

Effect of African Yam Bean (AYB) (*Sphenostylis stenocarpa*) on the Quality Characteristic of Extended Meat Ball

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Abstract The study was aimed at optimizing the basic formulation and processing conditions for the preparation of comminuted meat ball, extended with AYB paste (hydrated 1:1w/w). Four levels of African Yam Bean (AYB) paste (5, 10, 15, and 20%) were used as extender replacing lean meat in the formulation and preparation of comminuted meat ball. Physicochemical and sensory properties of the product were studied. pH, emulsion capacity, fat and moisture emulsion stability shows a significant difference ($P < 0.05$) with increase in the level of AYB paste with highest value for the product extended with 20% AYB. Fat and moisture loss as well as cooking loss decreased with increase in the levels of substitution. Moisture and protein percent increased significantly ($P < 0.05$) with the increasing extension level as compared with the control, while there was a reduction in fat content. Sensory evaluation for colour, texture decreased significantly ($P < 0.05$) with increasing levels of inclusion of AYB. The product showed no significant difference ($P < 0.05$) with control at 5% level of addition. However, flavour/taste compared favourably with the control up to 5% AYB up to 15% AYB flour addition in the comminuted meat ball. The study showed that AYB paste can be used as meat extender in the production of comminuted meat balls.

Keywords: African yam bean, meat, meat ball, quality characteristics

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1. Introduction

Increasing utilization of plant protein is required to support the production of protein-rich foods that can replace animal protein in the human diet so as to reduce the strain that intensive animal husbandry poses to the environment. Based on this, cookies have been fortified with *Moringa* leaves with the aim of replacing the use of milk and egg for the production of cookies [1]; as well as non-wheat cookies prepared from plantain flour and Bambara groundnut protein concentrate [2]. From a nutritional stand point with right combination, plant proteins can supply sufficient amount of essential amino acids for human health requirements. With the rapid growth in the world's population, food security has been seen as the next mega challenge for the agrifood industry. Better and more efficient utilization of plant-based proteins will become critical when the supply of animal proteins reaches maximum production capacity to feed the growing world population. The shift towards a more sustainable diet necessitates less reliance on foods of animal origin, and thus presents a huge potential for the agrifood industry to explore alternative sources of protein [3]. As a result of this, Emelike *et al.*, [4] reported defatted cashew kernel flour with protein content of 34.0% and stated that it could be a useful raw material source in

fabricated foods as meat analogues. Plant protein-based meat and dairy substitutes can deliver equivalent quality at lower costs, while fulfilling the world's priority of reducing greenhouse gas emissions [5].

The most important plant groups are cereal grains and food legumes, including oil-seed legumes. From environmental sustainability and food security point of view, there is an urgent need to increase the use of proteins from a wide range of plant sources directly for human food [6]. The high cost and limited availability of animal proteins in under developed countries have directed research interest towards several oil seed and legume proteins as potential sources of vegetable protein for food use. According to Adebowale and Sanni [7], African yam bean (AYB) is peculiarly regarded as underutilized crop due to its low esteem and lack of detailed information on its composition.

The seed and tuber of AYB contains different food fractions and minerals that are comparable to other food legumes. The seed is a highly priced food legume in South Eastern Nigeria owing to high crude protein content that falls between the ranges of 21 to 29% in tubers which is about 2 to 3 times the amount of protein in potatoes [8,9]. Emiola [10]; Oke *et al.*, [11] equally reported protein content of AYB to be about 24.72% and 23.53%, respectively. AYB ranks well among neglected crops and can contribute to food security if its genetic resources are

saved for utilization in breeding and improvement problems [12].

Different forms of local recipes have been formulated by various researchers from the crop to meet the dietary needs of the people. Among many others, Yetunde *et al.*, [13] formulated cakes from wheat and African yam bean flour blends to study the nutrient composition and sensory properties of the product. In most West African communities, the seeds are boiled and eaten with other staple foods such as yam, plantain cassava and corn/maize. The grains are usually cooked overnight because of the hard seed coat, owing to the presence of anti-nutritional factors in various quantities in AYB (like other legumes); the consumption of the bean will require processing for safety as human meals [14]. Cooked seeds of AYB have higher fibre content, high efficiency of protein digestibility, higher amino acid availability, high gross and metabolizable energy and good fatty acid profile [15]. The *lysine* and *methionine* contents of the protein are equal to or better than those of soybean protein [13]. Its protein concentrate has been reported to be used in fortification of starch, foods like maize, cassava and pap flours [16].

Most meat proteins from a variety of plant sources such as soy protein, common bean flour and corn flour [17,18,19] have been used as binders and extenders in comminuted meat products. Legumes provide energy, proteins, minerals, vitamins and most importantly dietary fibre required for human health. Most extenders enhance protein content, improve processing yields and reduce formulation cost [19]. Recent studies involving cowpea flour as an extender up to 10% inclusion in coarse smoked pork, meat balls and comminuted beef and pork frankfurter-style sausage have shown promising results in terms of yield and sensory qualities of these products [20]. Thus, the present study was envisaged to evaluate the effect of African yam bean paste as a replacer on the quality characteristics of comminuted meat product.

2. Materials and Method

African yam bean (*Sphenostylis stenocarpa*) was obtained from Mile one market in Port Harcourt, Rivers State, Nigeria. Beef meat of semi tendinous muscle (leg muscle) obtained from the local butcher shop in the day before experiment and stored in a refrigerator at 5±1°C overnight. Other ingredients such as spices, onion and salt (sodium chloride) were obtained from the local market. While sodium tripolyphosphate, sodium ascorbate and sodium nitrate were obtained from Sigma-Aldrich cehmic GmbH. (Representative of Aldrich chemical company Inc, USA).

2.1. Sample Preparation

African yam bean (AYB) flour was prepared by a modification of the method of Okoaka and Potter [21]. The seeds were soaked in warm water (35°C) for 12h using thermostatically control water bath. Soaked in acidified water at pH of 6.0 and stored in a refrigerator at 4°C±2 for 2h. After the storage time, the cotyledons were washed and blanched at 100°C for 6min.

Blanched cotyledons were dried at 50°C, milled into flour using a laboratory disc mill (Braun AG Frankfurt

Type: km32, Germany), passed through 0.2mm screen and kept in polyethylene bag for analysis.

2.2. Preparation of Comminuted Meat Ball

The meat was ground through a 0.64cm plate using kenwood chef mincer (Modal A920D) and divided into five of 0.4kg batches. Each batch was ground through a 0.32cm plate after the addition of 0%, 5, 10, 15 and 20% hydrated (1:2 water to flour) AYB flour by weight and other non-meat ingredients. Meat/AYB batter was stuffed into a narrow (45-50g casing) polyethylene bag (4.08 by 15.64cm). Stuffed products were weighed, heat sealed, cooked for 1.25h at 80°C in a water bath to achieve an endpoint product temperature of 71°C [22]. A raw sample of the comminuted meat ball was also prepared.

2.3. Physical Properties

2.3.1. Cooking Loss

The meat balls were weighed using digital electronic balance before and after heat treatment and the difference in weight (cooking loss) was determined.

$$\text{Cooking less (\%)} = \frac{\text{Raw weight} - \text{cooked weigh}}{\text{Raw weight}} \times 100.$$

2.3.2. Fat/Moisture Loss

The fat or moisture was done by calculating the difference between the moisture or fat content of raw comminuted meat batter and the cooked meat ball, all expressed as percent.

2.3.3. pH and Functional Properties

The pH of raw mix/emulsion was determined before and after cooking using pH meter (Ts 624, USA), water holding capacity (WHC) was determined by filter press method [23]. Emulsion stability (ES) was evaluated by comparing the crude fat and moisture content of the raw batter and cooked product using Keaten *et al.*, [24] method.

2.3.4. Fat/Moisture Emulsion Stability

A 30g batter sample removed at the end of stuffing was placed in a centrifuge tube (27.5mmx110mm) with a screw cap and heated for 30min at 70°C in a water bath. The tube was centrifuged for 3min at 4,000rpm. All the cook-out liquids were drained and measured. Results of water or fat were expressed as percentage (w/w).

2.4. Chemical Analysis

Proximate composition viz moisture, fat, ash and crude protein content of comminuted meat ball, raw and cooked sample were determined by standard method described by AOAC [25].

2.5. Sensory Evaluation

Sensory evaluation was carried out for attributes of colour, flavour/taste, texture and the general acceptability by a panel of trained members composed of staff and students of the University randomly selected according to the British Standard Institution guidelines to evaluate

products [26]. Based on a 9-point hedonic scale, where 9 denote extremely desirable and 1 denote extremely undesirable.

2.6. Statistical Analysis

The method of Wahua [27] was used. Analysis of Variance (ANOVA) table was constructed and means separated using the Duncan Multiple Range Test.

3. Results and Discussion

3.1. Proximate Composition

The proximate composition of the raw batter of the comminuted meat ball extended with AYB is presented in Table 1. The moisture content of the raw batter increased from 51.26% (control) to 61.13% for 20% inclusion of AYB. This trend may be attributed to the high protein content of the AYB. Similar range of moisture content had been reported by Mbougueng *et al.*, [28] for beef patties formulated with local spices. Similar trend was observed on the moisture content of the cooked comminuted meat balls as shown in Table 2. A reduction in fat content was observed on both the raw batter and the heat treated meat

ball. For the raw batter, the fat content decreased from 22.29% (control) to 19.14% for 20% AYB addition. This is due to the fact that the fat content of African Yam Bean (AYB) is low. A low fat content of 6.15% was reported by Olawuni *et al.*, [29]. This is beneficial because a number of health organization including the World Health Organisation (WHO), have made recommendation to reduce daily fat intake for improved health [30,31]. A reduction in fat was also reported by Teye *et al.*, [32] for using cowpea flour as an extender for beef and ham burgers. Protein content increased significantly from 23.04% (control) to 25.54% (20% AYB) with increase in the African Yam Bean paste used as extender in the production of comminuted meat ball. Moisture content and ash also follow similar trend. However, reverse trend was observed by Ammar [33] using mustard seed flour as extender for the production of beef burger patties. This observation was in agreement with the report of Teye *et al.*, [32] who used cowpea flour as extender in the making of beef burgers. Protein was observed to increase with increase in the level of cowpea flour added. Since the African Yam Bean is less utilized, it will help increased its utilization in other products such as sausage, burger.

Table 1. Chemical composition of raw batter extended of African yam bean (AYB) Level of AYB extension %

Parameters	Control	5	10	15	20
pH	6.72±0.07 ^a	6.84±0.66 ^a	6.82±0.03 ^a	6.82±0.04 ^a	6.78±0.03 ^a
Moisture %	51.26±0.80 ^d	51.52±0.44 ^d	53.80±0.72 ^c	60.25±0.52 ^b	61.13±0.40 ^a
Fat %	23.29±0.38 ^a	21.88±0.34 ^a	20.24±0.35 ^b	19.67±0.43 ^b	19.14±0.59 ^b
Protein %	20.19±0.38 ^b	21.27±0.37 ^a	21.35±0.44 ^a	21.52±0.35 ^a	23.23±0.44 ^a
Ash %	1.84±0.0.20 ^a	1.75±0.01 ^b	1.84±0.02 ^a	1.84±0.02 ^a	1.98±0.03 ^a

Mean ±SD with different superscripts in a row differs significantly (P<0.05).

Table 2. Chemical composition of heat processed comminuted meat ball extended AYB Levels of AYB Extension %

Parameters (%)	Control	5	10	15	20
Moisture	46.99±0.6 ^c	48.26±0.2 ^b	49.80±0.5 ^b	56.33±0.7 ^a	56.99±0.1 ^a
Fat	21.83±0.3 ^a	20.68±0.3 ^a	19.81±0.4 ^b	19.20±0.1 ^c	18.68±0.2 ^c
Protein	23.04±0.3 ^c	23.27±0.2 ^b	23.37±0.4 ^b	23.48±0.4 ^b	25.54±0.3 ^a
Ash	1.26±0.01 ^c	1.49±0.03 ^b	1.52±0.02 ^b	1.83±0.04 ^a	1.79±0.05 ^a

Mean ± SD with different superscripts in the same row differs significantly (P<0.05).

3.2. Physical Properties

The result of the physical properties showed that pH values ranged from 6.72 to 6.84 (raw) and 5.78 to 6.13 in the cooked meat ball as presented in Table 3. A slight drop in pH between the raw and cooked meat balls was observed. This may be due to a reduction in moisture content between the two samples. However, there was no significant difference in pH between the different levels of addition of African yam bean as extender. A non-significant pH values had been reported by Ammar [33]. Emulsion capacity and stability is higher in proteins with

globular nature. African yam bean isolate can be useful as protein enhancer [29].

The water holding capacity (WHC) of the comminuted meat ball increased from 65.86% (control) to 77.73%, increasing significantly, with increase in the level of AYB added. This may also be attributed to the increase in protein content of the product (meat ball) and also the ability of the protein to keep moisture in the matrix. Similar observation had been reported by Serdaroglu and Rmencioglu [19] that cowpea extenders in Turkish meat ball lowered product shrinkage. These observations also affected the moisture loss and fat loss which showed similar pattern.

Table 3. Physical test of the heat processed comminuted meat balls

Hydrated AYB (%)	pH	EC ^y	WHC ²	Moisture Loss %	Fat Loss %	FES ^s	MES ^w
0	5.78±0.02 ^b	86.78±0.23 ^d	65.86±0.51 ^d	8.34±0.07 ^a	6.21±0.01 ^a	97.98±0.43 ^a	91.66±0.50 ^b
5	5.90±0.03 ^a	91.93±0.26 ^c	69.72±0.49 ^c	6.32±0.03 ^c	5.48±0.03 ^b	95.18±0.44 ^c	93.68±0.43 ^a
10	6.03±0.04 ^a	95.30±0.34 ^b	72.52±0.53 ^b	7.41±0.04 ^b	2.08±0.02 ^b	95.65±0.40 ^c	92.59±0.59 ^b
15	6.05±0.01 ^a	97.50±0.30 ^a	73.83±0.61 ^b	6.52±0.05 ^c	2.39±0.04 ^c	97.48±0.32 ^b	93.48±0.50 ^a
20	6.13±0.01 ^a	98.5±0.50 ^a	77.73±0.52 ^a	6.52±0.02 ^c	2.40±0.01 ^c	98.71±0.34 ^a	93.22±0.44 ^a

Means ± Standard deviation of three determinations, means within column sharing the same letters are not significantly different.

Key: EC = Emulsion capacity, WHC = Water Holding capacity, FES = Fat Emulsion stability, MES = Moisture stability.

3.3. Cooking Loss

Cooking loss of the heat treated meat balls ranged from 23.6% (20% AYB) to 32.1% in the control; indicating a significant reduction in cooking loss with increase in African yam bean flour added as depicted in Figure 1.

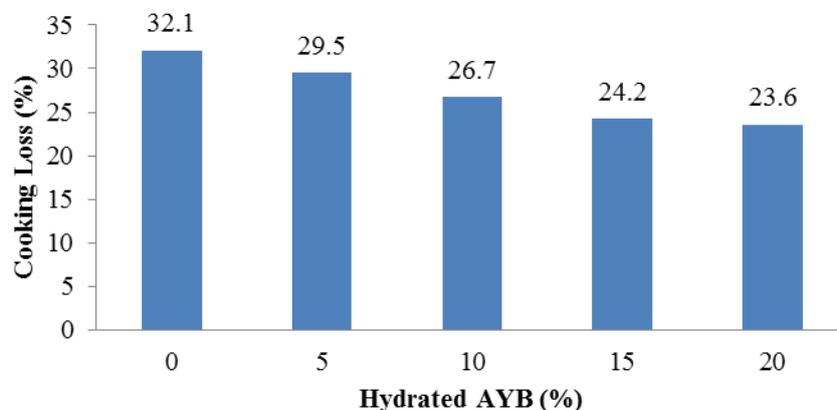


Figure 1. Bar chart representing the cooking loss of heat processed comminuted meat balls

3.4. Sensory Properties

The sensory properties as shown in Table 4, showed a decreasing effect as the percentage of AYB increased in the meat ball in all the sensory parameters investigated. When compared to the control, there were no significant difference in colour, texture and general acceptability of

This observation is in agreement with the report of Ammar [33], who reported a reduction in cooking loss with increase in mustard seed flour added to beef burgers. Mbougung *et al.*, [28] also observed a less significant cooking loss in beef patties formulated with different starches.

the comminuted meat ball at 5% AYB flour addition. However, flavour/taste compared favourably with the control up to 15% AYB flour addition in the comminuted meat ball. Similar observation was reported by Bhat and Pathak [34] for oven roasted chicken seekh kababs formulated with black bean and Ammar [33] using mustard seed flour as meat extender for beef-burgers.

Table 4. Sensory scores of comminuted meat-type product extended with AYB

Sample (%)	colour	Flavour/Taste	Texture	General Acceptability
0	7.4 ^a	7.0 ^a	7.8 ^a	7.0 ^a
5	6.9 ^a	6.6 ^a	6.2 ^a	6.8 ^a
10	5.5 ^b	6.4 ^a	5.5 ^b	5.7 ^b
15	5.2 ^b	6.4 ^a	4.9 ^c	5.7 ^b
20	5.1 ^b	4.7 ^b	4.6 ^c	5.5 ^b

Mean values bearing the same superscript within the same column do not differ significantly ($p > 0.05$).

4. Conclusion

The African Yam Bean used in comminuted meat ball showed good compatibility as a food ingredient and did not adversely affect the quality of the end products. Therefore, it is hoped that the use of AYB flour in comminuted meat type product will help to expand African Yam bean utilization.

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