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Physicochemical Properties of Breakfast Sausage Extended with Locust Bean Flour

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ABSTRACT

This study was carried out to assess the physicochemical and sensory properties of Breakfast Sausage (BS) prepared with varied levels of African Locust Bean (ALB) flour. All flours were assessed for functional properties. Batches of BS were prepared using either fermented or unfermented ALB flour at inclusion levels of 2%, 3%, and 4% in replacement of soybean flour at 4% (control), in a completely randomised design. Physicochemical and sensory parameters were determined using standard procedures. Data were analysed using ANOVA. Functional properties of ALB flours were significantly different. Fermented ALB flour had highest ($p<0.05$) bulk density while unfermented ALB had least ($p<0.05$) water (1.30) and oil (1.32) absorption capacities. Crude protein and ash contents of BS increased ($p<0.05$) with increasing inclusion of ALB flours while moisture content decreased ($p<0.05$). pH was highest ($p<0.05$) in Control sausage (6.21) while product yield decreased ($p<0.05$) with the inclusion of unfermented ALB. No significant difference was observed for sensory attributes of the sausages. In conclusion, fermented ALB flours have the properties that could enable its use in meat products and can be incoporated in breakfast sausages up to 3% without any adverse effects on sensory and physico-chemical properties.

Keywords: *African locust bean, Breakfast sausage, Functional properties, Physicochemical properties, Sensory evaluation*

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INTRODUCTION

Over the past decades, there has been an increased demand for functional meat products obtained from improved biotechnological applications because of their consideration as healthier, and sometimes cheaper food choices (Clonan et al. 2015). One of these biotechnological applications is the use of non-meat protein (NMPs) ingredients as functional ingredients in meat product development (Yetim et al. 2001).The use of these ingredients as extenders, binders and fillers allows for production of affordable, high quality emulsion-type meat products (Yetim et al. 2001). Meat extenders in meat products enhance the protein quality of the product, they are less expensive thereby reducing formulation costs and more stable while conveying acceptable product textural and nutritional properties (FAO 1991). Legume seeds such as peas, beans, lentils, peanuts, and other padded plants contains high protein (20-50%) that can serve as non-meat protein ingredients (Makri et al. 2005). Several researches has been carried out to evaluate the use of plant protein products as functional ingredients to improve the stability and nutritional quality of food products (Bhat and Pathak 2009; Yilmaz 2004). African locust beans (Parkia biglobosa) is a deciduous perennial tree found in a wide range of environment in Africa and are primarily grown for its pods that contain both a sweet pulp and valuable seeds (Ntui et al. 2012). The pods (locust bean) are oilseeds that are usually fermented to produce condiments with characteristic ammonia-like odour and flavour which enhances the taste of traditional soups and sauces (Omafuvbe et al. 2004). They are rich in lipids (29%), protein (35%), and carbohydrates (16%) (Ntui et al. 2012) and they have the potential to be used as NMP ingredients in communited meat products. This study was therefore carried out to determine the functional properties of fermented and unfermented African locust bean flours and assess its effect on the physicochemical properties of breakfast sausage.

MATERIALS AND METHODS

Location of study: This study was carried out at the Meat Science Laboratory of the Department of Animal Science, University of Ibadan, Nigeria.

Processing of African locust beans (ALB): The African locust beans were obtained from Bodija market in Ibadan, Nigeria. They were thereafter processed (figure 1) according to the method of Ijarotimi and Keshinro (2012) to obtain fermented and unfermented ALB.

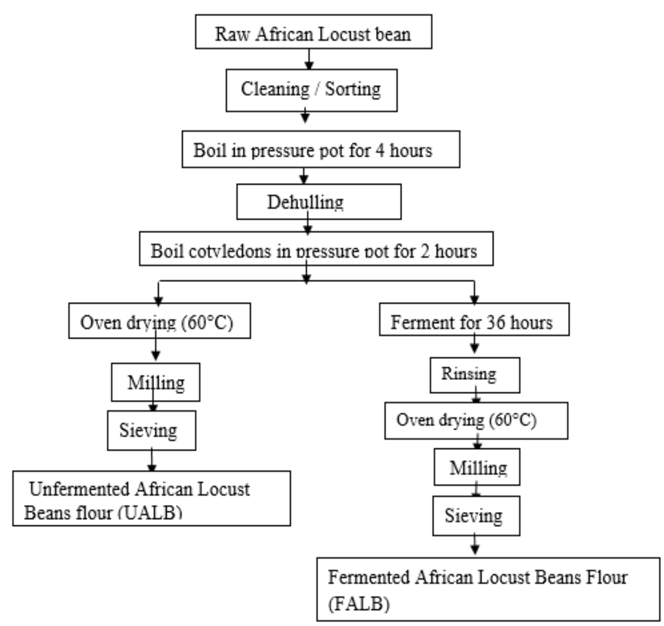

Fig. 1: Flowchart for processing of African Locust Beans

Production of Sausage: Breakfast sausage was produced according to Heinz and Hautzinger (2007). Fresh boneless beef obtained from the thigh muscle(Semi membranosusmuscle) was chopped into smaller pieces and minced using a 5mm sieve in a tabletop mincer. The ground meat was transferred into a bowl chopper for further comminution, ice cubes were added and mixed for 2 min, and other ingredients (Table 1) were added. Mixing was further

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continued for 5 min. The batter was stuffed into artificial casing (cellulose-based) using a manual stuffer, each casings were divided into links (units) of 10 cm in length by twisting. Sausages were cooked in a heating chamber to an internal temperature of 70 - 72°C, cooled, packaged in polyethylene bags and stored at 4°C for further evaluation. Sausages were prepared with graded levels of fermented and unfermented ALB while soybean flour was used as control (Table 1).

Table 1: Composition (%) of sausages using locust bean flours as extender

		Treatments					
Ingredients	**Control**	**Unfermented ALB**			**Fermented ALB**		
		2%	**3%**	**4%**	**2%**	**3%**	**4%**
Beef	65.00	65.00	65.00	65.00	65.00	65.00	65.00
Vegetable oil	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Soybean flour	4.00	2.00	1.00	-	2.00	1.00	-
Unfermented ALB	-	2.00	3.00	4.00	-	-	-
Fermented ALB	-	-	-	-	2.00	3.00	4.00
	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Sugar	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sodium nitrite	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Phosphate	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Water	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Dry spices‡	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Green spices§	2.19	2.19	2.19	2.19	2.19	2.19	2.19
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Control: 4% Soybean flour; ALB: African Locust Beans
‡Dry spices: calabash nutmeg 3%, red pepper 15%, monosodium glutamate 30%, thyme 20%, curry powder 10%.
§Green spices: onion 60%, ginger 20%, garlic 20%

Parameters measured

Determination of functional properties of differently processed ALB flours

Bulk density: A 10g flour sample was measured into a measuring cylinder containing 20 mL distilled water. The cylinder was tapped continuously until a constant volume was obtained. The bulk density (g·cm-3) was calculated as weight of flour (g) divided by flour volume (cm3) (Okaka and Potter 1979). Determination was carried out in triplicates.

Water and oil absorption capacity: Water and oil absorption capacities of the flour samples were determined by the method of Beuchat (1977). 1 g of each sample was weighed and hydrated with 10 ml water/oil, then mixed on a vortex for 1 (one) minute. It was allowed to stand for 30 minutes after which it was centrifuged at 220rpm for 30minutes. The supernatant was decanted and measured. Water/oil absorption was calculated as liquid retained/g sample. The experiment was carried out in triplicates.

Determination of physico-chemical properties of Breakfast Sausage

Proximate Composition (AOAC, 2004).

Product Yield: This was obtained using the following equation:

$$\text{Product yield (\%)} = \frac{\text{weight of final product} \times 100}{\text{Initial weight of raw sample}}$$

pH: The pH was determined using a digital pH meter (Model: PHS-25 Microfield Instrument England) according to the method described by AOAC (2004). Briefly, sausage samples (10 g) were weighed into a blender containing 90mL distilled water and homogenized until smooth slurry was formed. Readings were obtained in triplicates.

Cooking loss: Sausage samples (80 g each) were boiled at 80±1 °C for 40 min. After cooling for 30 min, the cooked samples were weighed and percentage weight loss was calculated using the following:

$$\text{Cooking loss (\%)} = \frac{\text{Weight of sausage before cooking - Weight of sausage after cooking} \times 100}{\text{Weight of sausage before cooking}}$$

Water Holding Capacity (WHC): Water holding capacity was evaluated as described by Suzuki et al. (1991). Cooked sausage samples (10 x10 x 5 mm) from each treatment was weighed onto two filter papers and pressed between two plexi glasses for a minute using a vice. The samples were then oven-dried at 65oC for 48 h in order to determine the moisture content. The amount of water released from the samples was measured indirectly by measuring the area of the filter paper wetted relative to the area of pressed sample.

The water holding capacity (WHC) of the meat was then calculated as follows:

$$WHC = \frac{100 - [(Ar - Am) \times 9.47)] \times 100}{Wm \times Mo}$$

Where Ar = Area of water released from meat (cm2); Am = Area of meat sample (cm2);

Wm = Weight of meat in mg; Mo = Moisture content of meat (%); 9.47 is a constant factor.

Sensory evaluation: Sensory evaluation of freshly prepared sausages from each treatment was performed using the method described byHyun-Woo et al (2015).A total of twenty panelists selected from the Department of Animal Science, University of Ibadan were sensitized prior to the evaluation to familiarize them with the characteristics to be evaluated. Sausage samples were cooked to an internal temperature of 70-75 ℃, cooled to room temperature, cut into small equal pieces and served to the panelists randomly. Sensory evaluation was done under white lightening and panelists were instructed to rinse their mouth between samples with water and salt-free biscuits. The aroma, texture, taste, juiciness, flavour, tenderness and overall acceptability were evaluated using a 9- point hedonic scale (1 for extremely dislike and 9 extremely like).

Experimental design and statistical analysis: The experimental design was a completely randomized design and data obtained were subjected to analysis of variance using SAS (2012) package and significant means were separated using Duncan Multiple Range Test of the same software.

RESULTS AND DISCUSSION

Functional Properties of flours of soybean, unfermented and fermented African locust beans: The functional properties (Table 2) was significantly (p<0.05) different for the flours assessed. The bulk density of the samples ranged from 0.55 g/mL for unfermented ALB flour to 0.65 g/mL for fermented ALB flour. The values obtained were generally higher than that reported by Edema et al. (2005) for flours from commercially sold soybean (0.38 g/mL) but fall within the range reported for pigeon pea (0.60 to 0.80g/ml) by Adebowale and Maliki (2011). The bulk density is of importance in product yield and packaging (Ijarotimi and Keshinro, 2012) and the higher bulk density observed in fermented ALB flour could be due to the fermentation process. Water absorption capacity ranged from 1.30 g/g for fermented ALB flour to 1.60 g/g for soybean flour. The value obtained for soybean was lower than that reported by Acuna et al. (2012), while values obtained for fermented and unfermented ALB were higher than that obtained for flours from soybean (1.12 g/g) as reported by Alfaro et al. (2004) and mucuna flour (1.2-2.0 g/g) as reported by Adebowale and Lawal (2004).

Table 2: Functional properties of flours of Soybean, unfermented and fermented African locust bean (Mean± SE)

Parameters	Flours		
	Soybean	Unfermented ALB	Fermented ALB
Bulk density (g/mL)	0.58^{b}±0.14	0.55^{b}±0.70	0.65^{a}±0.71
WAC (g/g)	1.60^{a}±0.28	1.35^{b}±0.77	1.30^{b}±0.14
OAC (g/g)	1.95^{b}±0.21	2.85^{a}±0.22	1.32^{b}±0.28

^{a,b,c}means along the same row with different superscripts are significantly different (p<0.05)

ALB: African Locust Beans; WAC: Water Absorption Capacity; OAC: Oil Absorption Capacity

The lower water absorption capacity observed in the ALB flours could be as a result of the nutritional profile of the locust beans (Ijarotimi and Keshinro, 2012),the rate at which they interact with water and probably their conformational characteristics (Iheke et al. 2017). Oil absorption capacity ranged from1.32 g/g for fermented ALB flour to 2.85 g/g for unfermented ALB flour. This result suggests that unfermented ALB flour has more hydrophobic interaction sites than other flours. The differences observed in the oil binding capacity of the flours could be as a result of variations in the availability of non-polar side chains which might bind the hydrocarbon side chains of oils among the flours (Adebowale and Lawal, 2004).

Proximate composition of breakfast sausage extended with African Locust Beans flours: The proximate composition of breakfast sausage extended with ALB flours is shown in Table 3. Crude protein contents of the sausages containing fermented ALB flours, 2% and 3% of unfermented ALB flours were not significantly different (p<0.05) from the control (soybean flour). This result is similar to the findings of Akwetey et al. (2012) who reported that the use of whole cowpea flours as substitution for ground beef does not affect the protein content of frankfurters. Obula et al. (2017) also reported reduced protein content of chicken meat patties with highest inclusion of oat flour. The result probably suggests that extending meat products with African locust beans flours does not reduce the nutritional quality of product though it could be more beneficial if the flours were fermented. It was observed that the breakfast sausages of the control treatment (soybean flour) had a significantly lower fat content compared to all treatments with ALB flours, even as breakfast sausages extended with unfermented ALB flours had significantly ($p<0.05$) higher fat content than those extended with fermented ALB flours. The lower fat content of sausages containing soybean flour, 2% unfermented ALB and 3% fermented ALB flours could result in improved shelf storage due to a possible reduction in the rate of auto-oxidation and rancid flavour development (Akwetey et al. 2012). The ash content of the sausages extended with soybean flour was significantly lower ($p<0.05$) than the sausages containing ALB flours while sausages with ALB flours had significantly ($p<0.05$) higher ash contents as level of inclusion of the flours increased.

Table 3: Proximate composition (Mean ±SE) of breakfast sausage extended with African Locust bean flours

		Treatments					
Parameters (%)	**Control**	**Unfermented ALB**			**Fermented ALB**		
		2%	**3%**	**4%**	**2%**	**3%**	**4%**
Protein	$12.79^{abc}\pm0.06$	$12.73^{c}\pm0.13$	$12.32^{cd}\pm0.62$	$11.93^{d}\pm0.05$	$12.87^{abc}\pm0.16$	$13.00^{ab}\pm0.05$	$13.39^{a}\pm0.07$
	$26.58^{d}\pm0.03$	$28.50^{c}\pm0.04$	$30.08^{b}\pm0.41$	$31.05^{a}\pm0.07$	$29.72^{b}\pm0.04$	$29.49^{c}\pm0.04$	$30.09^{b}\pm0.03$
	$2.94^{c}\pm0.10$	$3.04^{c}\pm0.03$	$3.06^{abc}\pm0.04$	$3.12^{ab}\pm0.14$	$3.16^{ab}\pm0.02$	$3.12^{abc}\pm0.02$	$3.22^{b}\pm0.02$
Moisture	$51.80^{a}\pm0.04$	$49.90^{b}\pm0.80$	$48.89^{cd}\pm0.05$	$48.71^{d}\pm0.03$	$49.68^{bc}\pm0.03$	$49.29^{bc}\pm0.05$	$49.09^{cd}\pm0.03$

means along the same row with different superscripts are significantly different ($p<0.05$)
Control: Soybean flour; ALB: African Locust Beans

This result suggests that including ALB flours in sausages could serve as a source of minerals for consumers (Appiah, 2011). Moisture content was significantly ($p<0.05$) higher in the control but reduced with increasing levels of the ALB flours. Prinyawiwatkul et al. (1997) reported similar findings when fermented flours were used as extender but the result contradicts the reports from Dzudie et al. (2002) and Akwetey et al. (2012) who reported lower moisture content for control treatments when common bean flour and whole cowpea flour were used in beef sausage and frankfurters, respectively. Most flours are known to possess heat induced gelation, water absorption and moisture retention properties that can be beneficial in meat emulsion formulations (Philips et al. 2003). However, ALB flours appeared not to have absorbed moisture from some of the water that was added during emulsification, and so did not retain a relatively greater portion during cooking compared to soybean flour alone. This correlates with the water absorption results obtained in this study.

Physico-chemical properties of breakfast sausage extended with African Locust Beans flours: The result of the physicochemical properties of prepared breakfast sausage is presented in Table 4. Significant effect of treatments was observed for all parameters measured. The product yield of the sausages ranged between 90.05 to 94.84% with the highest yield observed in sausage extended with 3% fermented ALB flours. It was observed that the yield of the control treatment (soy bean flour) was not significantly ($p<0.05$) different from the yield of sausages containing 4% unfermented ALB and 4% fermented ALB. The values obtained were however higher than that reported by Omojola et al. (2013) when breakfast sausage was extended with legume flours (80 to 89.14%). The result suggest that fermented and unfermented ALB flour can give comparable product yield to soybean flour when used for breakfast sausage production. The pH of the products ranged from 5.85 for sausages containing 4% fermented ALB flours to 6.21 for control containing soybean flour. The pH of breakfast sausage decreased ($p<0.05$) with increasing level of unfermented ALB flours while there was no significant difference in pH of sausages with increasing levels of fermented ALB flours. Dzudie et al. (2002) reported higher pH of sausages extended with common bean flours. The differences observed in these studies could be as a result of the type of carbohydrate –rich flours used to extend the meat components (Dzudie et al. 2002). The lower pH observed in sausages containing fermented ALB flours could be as a result of the fermentation process which resulted into production of some amino acids during protein synthesis (Uwagbuteet al. 2000).

Table 4: Physico-chemical properties of breakfast sausage extended with African Locust Beans flours (Mean ±SE)

	Control	Treatments					
		Unfermented ALB			Fermented ALB		
Parameters		2%	3%	4%	2%	3%	4%
Product yield (%)	90.50^c±0.22	94.02^a±0.16	93.00^b±0.92	90.50^c±0.15	94.47^a±0.40	94.84^a±0.32	90.51^c±0.70
pH	6.21^a±0.07	6.06^b±0.20	6.02^b±0.02	5.92^c±0.21	5.86^d±0.12	5.87^{cd}±0.11	5.85^d±0.40
WHC (%)	41.00^e±0.46	44.11^c±0.30	43.94^c±0.56	42.63^d±0.83	44.12^c±0.73	45.12^a±0.79	44.54^b±0.49
Cooking loss (%)	34.59^a±0.40	29.98^c±0.30	31.49^b±0.64	29.41^d±0.27	29.31^d±0.19	30.08^b±0.57	28.87^d±0.17

ALB: African Locust Beans WHC: Water holding capacity
a,b,c means along the same row with different superscripts are significantly different

Waterholding capacity (WHC) of meat is of great importance in the meat industry, as it affects both economic and sensory attributes of the meat (Oeckel et al. 1999). It influences the physical characteristics such as colour, texture, firmness, juiciness and tenderness of cooked meat. The range of WHC values (41.0 to 45.12%) obtainedwere lower than the range of 61.59 to 70.75% reported by Omojola et al. (2013) when breakfast sausage was extended with legume flours. The reduced WHC as level of inclusion increases could be as a result of reduced moisture content of the product as the ALB flours appeared not to have absorbed moisture from some of the water that was added during emulsification.Observed cooking loss values (28.87 to 34.59%) were higher than the range of 21.31 to 28.10% reported by Omojola et al. (2013). The control treatment (soybean flour) had the highest cooking loss probably because of the low water holding capacity of the carbohydrate fraction of the flour(Attoh-Kotoku et al. 2016).

Sensory evaluation of breakfast sausage extended with African Locust Bean flours: The treatments showed no significant differences in their scores (table 5), however, average sensory scores were obtained for all parameters. Overall product acceptability was highest at 4% inclusion of fermented ALB flour but generally, all products with ALB flours were equally acceptable to the panelists when compared with the control. Akwetey et al. (2012) reported similar findings when whole cowpea flour was used as extender in frankfurter sausage. Dei et al. (2008) also observed no significant differences in overall acceptability scores of smoked sausages when de-hulled cowpea flour was used as extender. The sensory properties of quail meat extended with different levels of soya and rice flours were also not significantly affected by flour treatments as reported by Dhond et al. (2017).

Table 5: Sensory evaluation of breakfast sausage extended with African Locust Bean Flour (Mean ±SE)

	Control	Treatments					
		Unfermented ALB			Fermented ALB		
Parameters		2%	3%	4%	2%	3%	4%
Aroma	4.31±1.20	4.60±1.01	4.21±1.32	4.50±1.50	3.03±1.22	3.30±1.44	4.63±1.61
Flavor	5.00±1.06	5.50±1.9	6.11±1.61	4.33±1.50	4.90±1.37	4.55±1.87	5.90±1.79
Colour	5.50±1.35	5.70±1.56	5.33±1.06	4.80±1.87	5.60±1.80	6.20±1.23	5.10±1.59
Tenderness	5.30±1.70	5.37±1.84	4.77±1.56	4.44±1.42	5.00±1.82	6.20±1.22	6.22±2.09
Juiciness	5.30±2.10	5.60±1.83	5.00±0.86	4.70±2.05	5.70±1.88	5.70±1.87	6.00±1.94
Overall acceptability	5.89±1.61	5.70±1.70	5.33±1.72	4.89±1.27	5.80±1.13	5.70±1.56	6.20±1.87

CONCLUSION

It can be concluded from this study that fermented ALB flour have the properties that could enable its use in meat products. It can be incoporated into breakfast sausages up to 3% without any adverse effects on sensory and physico-chemical properties of sausage.

COMPETING INTERESTS: The authors have no known competing interests either financial or personal between themselves and others that might bias the work.

ETHICS STATEMENT: Not applicable

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