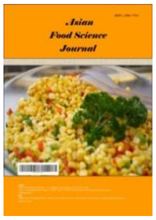

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Evaluation of Stiff Porridge (*Ruam nahan*) Produced from Composite Flour Blends of Pearl Millet (*Pennisetum glaucum*) and African Yam Bean (*Sphenostylis stenocarpa*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Quality attributes of stiff porridges prepared from Pearl millet and African Yam Bean (AYB) flour blends were studied. Various ratios such as A (100% pearl millet), B (90:10), C (80:20), D (70:30), E (60:40) and F (50:50) of pearl millet and African Yam Bean (AYB) composite flours were mixed and analyzed for functional, proximate composition, mineral elements and sensory properties. The blends were then prepared into stiff porridges for sensory evaluation using a 20-man sensory panel. Substitution of African Yam Bean with Pearl Millet led to increases in moisture (24.29 to 37.50%) protein (10.90 to 19.70%), fibre (1.30 to 2.00%), Ash (0.43 to 0.55%) and fat (3.80 to 5.20%) while the carbohydrate content of the blends decreased (from 62.07 to 39.85%) respectively. Functional properties such as bulk density decreased with increase in AYB from (1.80 to 0.72 g/ml, swelling index also increases from 0.75 to 0.56 g/ml, water absorption capacity decreases from 2.20 to 2.64 g/ml) and Least Gelation Concentration (6%). The sensory attributes

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of stiff porridges were not adversely affected by African Yam Bean flour. Therefore, it should be possible to incorporate up to 50% of legumes such as African Yam Bean with Pearl Millet in the preparation of stiff porridges.

Keywords: Pearl millet; African yam bean; functional properties; stiff porridge.

1. INTRODUCTION

Protein deficiency in diets is common in Nigeria and this is usually associated with deficiencies in calories leading to endemic Protein Energy Malnutrition (PEM) with its attendant health consequences mostly in children. Despite abundant global food supplied, widespread malnutrition persists in Nigeria and many other developing countries [1]. The WHO and UNICEF have been concerned about this trend, particularly of Protein Energy Malnutrition (PEM) and micronutrient deficiencies among infants, children and pregnant women. The United Nations" Standing Committee on Nutrition (SCN) pointed out that malnutrition is directly and indirectly associated with more than 50% of all children mortality, is the contributor to disease in developing world [2]. Seed proteins, especially from leguminous sources such as soybeans, have been put forward as potentially excellent sources of protein for the nutritional quality upgrading of starchy roots and tubers for use in foods [1]. From a nutritional point, legumes are of particular interest due to its high amounts of protein (18 – 32%) [3]. In addition to providing a good source of amino acids and bioactive peptides, pulse proteins contain functional properties such oil binding, water holding, foaming and gelation that increase their potential use in variety of food products [3]. Legumes are not solely good sources of protein but also, it is a good source of carbohydrates [4]. Starch and/or carbohydrates generally remains a major source of calories in the human diet and could be found in large amount in plants parts such as, its roots and tubers, stems, seeds and grains among others. Starch is the most important carbohydrate consumed on a worldwide basis because of its abundance and low price [4]. Legume starches promote slow and moderate postprandial glucose and insulin responses, and have low glycemic index [4]. It contains variable amount of lipids that interact with carbohydrates to play an important role in their functional properties, end product quality, shelf life and texture of starch-based foods [5]. Starch is a principal constituent of many foods, a major source of energy and an essential factor in the gross structure, texture or consistency of most foods. Commercial starches are obtained from grains such as maize, wheat and rice, and from roots and tubers such as Irish potato, sweet potato and cassava [6]. In the southern parts of Nigeria, starch is especially used in the preparation of Stiff porridges (with or without the addition of palm oil) which is then consumed with stews, *oha, ora* and/or vegetable soups. Stiff porridges are prepared mostly from cassava starch. In these parts of Nigeria as with most of sub-Saharan Africa, malnutrition is still prevalent notwithstanding the targets of the United Nations' Millennium Development Goal (MDG) and the Sustainable Development Goals (SDG) number one to eradicate hunger (visible and hidden) by 2015. This may be due in part to the frequent consumption of starchy foods that are often low in protein and micronutrients. Cassava, being the main starch source in the preparation of stiff porridges (*ruam nahan*) in most Nigerian homes, may be over-exploited especially with the crop being targeted, most recently as a principal source of biofuels in Nigeria. Foods with high glycemic index (eg. cassava starch) tend to release energy rapidly and raise blood sugar level. Such is undesirable in diets of individuals with compromised health challenge such as diabetics [4]. As the number of people diagnosed with diabetes continues to rise globally, nutritional approaches to diabetes prevention is one step researchers ought to take to address this situation. This could be achieved through formulating diets to optimize health and reduce the risk factors of metabolic syndrome in an aging population [7]; [4]. For this reason and others, research into alternative starch sources with slow and/or low digestibility in staple food preparations such as Stiff porridges have been made [6]; [4].

Pearl millet is an indispensable food for millions of people inhabiting the semi-arid tropics, and is more important in the diet of poor. It is used primarily for human food and remains a major source of calories and a vital component of food security in the semi-arid areas in the developing world. Pearl millet is processed in so many ways for preparation of various food products. Some of the primary processes employed are de-hulling and milling in order to produce flours, grits and de-hulled whole grains. These intermediate products are used to prepare staple foods like cooked whole grain, thin and thick porridges, steam cooked products, for example *couscous, burabosko, kunun zaki*, preparation of *tuwo* and *fura*. Millet can also be malted to produce alcohol/non-alcoholic beverages and weaning foods [8]. Relative little information on specific types of pearl millet that have optimum properties for each of these food systems in Nigeria is currently available. The knowledge of physical characteristics and chemical composition of millet cultivars is very important to food processors and nutritionist. The food processors need to understand what they are working with and what happen to the quality of the gains when they are subjected under various conditions of food processing. The nutritionists are interested in the nutrient composition of the food products in order to determine its nutritional value [8]. African Yam bean (AYB) is an under-utilized grain legume in Nigeria. African Yam Bean (AYB) is a good source of protein, fibre and carbohydrate. It is also rich in mineral elements such as phosphorus, iron and potassium [8] but contain some anti-nutrients such as trypsin inhibitor, phytate, tannins, oxalate and alkaloids [9,10]. This research article is aimed at developing a traditional food known as *ruam nahan* supplemented with African Yam Bean flour rich in protein and minerals elements for the less privilege population.

2. MATERIALS AND METHODS

2.1 Source of Materials

African Yam Bean (AYB) and Pearl Millet grain were purchased from wurukum Market, Makurdi, Benue state, Nigeria.

2.2 Preparation of Pearl Millet Flour

This was done according to the method as described by Ocheme, [11] One (1) kg of pearl millet grain were thoroughly cleaned, winnowed, washed and steeped. It was subsequently dried at 60°C for 12 hrs. after which it was milled, sieved (455µm) aperture to get the fine flour. The flour obtained was packaged and stored for further use. Fig. 1 shows the flow chart for the production of pearl millet flour.

2.3 Preparation of African Yam Bean Flour

The African Yam Bean (AYB) flour was prepared according to the method as described by Enenche, [12]. Two (2) kg of African Yam Bean (AYB) seeds were cleaned, winnowed to remove stones, debris, leave, stalks as well as bad and infested seeds etc. it was then steeped in tap water containing 0.1% sodium meta-bisulphite ($NaHSO_3$) solution for 12 hrs. The water was drained off and the soaked seeds were manually dehulled. It was then allowed to stand in hot water at 100°C for 8 mins. The water was drain off and the seeds were spread on the tray and placed in a hot air oven at 60°C for 12 hrs to dry. The dried seeds were then milled into flour using attrition mill and sieved through a 455 µm aperture to obtain a fine flour. The flour was packaged and kept for further use. Fig. 2 shows the flow chart for the production of African Yam Bean (AYB) flour.

2.4 Preparation of Stiff Porridge

Stiff porridge *(ruam nahan)* was prepared according to the modified method as described by Karim et al. [13] by pouring 500 ml of distilled water into a stainless-steel pot. The water was allowed to boil at 100°C. Two hundred and fifty (250) g of each composite flour was added to the boiling water while stirring vigorously and continuously with a wooden paddle until it forms a gelatinized (Stiff porridge) paste. The paste was covered and left on the fire for about 5 minutes to cook. It was further stirred, packed and wrapped with thin labeled polythene wraps.

2.5 Determination of Functional Properties

2.5.1 Determination of bulk density

Bulk density was determined using the method as described by Dendegh et al*.,* [14]. Ten (10) grams of sample was weighed into 50 mL graduated measuring cylinder and the bottom of the cylinder was tapped repeatedly on a firm pad on a laboratory bench until a constant volume was observed. The volume was recorded and bulk densities were calculated as the ratio of the sample weight to the volume occupied by the sample.

$$\text{Bulk Density} = \frac{\text{weight of sample (g)}}{\text{Volume occupied (ml)}}$$

2.5.2 Determination of water absorption capacity

Water and oil absorption capacities were determined according to the method described by Dendegh et al., [14]. One (1) gram of each sample was mixed with 20 mL distilled water (for water absorption capacity) and 20 mL of oil (for oil absorption capacity) in a flask shaker and centrifuged at 2,000 rpm for 1 hr. Water/oil absorbed by samples was calculated as the difference between the initial and final volumes of water/oil.

$$WAC = V_O - V_1$$

Where,

WAC = Water absorption capacity
V_O = Initial volume of water (20ml)
V_1 = Volume of water (supernatant)

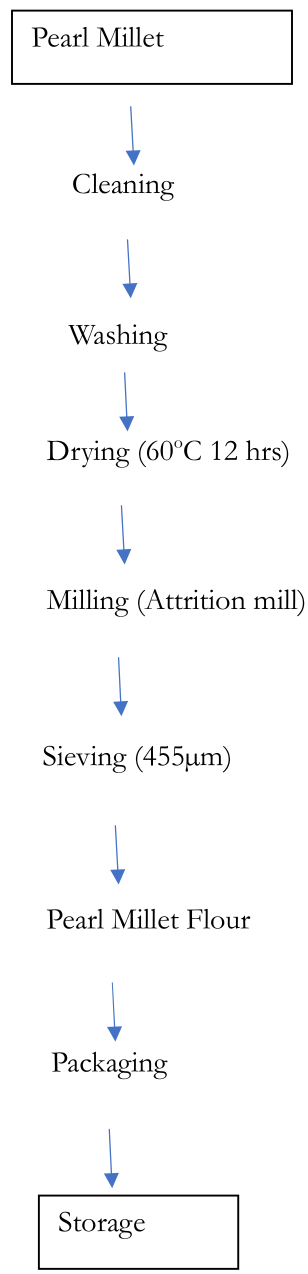

Fig. 1. Flow chart for the Production of Pearl Millet Flour

African Yam Bean

↓

Cleaning

↓

Soaking in 0.1 $NaHSO_3$ for 12 hrs

↓

Dehulling

↓

Steeping hot water (100°C for 8min)

↓

Draining

↓

Drying (60°C for 12 hrs)

↓

Milling (attrition mill)

↓

Sieving (455µm)

↓

African Yam Bean Flour

Fig. 2. Flow chart for the production of pearl millet flour

Table 1. Blend formulation

Sample code	Pearl Millet	African Yam Bean
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40
F	50	50

2.5.3 Determination of swelling index

Swelling index was determined using the modified method described by Dendegh et al., [14]. One (1) gram of the sample was put into 50 mL centrifuge tube. Fifty (50) mL of distilled water was added and mixed gently. The slurry was heated in a water bath at 80°C for 15 min. During heating, the slurry was stirred gently to prevent clumping of the flour. On completion of 15 min, the tube containing the paste was centrifuged at 3000 rpm for 10 mins. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of the sediments gel was, therefore, determined to get the dry matter content of the gel.

$$\text{Swelling Index} = \frac{\text{weight of wet sediment}}{\text{weight of dry matter in the gel}}$$

2.5.4 Least gelation capacity

The least gelation capacity was determined using the method as described by Onwuka, (2005). Two (2) to 15% (w/v) of sample was weighed into test tubes. Five (9) ml of distilled water was added and heated for one (1) hour in boiling water. The test tubes were cooled in ice cold water at $4^{o}C$ for 30 min. Gelation capacity was determined as the concentration that will not fall when the test tubes were inverted.

2.6 Proximate Composition

2.6.1 Moisture content determination

The moisture content of the samples was determined according to the method as described by Dendegh et al., [14]. Two grams each of the flour samples were weighed into different moisture cups. It was then placed in an oven at 100ºC for three hours. Drying was stopped after obtaining two consecutive values differing by 0.001. The samples were cooled in a desiccator and weighed

$$\%\, Moisture\ content = \frac{\mathrm{W2-W3}}{\mathrm{W2-W1}}\ X\ 100$$

Where:

W1 = initial weight of empty can,
W2 = weight of empty can + sample before drying,
W3 = final weight of empty can + sample after drying

2.6.2 Ash content determination

Ash content was determined according to the method described by Dendegh et al., [14]. Porcelain crucible was dried and cooled in desiccators before weighing. Two (2) grams of the sample flours were weighed into the crucible and the weight taken. The crucible containing the samples were placed in the muffle furnace and ignited at 600ºC. This temperature was maintained for 2 hours. The muffle furnace was then allowed to cool; the crucibles were then brought out, cooled and weighed. The ash content was calculated as follows:

$$\%\, Ash\ content = \frac{\mathrm{W2-W3}}{\mathrm{W1}}\ X\ 100$$

Where:

W2 = weight of crucible + ash,
W1 = weight of empty crucible

2.6.3 Crude fat content determination

The fat content of the samples was determined using the method as described by Dendegh et al., [14]. Two (2) grams each of the flour samples was weighed and transfered in a thimble and placed in a soxhlet reflux flask which is connected to a condenser on the upper side and a weighed oil extraction flask full with 200 ml petroleum ether. The ether was brought to its boiling point, the vapor condensed into the reflux flask immersing the samples completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation, and reflux was allowed to go on for four hours before the defatted samples were removed. The oil extract in the flux was dried in the oven at 60˚C for thirty minutes and then weighed.

$$\% \, Fat \, Content = \frac{W_4 - W_3}{W_2 - W_1}$$

Where:

W_1 = weight of oven dried thimble,
W_2 = weight of sample
W_3 = weight of round bottom flask,
W_4 = weight of round bottom flask with fat residue.

2.6.4 Crude fibre determination

The crude fibre of the samples was determined according to the method as described by Dendegh et al*.,* [14]. Two (2) grams of each of the sample (defated) were boiled under reflux for thirty minutes with 200 mL of the acid solution containing 1.25 g of H_2SO_4 per 100 mL of solution. The solution was filtered through linen on a flaunted funnel and washed with water until the washing is no longer acidic. The residue was then transferred to a beaker and boiled for thirty minutes with 100 mL of (NaOH) solution. The final residue was filtered through a thin but closer pad of washed and ignited asbestos in a Gosh crucible. The residue was then dried in an electric oven and weighed; the residue was incinerated, cooled, and weighed.

$$\% \, Crude \, Fibre = \frac{W_2 - W_3}{W_1} \, X \, 100$$

W_1 = weight of sample used,
W_2 = weight of crucible + sample,
W_3 = weight of sample crucible + ash

2.6.5 Crude protein determination

Crude protein of the sample flours was determined using the Kjeldahl method as described by Dendegh et al*.,* [14]. One gram of the sample was introduced into the digestion flask. Kjedahl catalyst (Kjedahl Tablets) was added to the sample. Twenty ml of concentrated H_2SO_4 was added to the sample and fixed to the digester for eight hours until a clear solution was obtained. The cooled digest was transferred into one hundred ml volumetric flask and made up to the mark with distilled water. The distillation apparatus was set and rinsed for ten minutes after boiling. Twenty ml of 4% boric acid was pipetted into a conical flask. Five drops of methyl red were added to the flask as an indicator and the sample was diluted with seventy-five ml distilled water. Ten ml of the digest was made alkaline with twenty ml of NaOH (20%) and distilled. The steam exit of the distillatory was closed and the change of color of the boric acid solution to green was timed. The mixture was distilled for fifteen minutes. The filtrate was then titrated against 0.1 N HCl. The percentage total nitrogen was calculated:

$$\%N = \frac{\text{titre value} - \text{Blank} \times 0.0014 \times 100 \times 25}{\text{Weight of sample}}$$

% protein = % nitrogen ×conversion factor (6.25)

2.6.6 Carbohydrate content determination

Carbohydrate content of the flour samples was determined by using the formula described by Ihekoronye and Ngoddy, [15].

% carbohydrate =100 −% (protein + fat + fibre + ash +moisture content.)

3. DETERMINATION OF MINERAL ELEMENTS

3.1 Sample Preparation

The samples were oven dried at 65 ^{0}C for 6 hours. One (1) g of each of the powdered components was digested as reported by Howe et al., [16].

3.2 Wet Digestion Method

To one (1.0) g of sample in 100 cm^3 beaker, 20 cm^3 of 1:3 HCl: HNO_3 was added. The beaker was covered with a watch glass and was allowed to stand overnight. It was then digested at 110 ^{0}C for 60 mins, using hot plate. The solution was allowed to cool and made up to the mark of 50 cm^3 volumetric flask with 2% Nitric acid (HNO^3. The flask was then covered and kept for analysis. The blank was prepared using the same procedure above but in this case the sample was excluded. The digest was then heated to boil, cooled and subsequently filtered through a What-man filter paper N0 1 into a 100 ml volumetric flask. Calcium, potassium and sodium were determined using Jenway Digital Flame Photometer (PFP7 Model) while other minerals apart from phosphorus were determined using Buck Scientific Atomic Absorption Spectrophotometer (Buck 210VGP Model).

3.3 Sensory Evaluation

Sensory evaluation of the stiff porridge samples prepared from the composite flours was performed 4 hr after production using the 9 points Hedonic scale 9- points hedonic scales (where 1 = dislike very much and 9 = like very much) as described by [17]. A total of 30 semi-trained panelists aged 18 years and above were involved in the evaluation of appearance, flavour, texture and overall acceptability. The samples (100 g each) were coded with random numbers using statistical random Tables and served to the panelists with bottled water for rinsing their mouth after every sample taste in a randomized order. The panelists were instructed to rate the attributes indicating their degree of liking or disliking by putting a number as provided on the hedonic scale according to their preference.

3.4 Statistical Analyses

All analyses were carried out in triplicate unless otherwise stated. Statistical significance was established using one-way analysis of variance (ANOVA), and data were reported as the mean standard deviation. Mean comparison and separation was done using Fisher's Least Significant Difference test (LSD) at $p \leq 0.05$. Statistical analysis was carried out using the SPSS 25 statistical package.

4. RESULTS AND DISCUSSION

4.1 Effect of African Yam Bean Supplementation on the Functional Properties of Stiff Porridge

The functional properties of composite flour from Pearl millet supplemented with African Yam Bean (AYB) samples are shown in Table 2:

4.2 Bulk Density

Bulk density ranged from 0.69 to 1.80 g/ml. Bulk density of the control (A) samples was higher than the composite flour samples. There were significant ($p< 0.05$) differences in bulk density among the samples. Bulk density shows that particle size of the samples is closely related as reported by [18]. This indicates that, the sample could exhibit the same packaging characteristics. Ocheme et al*.,* [19] reported that, high bulk densities indicate the samples suitability for use in various food preparations and this will benefits packaging and distribution, storage and transportation. The control (A) sample been the highest will occupy less space per unit weight compared to the other samples. Padmashree et al*.,* [20] reported that, higher bulk density is desirable for greater ease of dispersibility of flour. In contrast however, low bulk are suitable for complementary foods (e.g samples C) [21]. Bulk density of the food increased with increase in starch content. This explains why bulk density decrease with increase in African Yam Bean flour supplementation. Bulk density also indicates the volume of the packaging material required. Flour particle size and density are factors influencing their bulk density which is an indication of the porosity of a product and determinant on the cost and choice of packaging material, raw material handling and application in wet processing in the food industry.

4.3 Swelling Index

Swelling index indicates the ability of the sample to hold water (water holding capacity) due to starch, which has generally been used to demonstrate differences between various types of starches [22], [4]. Swelling index of the samples varied significantly ($p \leq 0.05$) from 0.49 to 0.75 respectively. Swelling index of the samples decreased with increase in African Yam Bean (AYB) flour supplementation. Swelling index of samples, A (control) and B were similar and higher than the other samples. The variation in swelling properties of the samples could be attributed to increase in African Yam Bean (AYB) flour supplementation. According to Swinkels [23], swelling index of these is affected by the presence of lipids. Degree of starch damage (Blue Value) could also affect the swelling index of the samples. Damaged starch granules have greater affinity for water, resulting in increased water absorption and swelling power. This could be responsible for low swelling index and water absorption capacity as observed in the samples when used in the preparation into stiff porridge *(ruam nahan)* [4].

4.4 Water Absorption Capacity

Water absorption capacity represent the ability of a product to interact or associate with water where water is limiting [24]; Chimma et al*.,* 2010). There was no significant ($p>0.05$) difference between samples D, E and F. The result also shows that sample B and C were not significantly ($p>0.05$) different. The water absorption capacity ranged from 2.20 to 2.64 g water/ml. These values tend to be higher than those reported by [25] for cowpea varieties.

According to [26], protein has both hydrophilic and hydrophobic properties therefore can interact with water in food samples. Other factors that affect water absorption may include nature of the molecules, presence of lipids, thermodynamic properties of the system (such as bond energy and interfacial tension) as well as the physicochemical environment such as pH, ion concentration, temperature and pressure [6]. Carbohydrates' have also been reported to influence water absorption capacity of foods [27]. Variation in the water absorption capacity could be due to difference in protein concentration, degree of interact and conformational characteristics [26]. Samples supplemented with African Yam Bean (AYB) had high values while the Control (A) sample had a low value. The high-water absorption capacity could be attributed to higher amount of carbohydrate and protein content in the samples. Also, the high-water absorption capacity in some instance could also be attributed to the removal of the non-polar groups (in cases of defatted samples) that may interfere with starch water interaction. The water absorption values obtained in this study were higher than values as reported by [28] who reported values ranging from 2.24 to 2.61g/ml of full fat starch from brown and yellow varieties of tiger-nut.

4.5 Least Gelation Concentration

The least gelation concentration shows that all the samples gelled at 6% concentration. This could be attributed to the supplementation with African Yam Bean (AYB) or the gelation properties of the flour. Iwe, (2003) reported that, the gelation ability of soy composite flour could be attributed to the good gelling properties of soy flour used. Least gelation concentration is the time taken for a solution of the material to form a gel when treated at constant temperature. It is useful in predicting the texture of food products as well as effect on water hydration capacity [17]. Lawal et al*.,* [29] reported that, gelatinization affects the digestibility and texture of fat containing foods.

4.6 Effect of African Yam Bean Supplementation on the Proximate Composition of Stiff Porridge (*ruam nahan*)

4.6.1 Proximate composition

The result of the chemical composition of starch blends (Table 3) shows that the supplementation of pearl millet with African Yam Bean (AYB) flour led to increases in the moisture (from 24.49 to 37.50%), protein (from 10.90 to 19.70%), fibre (from 1.30 to 2.00%), ash (from 0.43 to 0.55%), fat (from 3.80 to 5.20%) and carbohydrate decreased from (62.0 to 39.857%) respectively. Increase in the proximate composition of the blends could be attributed to African Yam Bean (AYB) flour supplementation with higher moisture, protein, fat and ash contents than the 100% pearl millet. Hoover, [30] reported some similar findings.

Table 2. Functional Properties of composite flour Produced from Pearl Millet and African Yam Bean for Stiff porridge (*Ruam nahan*)

Samples	Bulk Density (g/ml)	Swelling Index (g/ml)	Water Absorption Capacity (g/ml)	Least Gelation Concentration (6% conc)
A	1.80 ± 0.01^{a}	0.75 ± 0.01^{a}	2.20 ± 0.01^{c}	Gel
B	0.71 ± 0.01^{c}	0.75 ± 0.006^{a}	2.50 ± 0.027^{b}	Gel
C	0.69 ± 0.01^{c}	0.62 ± 0.01^{b}	2.30 ± 0.01^{b}	Gel
D	0.71 ± 0.01^{c}	0.58 ± 0.06^{c}	2.40 ± 0.13^{a}	Gel
E	0.76 ± 0.01^{b}	0.49 ± 0.02^{d}	2.40 ± 0.01^{a}	Gel
F	0.72 ± 0.01^{bc}	0.56 ± 0.006^{c}	2.64 ± 0.17^{a}	Gel
LSD	0.01453	0.02138	0.01572	-

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same row are significantly different from each other.

Key: A (Control) = 100% pearl millet, B = 90% pearl millet + 10% AYB, C = 80% pearl millet + 20% AYB, D = 70% pearl millet + 30% AYB, E = 60% pearl millet + 40% AYB, F = 50% pearl millet + 50% AYB, LSD = Least Significant Difference

4.6.2 Moisture content

There were significant ($p \geq 0.05$) differences in moisture content of the samples. The result shows that African Yam Bean (AYB) flour increased the percent moisture in the samples. The moisture content of the blended flour is above the limit FAO/WHO recommended value (<10%). This indicates that, the flour may spoil if not properly stored. Since the moisture content is high, molds etc can easily grow on it and render the product unfit for consumption. Moisture has an implication in terms of the consistency/texture and microbiological quality of food [31]. Olaoye et al*.,* [32] reported that lower moisture content in food have an implication to prevent from microbial contaminations. This finding agreed to the study of Nwosu et al*.,* [33] and Abraham et al*.,* [34] that reported decreasing moisture content as moringa leaf powder level increased in their complementary food prepared from maize flour, soybean flour and Moringa leaf powder.

4.6.3 Protein content

There was significant ($p<0.05$) difference in protein content of the composite flour blends. The protein content tends to increase with increase in African Yam Bean (AYB) flour supplementation. This was expected due to the high amount of protein in African Yam Bean (AYB) of 20.20 to 21.20%, this tends to agree with Enenche, (2016) who reported high protein content in African Yam Bean (AYB) over cowpea and Okoye and Egbujie, [35] reported 8.51 to 12.20% for Maize-soybean composite flour. This implies that an increase in legumes flour proportion will increase the protein content of *Stiff porridge*. Cereals are limiting in essential amino acids, lysine and tryptophan. It is expected that the amino acid of African Yam Bean (AYB) flour will complement that of the cereal flour. Protein is important for tissue replacement, deposition of lean body mass and growth [36].

4.6.4 Crude fibre content

The crude fibre content of the Stiff porridge *(ruam nahan)* ranged from 1.3 to 2.00%. The values obtained in this study were less than the fibre content from malted millet, plantain and soybean blends (2.72-3.52%) as reported by Bolarinwa et al. [37] but higher than the fibre content (0.04-2.27%) as reported by Onoja et al*.* [38] from sorghum, plantain and soybean blends. The high fibre content in this study could be attributed to African Yam Bean flours which increase as AYB increases. Nwakalor and Obi [39] reported that some legumes (e.g soybean) are rich in dietary fibre. The fibre content were just below in some cases equal to those reported by the Nigerian Raw Materials Research and Development Council (2. 0%). Crude fibre tends to add bulk to the food thus facilitating bowel movement and preventing gastrointestinal disease.

4.6.5 Minerals Content of Stiff Porridge *(Ruam nahan)* Produced from Pearl Millet and African Yam Bean composite flour blends

The mineral content of the stiff porridge is presented in Table 4. The calcium content of the stiff porridge *(ruam nahan)* ranged from 0.68 to 1.11 mg, magnesium content of the stiff porridge *(ruam nahan)* ranged from 0.41 to 0.90 mg, potassium content of the stiff porridge *(ruam nahan)* ranged from 0.34 to 0.82mg, phosphorus content of the stiff porridge *(ruam nahan)* ranged from 0.07 to 0.95 and the Iron content of the stiff porridge *(ruam nahan)* ranged from 3.11 to 6.23 ppm. The minerals content from the Table increases with increase in African Yam bean addition. This simply implies that African Yam Bean contain much mineral elements as compared to pearl millet flour. Quantitative determination of mineral elements present in foods is significant because its concentration and type present must often be labeled on food packages. Mineral elements are needed for the proper functioning of the human system, health growth and development [40]. The content of mineral elements in foods depends on the degree of the soils elements and its abundance, including the intensity of fertility [40]. Calcium is one of the mineral believed to be an important factor governing fruit storage quality [40]. Ca is the main constituent of the skeleton and is important for regulating many vital cellular activities such as nerve and muscle function, hormonal actions, blood clotting and cellular mortality. Calcium is essential for healthy bones, teeth and blood [40]. The health of the muscles and nerves depends on calcium. It is required for the absorption of dietary vitamin B, for the synthesis of the neurotransmitter [40]. These nutrients could significantly contribute to the body's metabolic processes, refreshing the body as well [41]. Magnesium provides bone strength, aids enzyme, nerve and heart functions [41]. Symptoms of magnesium deficiency ranges from growth retardation, nausea, muscle weakness and this deficiency may affect cardiac functions.

Table 3. Proximate Composition of Stiff porridge *(ruam nahan)* Produced from Pearl Millet and African Yam Bean flour

	Samples						
Parameters	**A**	**B**	**C**	**D**	**E**	**F**	**LSD**
Moisture	24.49±0.017[f]	24.80±0.10[e]	25.5±0.032[d]	26.0±0.081[c]	32.00±0.10[b]	37.50±0.10[a]	0.1413
Protein	10.90±0.100[f]	12.00±0.150[e]	13.13±0.060[d]	14.40±0.10[c]	15.30±0.01[b]	19.70±0.20[a]	0.2619
Fibre	1.30±0.020[e]	1.50±0.027[d]	1.59±0.023[c]	1.80±0.06[b]	1.80±0.01[b]	2.00±0.06[a]	0.0786
Ash	0.43±0.010[e]	0.44±0.017[de]	0.45±0.015[cd]	0.46±0.006[c]	0.08±0.006[b]	0.55±0.010[a]	0.0192
Fat	3.80±0.010[a]	3.97±0.010[b]	4.15±0.010[c]	4.26±0.032[d]	4.40±0.010[e]	5.20±0.010[f]	0.0278
Carbohydrate	62.07±0.036[a]	60.51±0.010[b]	58.80±0.016[c]	56.42±0.015[d]	49.90±0.012[e]	39.85±0.010[f]	0.0333

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same column are significantly different from each other
Key: A (Control) = 100% pearl millet, B = 90% pearl millet + 10% AYB, C = 80% pearl millet + 20% AYB, D = 70% pearl millet + 30% AYB, E = 60% pearl millet + 40% AYB, F = 50% pearl millet + 50% AYB, LSD = Least Significant Difference

Table 4. Minerals Composition of Stiff porridge *(ruam nahan)* Produced from Pearl Millet and African Yam Bean flour

	Samples						
Parameters (mg/100g)	**A**	**B**	**C**	**D**	**E**	**F**	**LSD**
Calcium	0.68±0.010[f]	0.75±0.010[e]	0.77±0.015[d]	0.86±0.010[c]	0.91±0.010[b]	1.11±0.010[a]	0.017
Magnesium	0.41±0.010[e]	0.65±0.010[d]	0.73±0.010[c]	0.80±0.010[b]	0.88±0.055[a]	0.90±0.010[a]	0.041
Potassium	0.34±0.010[f]	0.52±0.010[e]	0.66±0.005[d]	0.69±0.010[c]	0.71±0.010[b]	0.82±0.010[a]	0.014
Phosphorus	0.07±0.010[e]	0.08±0.00[d]	0.09±0.010[c]	0.90±0.010[b]	0.94±0.023[a]	0.95±0.004[a]	0.019
Iron (ppm)	3.11±0.010[f]	3.92±0.010[e]	4.08±0.015[d]	4.39±0.010[c]	5.37±0.010[b]	6.23±0.010[a]	0.018

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same column are significantly different from each other
Key: A (Control) = 100% pearl millet, B = 90% pearl millet + 10% AYB, C = 80% pearl millet + 20% AYB, D = 70% pearl millet + 30% AYB, E = 60% pearl millet + 40% AYB, F = 50% pearl millet + 50% AYB, LSD = Least Significant Difference

Table 5. Sensory Scores of Stiff porridge *(ruam nahan)* Produced from Pearl Millet and African Yam Bean composite flour blends

	Samples						
Parameters	**A**	**B**	**C**	**D**	**E**	**F**	**LSD**
Appearance	5.93^{a}	5.93^{a}	6.53^{a}	6.47^{a}	6.80^{a}	7.60^{a}	1.049
Texture	6.47^{b}	6.80^{a}	7.13^{a}	6.73^{a}	6.80^{a}	7.07^{a}	0.996
Flavor	6.60^{a}	6.40^{a}	6.67^{a}	6.13^{b}	6.00^{a}	6.60^{a}	1.257
Overall acceptability	6.93^{a}	6.80^{a}	6.60^{a}	6.80^{a}	6.87^{a}	7.53^{a}	0.834

Values are means and standard deviations of three determinations. Values not followed by the same superscript in the same column are significantly different from each other.

Key: A (Control) = 100% pearl millet, B = 90% pearl millet + 10% AYB, C = 80% pearl millet + 20% AYB, D = 70% pearl millet + 30% AYB, E = 60% pearl millet + 40% AYB, F = 50% pearl millet + 50% AYB, LSD = Least Significant Difference

Magnesium is important to prevent and/or treat diseases such as hypertension and heart diseases, diabetes, osteoporosis, migraine headaches and asthma [42]. Potassium is the third most abundant mineral in the human body and is essential to human life [41]. Potassium is the principal cat-ion in intracellular fluid and functions in acid base balance, regulation of osmotic pressure, muscle contraction and Na+/K+ ATPase [25; 43]. Moreover, has a role in the treatment of high blood pressure [42]. Phosphorous maintain blood sugar level, normal heart contraction dependent on phosphorous. It is also important for normal cell growth and repair. It helps in the process of ossification of bones by getting deposited in the form of Calcium Phosphate [41]. Iron is known in biological systems. It performs a wide range of biological functions. Iron occupies a unique role in the metabolic process. The role of iron in the body is clearly associated with hemoglobin and the transfer of oxygen from lungs to the tissue cells. Iron deficiency is the most prevalent nutritional deficiency in humans. Iron is an essential element for human beings and animals and is an essential component of hemoglobin. It facilitates the oxidation of carbohydrates, protein and fat to control body weight, which is very important factor in diabetes [41].

4.6.6 Sensory Scores of Stiff porridge *(ruam nahan)* Produced from Pearl Millet and African Yam Bean composite flour blends

The sensory score of the stiff porridge *(ruam nahan)* is presented in Table 4. The score for Appearance ranged from 5.93 to 7.60. The appearance of the samples show that, there is no significant (P<0.05) difference amongst the products produced. Sample F is the most preferred amongst the samples. There was significant (P<0.05) difference in terms of Texture between sample A and the other samples produced. Sample F was the most preferred sample. In terms of Flavour, sample A and F were most preferred and sample D was significantly (P<0.05) different from the rest of the samples. The overall acceptability show that sample F was the most preferred to the other samples produced in terms of all the parameters measured. These results are closely related to those presented by Chinma et al*.,* [4] who reported values for stiff porridge *(ruam nahan)* from defatted starches from cowpea and Soybean to be a bit higher than these ones.

5. CONCLUSIONS

The study showed that acceptable composite flour for stiff porridge *(ruam nahan)* could be produced from pearl millet and African Yam Bean flour. Also, low water absorption and swelling index of the composite flour was as a result of undefated African yam Bean flour. The bulk density was good as these values are high to enable proper packaging of the product. The addition of African Yam Bean flour to pearl millet for the production of stiff porridge *(ruam nahan)* led to higher protein, fibre, fat, Ash contents as well as lower carbohydrate contents and increased the moisture content. The mineral content shows increase in Iron content of the samples as compared to other especially in sample F. The sensory results show that acceptable stiff porridges could be prepared by using up to 50:50 of pearl millet and African Yam Bean composite flour.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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