulation and characterization of sweet potato-based complimentary food. Ph.D thesis. Department of Food Science and Technology, Kwame Nkrumah University of Science and Technology, Ghana. 2016.

16. Philips RD, Chinnan MS, Branch AL, Miller J, Mcwatters KH.Effects of pre – treatment on functional and nutritional properties of cowpea meal. Journal of Food Science. 1998;53:805–809.

17. Onwuka GI. Food analysis and instrumentations theory and practice. 1st edition. Lagos; Naphtali Prints. 2005;29–73.

18. AOAC. Association of official analytical chemist, official methods of analysis. 18th edition, Washington DC, USA; 2010.

19. AACC. Approved methods of American association of cereal chemists (10th edition). Minnesota: American Association of Cereal Chemists. St. Paul. 2000;276– 280.

20. Onyeka EU, Nwabekwu IO. Phytochemical profile of some leafy vegetables dried using solar dryer. Nigeria Food Journal 2007;1:72-82.

21. Prescott LM, Harley JP, Kelein OA. Microbial nutrition: Types of media. In: Microbiology, Sixth edition. New York; McGrawill. 2005;93–105.

22. Ihekoronye, AI. Ngoddy, PO. Integrated Food Science and Technology for the Tropics. Macmillan publishers Ltd., London, 1985; pp 345 – 360.

23. SON Nigerian industrial standard for pastas. Standard organization of Nigeria. ICS : 2007;664.68. pp. 1-8.

24. Wardlaw, GM. Kessel, MW. Minerals: Dietary Needs Absorption, Transport and Excretion. In: Perspective in Nutrition. (5th edition), McGraw-Hill Companies Incorporation, New York, pp 2002;418-464.

25. Mohammad K, Ziaul H, Sheikh N. Comparison of the proximate composition, total carotenoids and total polyphenol content of nine varieties of orange-fleshed sweet potato grown in Bangladesh. Institute of Nutrition and Food Science, University of Dhaka, Dhaka, Bangladesh; 2016.

26. Kure OA, Bahago EJ, Daniel EA. Studies on the proximate composition and effect of flours particle size and susceptibility of biscuits produced from blends of soybeans and plantain flours. Namado Technology Scope Journal. 1998;3(2):17-22.

27. Matil KF. Functional requirement of proteins for foods. Journal of American Oil Chemistry Society. 2007;48: 477-480.

28. Taira H. Buckwheat introduction. Encyclopaedia of Food Technology. 2010;139.

29. Apata, DF. Ologhoba, AD. . Some Aspects of Biochemistry and Nutritive Value of African yam bean Seed (*Sphenostylis stenocarpa*). Food Chemistry.,1990; 36: 271 – 280.

30. Chukwu O, Abdul-kadir JA . Proximate composition of acha (*Digitaria exilis* and *Digitaria iburua*) grains. J. Food. Technol. 2008;6: 214-216.

31. Mbaeyi-Nwaoha IE, Uchendu NO . Production and Evaluation of Breakfast Cereals from Blends of acha and Fermented Soybean Paste (Okara). J. Food. Sci.Technol. 2016;53(1): 50-70.
32. Agu HO, Eze GC, Jideani AIO (2008). Quality assessment of acha-based biscuit improved with bambara nut and unripe plantain. Afr. J. Food. Sci. 8(5): 278-285.

33. Kidane G, Abegaz K, Mulugeta A, Singh P Nutritional analysis of vitamin A enriched bread from orange flesh sweet potato and locally available wheat flours at Samre Woreda, Northern Ethiopia. J. Current. Nutr. Food. Sci. 2013; 1(1): 49-57.

34. Uguru, MI. Madukaife, SO.. Studies on the variability in agronomic and nutritive characteristics of African yam bean *(Sphenostylis stenocarpa*). Journal of Plant Products and Resources,2001; 6:10-16.
35. Okoye, JI. Obi, CD. Chemical composition and sensory properties of wheat-African yam bean composite flour cookies. Discourse Journal of Agriculture and Food Sciences, 2017;32(1):31-37.

36. Okoye, JI., Alugwu, SU. Obi, CD. Effect of processing methods on the proximate composition and functional properties of African yam bean (*Sphenostylis stenocarpa*). seed flours. Journal of Science, Agriculture, Food Technology and Environment, 2015; 14:1-6.

37. Igbabul B, Num G, Amove J . Quality evaluation of composite bread produced from wheat, maize and orange fleshed sweet potato flours. Amer. J. Food. Sci. Technol.2014; 2(4): 109-115.
38. Jeckins DJA. Dietary fibre, Lente carbohydrates and the insulin resistant diseases. British Journal of Nutrition 2000; 83:157-163.
39. Usman GO. Production and evaluation of breakfast cereal made from blends of sorghum, soybeans and defatted coconut. An M.Sc dissertation of the Department of Food Science and Technology, University of Nigeria, Nsukka, 2009.
40. Temesgen L, Abebe H, Tigist F. Production and quality evaluation of cookies enriched with β-carotene by blending orange-fleshed sweet potato and wheat flours for alleviation of nutritional insecurity. Intern. J. Food. Sci. Nutr. Eng.2015; 5 (5): 209-217.
41. Mbaeyi IE . Production and evaluation of breakfast cereal using pigeon-pea (*Cajanus cajan*) and sorghum (*Sorghum bicolor*), An M.Sc. dissertation of Department of Food Science and Technology, University of Nigeria, Nsukka, 2005.
42. Tewe OO, Ojeniyi FE, Abu OA. Sweet potato production, utilization and marketing in Nigeria. Department of Social Sciences, International Potato Centre (CIP), Lima, Peru; 2003.
43. Umego E. Chemical composition, physical and sensory properties of fried noodles prepared from wheat, sweet potato and soybean flour blends. A B.Sc. Project, Department of Food Science and Technology, University of Nigeria, Nsukka; 2012.
5 Ge