

Original Research Article

Effect of African yam bean flour as an extender on the physicochemical and sensory properties of cooked beef sausage

ABSTRACT

Purpose: The effect of African yam bean flour as an extender on the physicochemical and sensory properties of cooked beef sausage was studied.

Methodology: Sausage samples were produced using beef and African yam bean flour (AYBF) as extender at 5%, 10%, 15% and 20% substitution levels while 100% beef sausage served as the control. The proximate composition and sensory properties of the formulated products were determined using standard methods.

Findings: Proximate analysis revealed a significant ($p < 0.05$) decrease in moisture content (71.45-65.50%), ash (2.45-0.30%), and fat (10.10-1.90%) with a corresponding increase in crude protein (23.06-28.00%), crude fibre (3.80-16.20%) and carbohydrate (5.74-7.91%) as beef was partially replaced with AYBF. Beef sausages containing AYBF showed a significantly lower pH and better water holding capacity and emulsion properties compared to the control sample. Sensory analysis also showed a significant ($p < 0.05$) decrease in the mean sensory scores for taste, mouthfeel, aroma and overall acceptability. Colour and hardness of the products were improved at AYBF supplementation level of 5%. Generally, the control sample was not significantly ($p > 0.05$) different from samples supplemented with 5% AYBF.

Recommendations: It is concluded that the incorporation of AYBF could be an effective ingredient to improve the quality and sensory properties of beef sausage with reduced fat content. Thus, the use of full African yam bean flour as an extender at 5% substitution level for cooked beef sausages is feasible as this will reduce the amount of meat used, thereby reducing the cost of the cooked beef sausage and at same time producing nutritious sausages.

Keywords: African yam bean; extender; sausage; physicochemical property; sensory property

1.0. INTRODUCTION

Sausages are made by combining ground beef with oil, salt, preservatives, and other substances before wrapping it in a casing [1]. The use of predominantly boneless meat in sausages enhances the production cost due to the high cost of boneless meat. Consumers' rising desire for healthy beef sausage has driven sausage manufacturers to consistently develop new or better quality products at a low cost, with minimum fat and health-enhancing ingredients with improved functional qualities, palatability, and nutritional value. Plant proteins are increasingly being employed in the manufacturing of sausages due to their high protein content. Plant proteins are sometimes referred to as meat extenders or meat substitutes since they compete effectively with beef in terms of flavor and chewiness [1]. They are frequently used as a binder in meat products to increase emulsion stability and as a meat alternative to reduce expenses [2].

Plant proteins can be employed to increase the shelf life of meat products while simultaneously providing a low-cost, high-protein meal element [3]. They have structural integrity and a distinct

feel, allowing each unit to tolerate hydration during cooking and other techniques of food preparation [4]. Meat extenders, particularly those produced from legumes, are a feasible solution to the problem of protein insufficiency since they are good alternatives to animal protein that might replace meat in diets [5]. As a meat extender, soybean flour is a common basic ingredient. Soybean is commonly used because it contains more nutrients than other leguminous crops. Soy protein-derived products have been used as functional food components in practically every food category available to consumers. However, one factor that may limit the use of soybean as a meat extender in rural populations is its unavailability or high cost [4], necessitating the use of other legumes such as African yam bean as an alternative to soybean.

African yam bean (*Sphenostylis stenocarpa*) is a lowland tropical climbing legume [6]. It is a minor underutilized legume and an important crop in Western Africa consumed in a geographical region of Nigeria, specifically the Southern, Eastern, and Western sections. The seeds have high protein content (21-29%) and a carbohydrate content of roughly 50% [7]. According to Raji *et al.* [6], the lysine and methionine content of African yam bean seeds are comparable to, if not superior to, that of soybeans. However, its application has been hampered by the presence of anti-nutritional components such as phytic acid, oxalate, trypsin inhibitor, tannin, and others, which can be decreased or eliminated through processing procedures such as boiling, soaking, fermentation, and germination [8]. African yam bean tubers and seeds are occasionally cooked and eaten alone or in combination with vegetables or other dishes [9]. They may be used to make sauces, wrapped in plantain leaves and boiled to make okpa. Milk can be extracted from its seeds, while the flour from its tubers can be used to make moi-moi [7, 10].

In recent years, there has been a focus on local and underutilized seeds for potential development and use in supplementing traditional ones. One conceivable strategy to achieve this in industrialized countries is to leverage on existing local resources in order to meet the requirements of an expanding population [11]. Several studies on the manufacturing of sausages utilizing various meat extenders such as cowpea flour [12], full-fat soy flour [1], mung bean powder [13], and texturized soy protein have been conducted [2]. As a legume like soybean, African yam bean is an unexploited but protein rich seed with high potential which can be used as an extender in sausages.

Meat and meat products are more popular, but their price is prohibitively expensive. As a result, the finished product becomes more expensive for consumers, limiting their patronage to only the wealthy or upper income earners in society. There is a growing need to reduce the formulation cost of meat products by using meat extenders in order to lower their cost while keeping high biological value and making them affordable to the majority of the people.

Soybean is currently commonly utilized as an extender in meat products to give a low-cost, high-quality protein source. There is a need to investigate other underutilized legumes as a substitute and to lessen the reliance on soybeans. Despite its composition, African yam bean is underutilized and has a low consumption rate. It is for this reason that alternative method of utilizing African yam bean as an extender for beef sausage is being sought as this is expected to make sausage more affordable for households and consumers.

2.1. MATERIALS AND METHODS

2.1. Collection of materials: African yam bean (*Sphenostylis stenocarpa*), lime, fresh boneless beef chunk, casing (intestine) and other ingredients such as seasoning cube, onions, salt, sugar, mixed spices were purchased from local traders in Mile 3 Market in Port Harcourt, Rivers State. Chemicals and equipment used were of analytical grade and obtained from the Food

Analysis Laboratory, Department of Food Science and Technology and the Department of Home Science and Management Laboratory, Rivers State University.

2.2. Production of African yam bean flour: African yam bean seed milk was prepared using the method described by China *et al.* [4]. African yam beans were sorted, clean and soaked overnight in 0.5% NaHCO₃ solution to facilitate reduction of beany off flavor and dehulling of the seeds (Fig 1). It was washed with cold water and dehulled thereafter dried overnight at 55°C, milled using a hammer mill into flour and sieved.

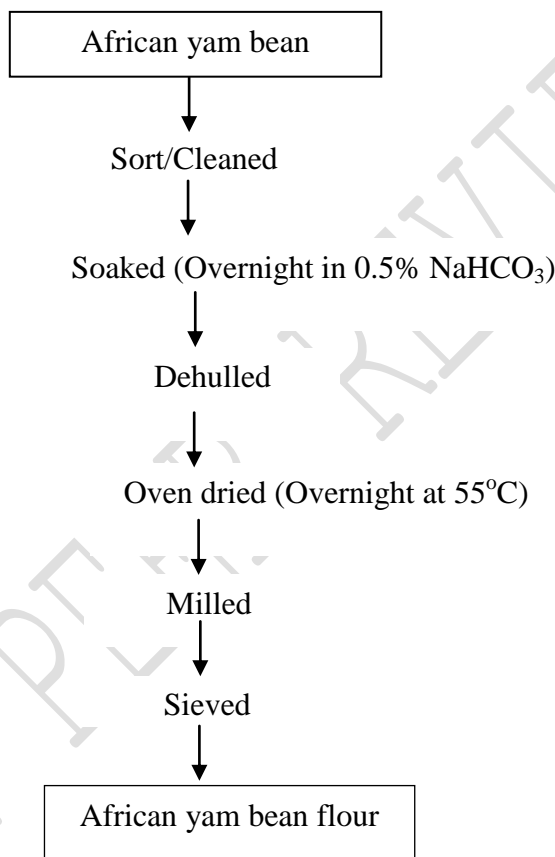


Fig. 1: Production of African yam bean flour

Source: China *et al.* [4]

2.3. Preparation Cooked Beef Sausage

The cooked beef sausage was made according to Amadi [1] method, as shown in figure 2. Fresh beef was sliced into little cubes before being minced with an electric grinder. Following grinding, non-meat elements such as African yam bean flour, water, salt, onion, thyme, nutmeg, black pepper, and seasoning cube were added in the amounts specified in Table 1. To make several sausage samples, African yam bean flour was used at varying percentages: 5%, 10%, 15%, and 20%. To achieve a uniform distribution of any non-meat elements inside the product, the meat and non-meat ingredients were thoroughly combined (to a size of 8 mm) in a mixer. After blending, the sausage batter was packed into 23 mm casings and joined at 15 cm lengths with pumping equipment. The stuff casings were split into uniform segments of identical length,

the casing was linked by twisting it, and the sausage was ready to cook at 80°C for 45 minutes. After cooking, the sausage was drenched in cold water. The sample was cooled to/maintained at room temperature (28°C). The cooled sausages were then placed in an airtight container until they were needed for analysis [1].

Table 1: Recipe formulation for the production of cooked beef sausage from blends of beef and African yam bean flour (AYBF)

Ingredients	Sample (Beef: AYBF)				
	A (100:0)	B (95:5)	C (90:10)	D (85:15)	E (80:20)
Beef (g)	200	190	180	170	160
AYBF (g)	0	10	20	30	40
Water (ml)	30	30	30	30	30
Salt (g)	4	4	4	4	4
Sugar (g)	2	2	2	2	2
Onion (g)	3	3	3	3	3
Seasoning cube (g)	2	2	2	2	2
Mixed spices (g)	3	3	3	3	3

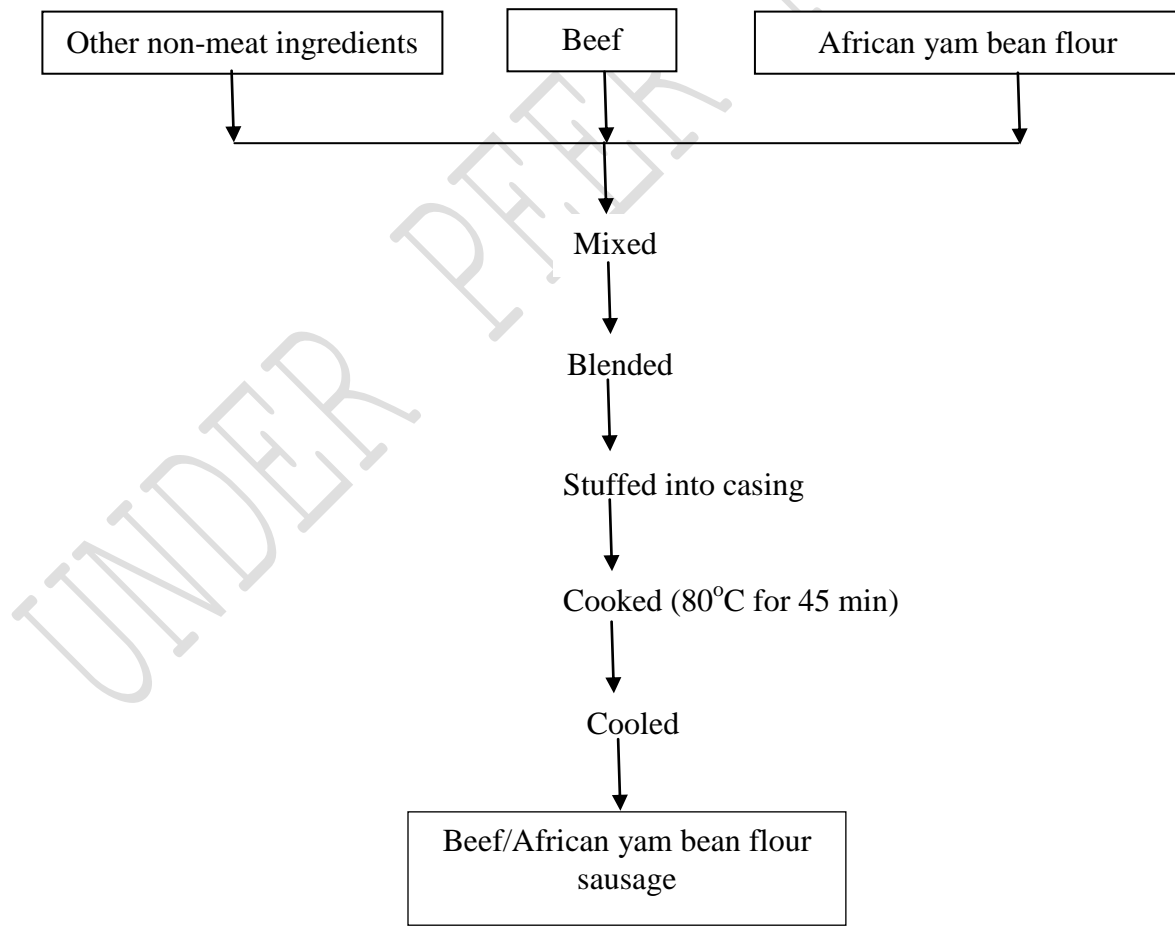


Fig 2: Production of cooked beef/African yam bean flour sausage.
Source: Amadi [1]

2.4. Proximate Analysis of the Sausages

Proximate analysis (moisture, ash, protein, fat and crude fibre) of the sausages was determined using the method of Association of Official Analytical Chemist [14] while total available carbohydrate was calculated by difference using the formula:

$100\% - (\% \text{ Moisture} + \% \text{ Ash} + \% \text{ Crude protein} + \% \text{ Fat} + \% \text{ Crude fibre})$ [14]

2.5. Sensory Analysis

Sensory analysis of the sausages was carried out using a thirty member panelist consisting of students of the Department of Home Science and Management, Rivers State University, Port Harcourt. Panelists were asked to evaluate the samples for consumer acceptance of colour, taste, texture, aroma, **hardness** and mouth feel using a 9-point hedonic scale with 9 as like extremely and 1 as dislike extremely [15] while overall acceptability was deducted as mean values of all the other sensory attributes assessed. The sausages were served with glasses to the panelists while portable water was provided to rinse the mouth between evaluations.

2.6. Physical Analysis

2.6.1. Determination of pH

The pH of the samples was determined using a pH meter (TS 625, USA). Two grams (2.0 g) of the sample was transferred into a beaker followed by the addition of 20 ml of distilled water and left for 20 mins. The pH was then determined after the meter was calibrated using standard buffer of pH 4.0 and 7.0, sufficient time was allowed for stabilization before readings were taken.

2.6.2. Determination of Fat/Moisture Emulsion Stability

Ten grams (10.0 g) of the sample was placed in the centrifuge tube with a screw cap heated for 30 min at 70°C in a water bath. The tube was centrifuged for 3 min. After centrifuging the cook out liquid (Fat and water) were drained and calculated [16].

$$\text{Emulsion Stability} = \frac{W_2}{W_1} \times 100$$

Where W_2 = Weight of sausage emulsion in the tube after drainage of the lipid/moisture layer
 W_1 = Weight of the sausage emulsion in the tube before heating.

2.6.3. Determination of Water Holding Capacity (WHC)

The filter press method was used to calculate the water holding capacity [16]. A 0.5 g sample of the beef emulsion was placed between two filter papers, which were then placed between two glass sheets weighing 4.64 g, and a 50 g weight was placed over all of this. On the beef, this resulted in a total compression weight of 54.64 g. The setup was compressed and squeezed out before being absorbed into the filter paper. After drying, the area of the filter paper for the shape of the meat and that of the absorbed water were measured using a plastic ruler. The water holding capacity was obtained by taking the difference between areas of absorbed water borderline on the filter paper (moisture) and the area covered by the meat [17].

$$\text{WHC} = \frac{A_1 - A_2}{A_1} \times 100$$

Where A_1 = Area covered by the absorbed water
 A_2 = Area covered by the beef

2.6.4. Determination of Emulsion Capacity

The Onwuka [18] technique was used. In a blender, 2.0 g of the sample was combined with 25 ml of distilled water. Blending at 1600 rpm for 30 seconds produced a perfect dispersion. Following that, 25 ml of vegetable oil was progressively added to the dispersion, and the mixing process was continued for another 30 seconds. The dispersion was then placed in a graded centrifuge and spun at 1600 rpm for 5 minutes. The volume of oil separated from the sample after centrifugation was directly read from the centrifuge.

$$\text{Emulsion Capacity} = \frac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume before whipping}} \times 100$$

2.7. Statistical Analysis

Data obtained from the analysis was subjected to one-way analysis of variances, in line with the method of Wahua [19]. All means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level ($p > 0.05$) using SPSS version 20.0 software 2011.

3.0. RESULTS AND DISCUSSION

3.1. Proximate composition of beef sausages supplemented with African yam bean flour

Table 2 shows the proximate composition of beef sausages supplemented with African yam bean flour. Moisture content of the beef sausages ranged from 65.50 to 71.45% with sample E having the lowest value (65.50%) while sample A had the highest. There was a decrease in the moisture content of the samples as the proportion of African yam bean flour (AYBF) increased. These decreases were only significant ($p < 0.05$) at 20% AYBF substitution. The higher moisture content of sausage samples without AYBF could imply that beef has a higher water holding capacity than African yam bean flour. The moisture content of the sausage samples were within the value of 66.71% obtained by Agrihotri & Pal [20] for chevon sausage. The low residual moisture content of the beef sausage supplemented with African yam bean flour from this study is advantageous in that microbial proliferation is reduced and storage life is enhanced and prolonged, as a lower moisture content of a product is linked to better shelf stability.

Ash content of the beef sausages ranged from 0.30-2.45% with sample E recording the lowest value (0.30%) while sample A had the highest (2.45%). Partial replacement of beef with African yam bean flour resulted in a significant ($p < 0.05$) decrease in the ash content of the beef sausages. This might be due to dilution effect. This is illustrated by sausage samples from 100% beef which contains 2.45% ash but which upon inclusion of AYBF up to 20%, contains 0.30% ash. The values were however lower when compared with the values of 3.10-4.24% obtained by Amadi [1] for beef sausage supplemented with full fat soy flour. Ash content from this study is also slightly low when compared with those of Dharmaveer *et al.* [21] for chevon sausage (3.00%) and also higher than the values of 4.46- 4.69% for meat sausage partially substituted with soybean protein and finger millet flours [22]. These differences could be attributed to the raw material used.

Fat content of the samples ranged from 1.90-10.10% with sample E having the lowest value (1.90%) while sample A had the lowest (10.10%). There was also a significant ($p < 0.05$) decrease in the fat content of the beef sausages as African yam bean flour was partially replaced with beef. This could be attributed to concentration effect following processing as well as the nature of beef cuts used. However on addition of African yam bean flour, the fat content was reduced, implying that addition of AYBF caused a dilution effect. The decrease in fat content of burger samples

with increase mushroom levels could have been due to the low fat content (1.9%) of African yam bean flour reported by Onyechi & Nwachi [23]. This is a healthy development since according to Diet and Fitness Today [24], all animal fats such as those in beef, poultry and dairy products are saturated. It is further reported that the saturated fats are the very unhealthy fats. They make the body produce more cholesterol which will increase the blood cholesterol levels. The inclusion of African yam bean flour in view of its low fat content invariably implies a reduction in the saturated fats content of the sausages with African yam bean flour. This will result in the alleviation of the health risk of red meat reported by Karen [25].

Crude protein content of the beef sausages ranged from 23.06-28.00%. The progressive inclusion (5% 10%, 15% and 20%) of African yam bean flour showed progressive increase in protein content due to dilution effect. Progressive inclusion of African yam bean flour also showed significant differences ($P < 0.05$) in the protein content among all the sausage samples. This increase was also reported by Elbakheet *et al.* [26] for beef sausage extended with wheat germ flour. The increase in protein content is a reflection of African yam bean over beef in terms of protein content and it demonstrated their mutual supplementation effect. The high crude protein content of sausages with African yam bean flour is indicative of its potential as an extender in cooked beef sausage. The protein content from this compares well with those reported by Behailu and Abebe [22] for beef meat partially substituted with soybean protein and finger millet flours (21.57-25.10%).

Crude fibre content of the samples ranged from 3.80-16.20%. Beef sausages extended with African yam bean flour (5% 10%, 15% and 20%) had significantly ($p < 0.05$) higher crude fibre content than those with 100% beef. The increase in fiber content may occur because African yam bean is a vegetable-based fiber: mixture of amylopectins and cellulose [27]. The increase in fibre indicates low cooking loss as dietary fiber supplementations increase the bulk and prevent cooking loss in meat products with no or fewer changes in textural parameters by enhancing water binding capabilities. This is also of great economic advantages for both the consumers and producers [28]. Dietary fibre in meat products are also of health benefits and an excellent meat substitutes due to their inherent functional and nutritional effects [29].

Extension of cooked beef sausage with African yam bean flour led to a significant ($p < 0.05$) increase in the carbohydrate content (5.74-7.91%) with the control sausage having the lowest and sausage extended with 15% AYBF as highest. The result from this study is close to the values (0.32-8.84%) reported by Behailu and Abebe [22] for meat sausage extended with soybean protein and finger millet flours.

Table 2: Proximate composition (%) of beef sausages supplemented with African yam bean flour

Samples	Moisture	Ash	Fat	Crude protein	Crude fibre	Carbohydrate
A	71.45 ^a ±0.50	2.45 ^a ±0.07	10.10 ^a ±0.14	23.06 ^d ±0.00	3.80 ^d ±0.00	5.74 ^a ±1.13
B	70.73 ^a ±0.39	1.52 ^b ±0.04	6.10 ^a ±0.14	24.94 ^c ±0.00	7.40 ^c ±0.57	6.48 ^a ±0.83
C	70.15 ^a ±0.21	1.35 ^c ±0.07	3.10 ^c ±0.14	25.28 ^{bc} ±1.34	15.20 ^b ±0.57	7.35 ^a ±1.59
D	69.88 ^a ±0.17	0.48 ^d ±0.04	2.70 ^d ±0.14	26.84 ^{ab} ±0.00	14.50 ^b ±0.71	7.91 ^a ±0.21
E	65.50 ^b ±1.41	0.30 ^e ±0.07	1.90 ^e ±0.14	28.00 ^a ±0.71	16.20 ^a ±0.57	6.99 ^a ±1.78

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEYS:

A=100% beef sausage

B=95% beef: 5% African yam bean flour

C=90% beef: 10% African yam bean flour
D=85% beef: 15% African yam bean flour
E=80% beef: 20% African yam bean flour

3.2. Physical Properties of beef sausages supplemented with African yam bean flour

Table 3 shows the physical properties of beef sausages supplemented with African yam bean flour. Water holding capacity (WHC) of the sausages ranged from 59.65-72.75% with sample A recording the lowest value (59.65%) while sample E had the highest (72.75%). The addition of AYB significantly ($p < 0.05$) increased the value of WHC of the sausages. From this result, it can be concluded that the substitution of beef with AYB can improve the WHC of sausages. The increase of WHC in the samples can be caused by several reasons. AYB has a higher protein level that is more water soluble than beef, allowing it to bind to water more effectively. Furthermore, AYB has a lower fat content than beef, and the lack of these lipids allows the protein to more freely bind water, increasing the water retention capacity [30]. WHC is an important element in influencing the juiciness of meat products, along with flavor, texture, and color in the process of physical and chemical treatments [31]. This study supports the findings of Hidayat *et al.* [30], who found that adding protein increased the water retention capacity of sausage. Cardoso *et al.* [32] also stated that the addition of other substitution material rich in protein and fiber will increase the WHC value of meat products, resulting in better texture and quality.

pH of the sausages ranged from 5.05-5.30 with sample E recording the lowest value (5.05) while sample A had the highest (5.30). In this research, average pH of the control and samples supplemented with AYBF is approximately 5. pH is one of the fundamental factors that will influence the texture of sausages [22]. The pH range from this study falls within the range of pH (4-6) recommended for beef sausages [33].

Fat and water emulsion stabilities of the sausages ranged from 69.87-89.15% and 81.30-83.86%, respectively. There was a significant ($p < 0.05$) increase in the fat emulsion stability of the sausages as the supplementation of beef with AYBF increased. On the other hand, AYBF supplementation had no significant ($p > 0.05$) effect on the water emulsion stability of the sausages. The sausages supplemented with AYBF presented improved fat emulsion stability due to the water binding capacity of AYBF added to the product. Similar finding was also reported by Pereira *et al.* [34] for sausages supplemented with rice flour. The major contribution to water binding in meat products is added dietary fiber from African yam bean, which leads to improved emulsion capacity and stability. The emulsion stability of sausages is an index that estimates the physical properties of a meat product and is an indicator of unseparated water and fat retained by meat products [35].

Table 3: Physical properties of beef sausages supplemented with African Yam bean flour

Samples	Water holding capacity	Emulsion capacity	Fat emulsion stability	Water emulsion stability	pH
A	59.65 ^c ±1.92	71.06 ^d ±0.23	69.87 ^c ±0.74	82.00 ^a ±1.00	5.30 ^a ±0.00
B	60.77 ^c ±1.09	82.62 ^c ±1.83	76.75 ^{bc} ±2.47	81.30 ^a ±1.15	5.19 ^c ±0.00
C	64.00 ^b ±1.41	84.78 ^c ±0.64	73.45 ^{bc} ±7.84	83.86 ^a ±1.21	5.08 ^d ±0.00
D	69.95 ^a ±0.21	90.80 ^b ±1.12	82.79 ^{ab} ±2.67	82.86 ^a ±1.21	5.26 ^b ±0.01
E	72.75 ^a ±0.36	93.92 ^a ±0.83	89.15 ^a ±1.21	81.19 ^a ±0.73	5.05 ^e ±0.00

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEYS:

A=100% beef sausage

B=95% beef: 5% African yam bean flour

C=90% beef: 10% African yam bean flour

D=85% beef: 15% African yam bean flour

E=80% beef: 20% African yam bean flour

3.3. Sensory Properties of beef sausages supplemented with African yam bean flour

Table 4 shows the mean sensory scores of beef sausages supplemented with African yam bean flour. The mean sensory scores of the beef sausage showed that there was a significant ($p < 0.05$) decrease in the colour, taste, mouth feel, aroma, hardness and overall acceptability as the supplementation of African yam bean flour increased. However, the control sample was not significantly ($p > 0.05$) different from samples supplemented with 5-15% AYBF for colour. Taste and mouthfeel of the control sample was also not significantly ($p > 0.05$) different from samples supplemented with 5-10% AYBF. Hardness, aroma and overall acceptability of the control sample was not significantly ($p > 0.05$) different from samples supplemented with 5% AYBF. The overall sensory scores showed that the sample supplemented with 5% AYBF was not significantly ($p > 0.05$) different from the control sample with an overall mean score of 7.04. The result from this study therefore reflects the ability of using African yam bean flour at 5% as an extender without negatively affecting the sensory properties of cooked beef sausages. This same trend was also reported by Ammar [36] who concluded that the incorporation of mustard flour into beef burger patties had no negative effect on sensory properties of beef burger. Showkry [37] also reported that the beef burger containing quinoa flour (QF) exhibited an excellent sensory acceptance especially the texture, tenderness and juiciness which appeared to be reinforcement by adding QF to the beef burger.

Table 4: Mean sensory scores of beef sausages supplemented with African yam bean flour

Samples	Colour	Taste	Mouthfeel	Aroma	Hardness	Overall Acceptability
A	6.60 ^a	7.65 ^a	7.35 ^a	7.65 ^a	7.10 ^a	7.28 ^a
B	6.75 ^a	7.55 ^a	6.85 ^{ab}	6.90 ^{ab}	7.25 ^a	7.04 ^{ab}
C	6.80 ^a	6.65 ^a	6.55 ^{ab}	6.70 ^b	5.80 ^b	6.18 ^c
D	6.15 ^a	6.15 ^b	6.20 ^{bc}	6.75 ^b	5.60 ^b	6.31 ^{bc}
E	6.12 ^b	5.37 ^b	5.47 ^c	5.72 ^c	5.70 ^b	5.64 ^c

Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

KEYS:

A=100% beef sausage

B=95% beef: 5% African yam bean flour

C=90% beef: 10% African yam bean flour

D=85% beef: 15% African yam bean flour

E=80% beef: 20% African yam bean flour

4.0. CONCLUSION

The supplementation of African yam bean flour at increasing levels in cooked beef sausage caused an increase in the protein, crude fibre and carbohydrate contents with a corresponding decrease in ash, moisture and fat content. Fat, moisture and carbohydrate contents of beef sausage supplemented with 5% African yam bean flour was not significantly ($p>0.05$) different from the control sample. Incorporation of AYBF in beef sausage at 15 and 20% in beef sausage provided more significant effect in improving emulsion properties and water holding capacity. There was also an improvement in the colour and hardness of the beef sausage at AYBF supplementation level of 5%. Overall acceptability scores also showed that the control sample was not significantly ($p>0.05$) different from the sample supplemented with 5% AYBF. **This study contributes to providing a cheap alternative extenders and enriched sausages.** It is therefore recommended that African yam bean should be used as a non-meat ingredient at level of 5% in order to reduce the amount of meat used, thereby reducing the cost of the cooked beef sausage.

DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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