Macrothink Institute™

Journal of Biology and Life Science
ISSN 2157-6076
2013, Vol. 4, No. 2

Quality of Breakfast Sausage Containing Legume Flours as Binders

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Received: May 16, 2013 Accepted: June 1, 2013
doi:10.5296/jbls.v4i2.3701 URL: http://dx.doi.org/10.5296/jbls.v4i2.3701

Abstract

The effects of different legume flours, viz., soybean, groundnut and cowpea flour, on the quality of breakfast sausage was studied. The study comprised of four treatments, treatment one with sodium caseinate served as the control while the remaining treatments contained soybean, groundnut and cowpea flour at 4% inclusion level respectively. Each treatment was replicated four times in a completely randomized design. Sausage with sodium caseinate had the highest ($P<0.05$) yield (92.20%), this was followed by products with cowpea (89.14%), soybean (89.00%) however, the least was obtained with product containing groundnut (80.02%). Sausage samples containing groundnut flour lost an average weight of 28.10% during cooking ($P<0.05$) whilst those containing sodium caseinate, soybean and cowpea flour lost an average weight of 20.91, 21.31and 21.44 % respectively. The water holding capacity of sodium caseinate products increased significantly compared to that of soybean (70.75%) and cowpea flour (69.34%) while the least was observed in products containing groundnut flour.

Formulations with soybean flour registered higher thiobarbituric acid values (mg malonaldehyde/kg sample) of 0.75 as against 0.57, 0.52 and 0.51 for formulations with cowpea flour, sodium caseinate and groundnut flour respectively. Sausage with soybean flour had higher (P<0.05) overall acceptability (6.30) than products with sodium caseinate (5.50), groundnut (5.10) and cowpea (4.00). However, sausage with cowpea flour had similar (P>0.05) moisture content (79.50%) with sausage that contained soybean flour (80.24%) while the highest (P<0.05) crude protein content was in treatment with sodium caseinate (19.50%) and least in sausage with cowpea flour (15.55%). The fat content was highest (P<0.05) in sausage with cowpea flour (15.35%), followed by 13.35% for sausage with soybean flour, 11.10 for formulation with groundnut flour and 10.25% for those with sodium caseinate. The quality attributes in terms of nutrient, flavour, juiciness and tenderness were better in sausage with soybean flour compared to sausage produced using other legume flours.

Keywords: Legume flours, Binder, Breakfast sausage, Sausage quality

1. Introduction

In the meat processing industry the inclusion of non-meat ingredients are considered an important strategy for reducing overall production costs while maintaining nutritional and sensory qualities of end products (McWatters, 1990). Legumes are of prime importance in human and animal nutrition due to their high protein content (Ustimenko –Bakumovsky, 1983). The use of plant protein products in food as functional ingredients to improve the stability and texture as well as the nutritional quality of the product or for economic reasons is much extended (Messina, 1999). Legume flours are consumed around the world as nutritious protein source, whose consumption has been shown to reduce low density lipoprotein (LDL)-cholesterol and the risk of acquiring type-2 diabetes (Shand *et al.*, 2011).

However, Sodium caseinate used in sausage production as a binder is a stabilized molecule of sodium hydroxide and casein. Reports by Friedman *et al.*, (1984) indicates that stabilizing casein and other molecules by alkalization with sodium hydroxide creates many potentially harmful products since the pH of protein has been altered, the kidney ends up having difficulty purifying the materials moving through them. This lack of purification has the potential to cause a systemic shut down of the kidney that may cause kidney failure. Casein has also been reported to have the potential to lower overall blood pressure when consumed daily for two weeks (Cadee *et al.*, 2007). Although, casein is a highly nutritious protein, containing many essential amino acids; however, any one with milk allergy must be aware of its presence in any food item. A possible allergic reaction to sodium caseinate is the most likely cause for concern because allergic reactions can vary widely in severity ranging from stomach upset to rashes, to respiratory arrest (Ciacci *et al.*, 2004).

Therefore, research attention has been directed toward increasing utilization of plant protein sources for food use. Such research includes the use of pigeon pea (Akintayo *et al.*, 1999), peanut (McWatters *et al.*, 1976) and sunflower (Hufman *et al.*, 1975). Though, extensive works have been done on utilization of these plant proteins for food, there is insufficient information on the use of soybean, cowpea and groundnut flour as possible replacement for sodium caseinate in sausage production. Therefore, the objective of this study was to compare the yield, physico-chemical and eating quality of breakfast sausage prepared using different protein binders.

2. Materials and Methods

2.1 Location of Study

The research was conducted at the Meat Science Laboratory of the Department of Animal Science, University of Ibadan, Nigeria.

2.2 Preparation of Legume Flours

The seeds of the black eye cowpea (*Vigna unguiculata*) variety were obtained from a local market and soaked in water for ten minutes, while soybean seeds were soaked in hot water (100^{0}C) for one hour. The testa of the soaked beans were removed and were soaked in hot water (80^{0}C) for one hour to remove the beany flavour and sundried for 48 hours at an ambient temperature of 28^{0}C and ground into flour using a conventional corn mill.

Groundnut seeds (*Arachis hypogaea)* were obtained from the same market, screened to remove spoilt seeds and impurities. The screened seeds were soaked in warm water (80^{0}C) over night for easy removal of the testa and dried in an oven (Wagtech Oven, model GP120SE300HYD) for 48 hours at 60^{0}C and milled to fine powder using an attrition mill.

2.3 Sausage Production

Fresh boneless beef (8kg) was obtained from the thigh muscle (*Semi membranosus* muscle) immediately after slaughter (within one hour post-mortem), chopped into smaller pieces and minced using a 5mm sieve in a tabletop mincer (Breville, Model UTP141, United Kingdom).The minced meat was apportioned into four groups of 2 kg. Group one contained 4% Sodium caseinate as extender while groups 2, 3, and 4 contained soybeans, cowpea and groundnut flour each at 4% inclusion level. Each treatment group was replicated four times in a completely randomized design.

Slurry of salt (NaCl), sodium nitrite, phosphate and sugar was prepared in the proportion shown in Table 1.

Table 1. Sausage formulation using different protein extenders (%)

Ingredients	Sodium caseinate	Soybean flour	Groundnut flour	Cowpea flour
Beef	65.00	65.00	65.00	65.00
Lard	20.00	20.00	20.00	20.00
Sodium caseinate	4.00	-	-	-
Soybean flour	-	4.00	-	-
Groundnut flour	-	-	4.00	
Cowpea flour	-	-	-	4.00
Sugar	1.00	1.00	1.00	1.00
Sodium nitrite	0.01	0.01	0.01	0.01
Phosphate	0.30	0.03	0.03	0.03
Ice water	3.00	3.00	3.00	3.00
*Dry spice	2.00	2.00	2.00	2.00
**Green spice	2.69	2.69	2.69	2.69
Total	100.00	100.00	100.00	100.00

*Dry spice composition (%) - Black pepper 15.00: Nutmeg 7.00: Calabash nutmeg 3.00: Red pepper 15.00: Monosodium glutamate 30.00: Thyme 20.00: Curry powder 10.00.

**Green spice composition (%)- Onion 48.70: Garlic 25.65: Ginger,25.65.

The spices were thoroughly mixed with the meat and the fat. All other ingredients were added in equal amounts (g/100g) as shown in Table 1. The minced meat and the other ingredients were mixed thoroughly in a mixer (Oster 8-Speed Blender Model, MG—MB E103TI -Mexico) for 5 minutes. The thoroughly mixed meat samples were stuffed into natural casing (conditioned pig intestine) of about 2 cm diameter (after stuffing). The stuffed casings were twisted at 10cm intervals to obtain shorter linked units.

2.4 Cooking Loss

Sausages from the different groups were weighed using an electronic scale (Cuisinart KML-K03BV36246-China) before cooking into an internal temperature of 75^{o}C and after cooking.

$$\text{Cooking loss} = \frac{\text{weight before cooking- weight after cooking}}{\text{Weight before cooking}} \times 100$$

2.5 Thermal Shortening

Thermal shortening of the sausages were calculated as the difference in length of each sausage sample before cooking to an internal temperature of 75^{o}C in a moist heat cookery and the length after cooking.

$$\text{Thermal shortening} = \frac{\text{Length before cooking – length after cooking}}{\text{Length before cooking}} \times 100$$

2.6 Drip Loss

Drip loss was determined by the procedure described by Ibraheem and Abdullahi (2000) and this was calculated using the formula

$$\text{Drip loss} = \frac{\text{Purge weight}}{\text{Sample weight}} \times 100$$

2.7 Water Holding Capacity (WHC)

Water holding capacity was determined following a slightly modified method of Suzuki *et al.*, (1991). In the process, cooked sausage samples (10 x10 x 5 mm) from each treatment were weighed individually onto two filter papers and pressed between two plexi glasses for a minute using a vice. The samples were then oven dried at 65^{o}C for 48 h in order to determine the moisture content. The amount of water released from the samples was measure 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 (Suzuki *et al.*, 1991)

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

Where Ar = Area of water released form meat (cm^2); Am = Area of meat sample (cm^2); Wm = Weight of meat in mg; Mo = Moisture content of meat (%); 9.47 is a constant factor.

Yield of the product

Yield of the product was calculated using the following formula

$$\text{Yield} = \frac{\text{Weight of product}}{\text{Initial weight of sample}} \times 100$$

2.8 Sensory Evaluation

Sensory evaluation was conducted on freshly prepared sausage (day0). A total of twenty panelists (60% male and 40% female) with age ranging between 22 and 40 years were selected and trained according to the British Standard Institution (BSI, 1993) guidelines to evaluate the product. The panelist evaluated the products for aroma, texture, taste, juiciness, flavour, tenderness and overall acceptability on a nine- point hedonic scale (1 for extremely dislike and 9 extremely like).

The sausages were sliced to approximately1.5 cm and wrapped in kitchen foil, blind coded with 3-digit random number and oven warmed at 180°C for 5 minutes before serving. The order of serving samples were randomized and counterbalanced so that all treatments occurred equally. The taste evaluation took place under a well illuminated (white fluorescent) laboratory condition (Poste *et al.*, 1991) that ensured independence throughout the entire duration.

2.9 Proximate Composition

The products were analyzed for moisture, crude protein, fat and ash content according to the method described by the Association of Official Analytical Chemist (AOAC, 1999). Analyses were conducted in duplicates and all reagents were of analytical grade.

2.10 Thiobarbituric Acid Reactant Substance (Tbars)

Samples for TBARS assay were from sausage samples stored at 4°C for 5 days. Thiobarbituric acid test was determined through the extraction methods process as described by Rosimini *et al*. (1996) and Pikul *et al*. (1998).

2.11 Statistical Analysis

All data obtained were subjected to analysis of variance and where significance differences occur, the means were compared using the Duncan's Multiple Range Test (DMRT). The SAS computer soft ware package (1999) was used for all statistical analysis.

3. Results

The result of the yield, cooking loss, thermal shortening and water holding capacity of the sausage after cooking are presented in Table 2. Sausage with sodium caseinate had the highest

(P<0.05) yield (92.20%), this was followed by products with cowpea (89.14%) and soybean (89.00%) and least value was observed in the product with groundnut flour (80.02%). Sausage samples containing groundnut flour lost an average weight of 28.10% during cooking (P<0.05) whilst those containing sodium caseinate, soybean and cowpea flour lost average weight of 20.91, 21.31and 21.44 % respectively. Product with sodium caseinate had the highest (P<0.05) water holding capacity (84.64%), followed by sausage containing soybean (70.75%) and cowpea flour (69.34%) while the least value was obtained in products containing groundnut flour (61.59%). The ultimate pH of the sausage ranged from 6.17 to 6.40 after 24 h storage at 4^{o}C.

Table 2. Product yield and physical characteristics of sausage prepared using different binders

Parameters (%)	Sodium caseinate	Soybean flour	Groundnut flour	Cowpea flour	SEM
Yield	92.20^{a}	89.00^{b}	80.02^{c}	89.14^{b}	0.07
Thermal shortening	5.72^{a}	4.96^{b}	3.69^{c}	4.99^{b}	0.37
Cooking loss	20.91^{b}	21.31^{b}	28.10^{a}	21.44^{b}	1.12
Water holding capacity	84.64^{a}	70.75^{b}	61.59^{c}	69.34^{b}	2.61

^{abc}Means along the same row with similar superscripts are not significantly different (P<0.05)

The result of the moisture, fat, crude protein and ash content of the sausages are presented in Table 3. The use of sodium caseinate in sausage production increased the crude protein significantly (P < 0.05) whilst the moisture content was lowered. The fat content was highest (15.35%) in sausages containing cowpea flour, followed by those with soybean flour, groundnut flour and sodium caseinate with values of 13.35, 11.10 and 10.02% respectively. Significance differences (P<0.05) occurred in the ash content of the various sausages. Soybean flour sausage contained the highest ash content (3/40%) followed by sausage with sodium caseinate (2.80%) and 2.60% for cowpea flour sausage while groundnut flour sausage contained the least (P<0.05) ash content (2.10%).

Table 3. Chemical composition of sausage prepared using different protein binders

Parameters	Sodium Caseinate	Soybean flour	Groundnut flour	Cowpea flour	SEM
Moisture (%)	70.25^{b}	80.24^{a}	69.80^{b}	79.50^{a}	1.49
Fat (%)	10.25^{d}	13.35^{b}	11.10^{c}	15.35^{a}	0.06
Crude protein (%)	19.50^{a}	17.60^{b}	16.80^{c}	15.55^{d}	0.56
Ash (%)	2.80^{b}	3.40^{a}	2.10^{d}	2.60^{c}	0.15
TBARS (mg/kg)	0.52^{c}	0.75^{a}	0.51^{c}	0.57^{b}	0.03

^{abc}Means along the same row with similar superscripts are not significantly different (P<0.05)

Thiobarbituric acid reactant substance (TBARS) was determined to measure the lipid peroxidation in the product. The TBARS were between 0.51 and 0.75mg/100g. The product containing soybean flour had the highest (P<0.05) value while those with sodium caseinate and groundnut had similar (P>0.05) values which were the least (Table3).

Sausage with soybean flour had higher overall acceptability score (6.30) than formulations with sodium caseinate (5.50), groundnut (5.10) and cowpea (4.00). Sausage with soybean flour had better score (P<0.05) in terms of, flavour, juiciness and tenderness compared to sausage with other legumes (Table 4).

Table 4. Organoleptic attributes of sausage prepared using different protein extenders

Parameters	Sodium Caseinate	Soybean flour	Groundnut flour	Cowpea Flour	SEM
Flavour	5.70^b	6.31^a	3.66^c	3.90^c	0.35
Juiciness	6.40^a	6.22^a	5.00^b	5.10^b	0.19
Colour	6.00 ^{a}	5.00^b	5.10^b	5.00^b	0.13
Tenderness	4.90^c	6.30^a	5.20^b	3.60^d	0.29
Overall Acceptability	5.50^b	6.30^a	5.10^c	4.00^d	0.21

^{abc}Means along the same row with similar superscripts are not significantly different (P<0.05)

4. Discussion

Sausage with sodium caseinate (Control) had the highest yield most probably due to the high WHC of the product and subsequently its low cooking loss. The products with legume protein gave lower yield most probably because mincing destroys the structural integrity of the cell proteins lowering their ability to hold on to its water upon the application of an external force. This became pronounced during cooking since high temperatures cause protein denaturation and a further increase in cooking loss (Lawrie, 1998).

Sausages extended with legume flours had higher moisture content than those with sodium caseinate with the exception of groundnut flour products that had similar (P>0.05) moisture content value with the control. The findings in the current study contradicted the observation of Prinyawiwatkul *et al.*, (1997) who reported higher moisture contents for nuggets without flour extender. This research utilized unfermented legume flours that possibly had higher potential to absorb and retain moisture in meat formulations as against fermented flours used by Prinyawiwatkul *et al.*, (1997).

The crude protein (CP) of the sausage with different binders varied significantly with the highest in products with sodium caseinate. The CP of the various binders could be responsible for the differences in the CP of the products. The cooking loss value most probable had an inverse relationship with the CP of the products. The high CP content of sausages with soybean flour is indicative of its potential as a possible replacement for sodium caseinate in breakfast sausage formulation. The low fat content of sausages with sodium caseinate and groundnut flour could result in improved shelf storage due to a reduction in the rate of auto-oxidation and rancid flavour development. The high fat content of sausage formulation with cowpea flour could be due to the fact that cowpea flour has a high fat binding property (Philips *et al.*, 2003) and this could be beneficial in meat applications. The high ash and fat content of sausage formulations with soybean and cowpea flour is an indication that these two plant proteins when used in sausage production could be important sources of minerals and energy for consumers (Brown, 1999)

Thiobarbituric Acid Reactant Substances (TBARS) is an indication of the level of lipid peroxidation which eventually predicts the storability of the product. The low TBARS number in the product after storage at 4^{o}C for five days could be as a result of the composition of the green spices used in the ingredient formulation (Table 1) that contained some antioxidative substances. Minced meat and meat products undergo oxidative changes quickly as grinding exposes lipid membranes to metal oxidation catalyst (Barana *et al.*, 2011). In cured meat, sodium nitrite acts as a very effective antioxidant (Kanner, *et al.*, 1984). The TBARS numbers in each of the product was between the minimum threshold values of 0.5-1mg malonaldehyde/kg from cooked meat product during storage (Tarladgis, 1960) but was below the level of 1.1mg/kg that elicited off flavour in Buffalo meat nugget as reported by Rajendram *et al.*, (2006).

Colour and product appearance are very important criteria that influence consumer patronage (Comfort, 1994) Colour is the single most important factor of meat products that influences consumer buying decisions, as it indicates freshness or otherwise of the product (Boles and Pegg, 2010). The colour rating of the products with legume flours fell within the intermediate range on a nine-point hedonic scale, which is an indication that any of the legumes used in the present study could be used for breakfast sausage preparation without compromising the colour of the product. The sensory score for flavour, tenderness and overall acceptability were highest ($P<0.05$) in sausage with soybean flour. This might be attributed to the high moisture content of the product containing soybean flour because high moisture content in a product improves tenderness (Serdaroglu, 2005) and the high flavour perception could be attributed to the inherent flavour of soybean which becomes intense upon cooking.

5. Conclusion

Incorporation of 4% soybean flour as binder in breakfast sausage effectively improved the eating qualities of the product in terms of juiciness, flavour, tenderness and overall acceptability. The yield and water holding capacity of the product were also enhanced however, the TBARS value was highest in products with soybean flour. The results obtained from the study showed that soybean flour have great potential as binder in sausage production and can be successfully used to replace sodium caseinate in breakfast sausage.

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