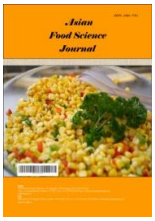

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Effect of Replacement Levels of Wheat Flour on the Physicochemical and Sensory Properties of Smoke-Dried Sausage

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Authors' contributions

This work was carried out in collaboration between both authors. Author II designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and also managed the analyses of the study. Author IGO managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

In the olden days, there was no refrigeration for meat preservation and sausage making was a way to solve this problem. Sausage making evolved as an effort to economize and preserve meat which could not be consumed immediately after slaughter. This study evaluated the effect of replacement levels of wheat flour on the physicochemical characteristics and sensory qualities of smoke-dried sausage. Beef, wheat flour, sodium chloride, seasonings (Table 1) were bought, pre-processing operations were carried out. Sausage was processed by adding wheat flour, seasonings, salt to minced meat at different replacement levels (5%, 10% and 15%) with 0% as control and later smoke-dried. Sensory evaluation and physicochemical properties were determined. Data generated were analyzed. The results from sensory evaluation showed that Product A had the highest response (5.00) to sausage colour. Product A (5.00), B (5.00) and C (4.90) had the highest response for product juiciness. Product A (5.00) and product B (5.00) had better response to taste. For overall acceptability, Product A (5.00) was not different from other products. The addition of wheat flour resulted in higher and greater elasticity and increased

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acceptability due to higher scores for texture and colour. The protein content showed that Product D (56.33%) had the lowest value, followed by Product B (58.23%), next was Product C (59.57%), and the highest was observed in Product A (60.42%). Product C had the highest value for potassium and phosphorus (122.0 mg/100g and 13.40 mg/100g). Product B and C had the same value (6.17) for pH, next was product A (6.13), the least pH was observed in Product D (6.07). Sausage manufacture is a means of adding value to off-cuts and thereby increasing the utilization of meat. The incorporation of 10% wheat flour to sausage is highly nutritive with better sensory qualities and better economic value.

Keywords: Flour; sausage; replacement; sensory evaluation; minerals.

1. INTRODUCTION

Sausage is derived from the Latin word 'Salsus' meaning salted or preserved by salting or 'Salsicia' meaning something salted. Sausage was originally applied to cured or salted meat. Sausage manufacture is a means of adding value to off-cuts and thereby increasing the utilization of meat. Sausage is a cylindrical meat product usually made from ground meat, often pork, beef, or veal (the flesh of a calf) along with salt, spices, flavour enhancers and bread crumbs, with a skin around it. Typically, a sausage is formed in a casing traditionally made from intestine, but sometimes synthetic materials. Sausages that are sold uncooked are usually cooked in many ways, including pan frying, boiling and barbecuing. Some sausages are cooked during processing and the casing may then be removed. Sausage-making is a traditional food-processing preservation technique. It may be preserved by curing, drying (often in association to preservation), smoking or freezing. Some cured or smoked sausages can be stored without refrigeration. Most cured sausages must be refrigerated or frozen prior to cooking. There is a huge range of national and regional varieties of sausage which differ by their flavouring and spicing ingredients, the meat used in them and their method of preparation [1]. In some jurisdictions foods described as sausage must meet regulation governing their content for example, in the United States of America. The Department of Agriculture specifies that the fat content of different types of sausage may not exceed 30% or 50% by weight. Some sausages may contain binders or extenders. Many traditional style of sausage from Asia and Mainland Europe use no bread based filter and include only meat (lean meat and fat) and flavouring. In the United Kingdom and other countries with English cuisine traditions, many sausages contain a significant proportion of bread and starch-based filter, which may comprise 30% of ingredients. The filter used in many sausages help them to keep their shape as they are cooked [1]. When the food-processing industry produces sausages for a low price point, almost any part of the animal can end up in sausages, varying from cheap fatty specimens stuffed with meat blasted off the carcasses (mechanical recover meat MRM) and rusk [2]. On the other hand, the finest quality contain only choice cut of meat and seasonings. In Britain, meat declared on labels could in the past contain fat, connective tissue and mechanical recovered meat. These ingredients may still be used, but must be labeled as such and up to 10% water may be included without been labeled. Sausage are emulsion type products, they are composed of solid fat and stabilizing them in water. The objective of this study was to investigate the effect of replacement levels of wheat flour on the physicochemical and sensory properties of smoke-dried sausage.

2. MATERIALS AND METHODS

2.1 Source of Materials

Fresh muscle and large intestine were obtained from a clean abattoir at Aviele, along Benin-Abuja Express Road, Edo State, Nigeria. Wheat flour, flavor enhancer, spices, salts and other materials were obtained at Uchi Market, Etsako-West, Auchi , Edo State, Nigeria.

2.2 Steps in the Production of Meat Sausage

2.2.1 Raw meat

Raw materials used were of high quality and subjected to microbial analysis; all ingredients were properly weighted prior to mixing. The fresh lean meat was well-trimmed to a level of less than 10% of non-trimmable fat and connective tissue, the trimmed lean meat thus being practically free from sinews and

gristle and entirely free from ligament, bones and cartilage particles. The selection of meat was such that the meat had a good water-binding capacity. Twenty percent (20%) of the fat was needed for good texture, taste and flavour.

2.2.2 Meat grinding

The fist- size chunks (100g) of lean meat and fatty tissues were first ground by a grinder (Kitchen FGA Food Grinder) for 10 minutes. Tripe and filler meats were ground twice. Curing salts were then added and then mixed in a mechanical mixer (KitchenAid 5-Quart Artisan Series Mixer) to ensure that the ingredients are well dispersed. The curing process took place over night in a chiller at 3°C [2].

2.2.3 Mincing

The experiment was designed to produce sausages with different replacement levels of wheat flour. Four replacement levels of meat by wheat flour were used at 0%, 5%, 10% and 15%. After grinding, the meat was minced into a very fine particle size for easy protein extraction. Protein has the function of binding the water surrounding fat droplets and keeping them dispersed. Prior to mincing, the lean meat was chopped with a kitchen knife. Other processes include fat trimmings, addition of spices and water. The water was taken up by the disintegrated and homogenized meats. The curing ingredients were dissolved in 20ml of warm water before been added. Minced meat was mixed in a mixer; spices, salts, sugar and wheat flour were added to the minced meat. It was then transferred into a stuffer to be stored in a casing (large intestine) which was obtained from a cow [2].

2.2.4 Filling

Before filling into casing, oxygen was excluded from the mixture by AK6200 Vacuum Filling Machine and the temperature of the mixture was 2^{o}C. Natural casing was made from intestine of slaughtered cow. It was washed thoroughly in and out, and soaked in solution of salt to prevent microbial contamination. Salt was removed by rinsing casings in running water and then soaked for 1hour prior to use in order to make casing soft. Minced meat and non-meat was stuffed into casing. Casing also help to minimizes product weight loss during cooking [3].

2.2.5 Smoke –drying and packaging

The sausage was immediately smoke-dried in a standard smoking kiln that uses charcoal and meat was allowed to cool before packaging. The products were packaged in plastic film in order to retain quality, extend shelf life, to prevent microbial contamination, physical as well as chemical changes.

2.3 Proximate Composition

Moisture content of products was determined by drying the product at 105^{o}C in a drying oven till a constant weight was attained [4]. Ash content was determined using a muffle furnace at 550^{o}C for 8 hours by AOAC method [5]. Protein content was determined by [6] Kjeldahl method by first determining the percent nitrogen content and then converted to % crude protein by multiplying with the factor 6.25. Crude fiber was determined by acid-alkali hydrolysis [6]. Carbohydrate was calculated by difference [6].

2.4 Mineral Content Determination

Analyses of mineral content were carried out using an Atomic Absorption Spectrophotometer (Perkin Elmer Analyst 200) according to the method [5].

2.4.1 pH Determination

The pH was determined on dispersion of 5 gram of ground sausage in 50ml of distilled water to form a homogenized mixture, later a pocket pH meter was used for measurement of the pH value [7].

2.5 Sensory Evaluation

Ten semi-trained panelists of Food Technology Department evaluated the smoke-dried sausage samples for colour, taste, texture, juiciness and overall acceptability using 9-point Hedonic scale, where 1=extremely dislike and the highest point 9=extremely like [8].

2.6 Statistical Analysis

Data generated were subjected to analysis of variance (ANOVA) in a Randomized complete block design. Where significant differences existed, Duncan's multiple range test was applied to indicate where the differences occur using Genstat statistical software package 2005, 8^{th} Edition (Genstat Procedure Library Release PL16).

Table 1. Sausage formulation

Meat and Non-Meat	Replacement levels of wheat flour			
ingredients	**0% (control)**	**5%**	**10%**	**15%**
Meat (g)	1000	900	800	700
wheat flour	-	100	200	300
sodium chloride	30	30	30	30
sugar	30	30	30	30
phosphate	0.01	0.01	0.01	0.01
ginger	15.0	15.0	15.0	15.0
thyme	15.0	15.0	15.0	15.0
curry	15.0	15.0	15.0	15.0
nutmeg	15.0	15.0	15.0	15.0
pepper	15.0	15.0	15.0	15.0
water (ml)	20	20	20	20
Total	1155	1155	1155	1155

Product A=0%, Product B=5%, Product C=10%, Product D=15%

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation of Smoke-Dried Sausage

The results from Table 2 showed that there was significant difference ($p<0.05$) among the products based on treatments of sausage on sensory attributes.

Product A (5.00) had the highest response to sausage colour and this was not significantly different ($p>0.5$) from Products B (4.80) which had 5% wheat inclusion. However, Product B (4.80) was not significantly different ($P>0.05$) from Product C (4.50) and Product D (4.50). The results from the colour of these products reflect that as inclusion level of wheat flour increases in the products, the more appreciable the colour of the products. Smoke drying imparts attractive colour to food which make the food acceptable. It has been reported that colour is one of the major response variables governing food acceptance [9]. Colour influences consumer buying decision. Colour of meat is a very important consideration in the consumer perspective of meat and definitely will affect marketability [10].

Product A (1.90) had the lowest response of product texture and this was significantly different ($p<0.05$) from other products. The results of texture showed that the more the inclusion of wheat flours the harder the texture. It was reported that incorporation of non-meat ingredients such as wheat protein flour in sausages increases the hardness and decreases the elasticity of sausage [2].

Product A (5.00) and product B (5.00) had better response to taste and there was no significant different ($p>0.05$) between the two products. However, they were significantly different ($p<0.05$) from other products. Product D (2.50) had the least taste; this could be attributed to high inclusion level (15%) of wheat flour resulting to decrease in taste. The results from the taste showed that as wheat flour was added to the sausage, the taste of the sausage dropped. Studies have shown that aroma and taste are the most important attributes that influences the sensory properties of a meat product extended with non-meat protein additives [11].

Product A (5.00), B (5.00) and C (4.90) had the highest response of the product juiciness and these were not significantly different ($p>0.05$) from each other, but significantly different ($p<0.05$) from Product D which had the lowest juiciness as a result of having the lowest fat content (9.23%). It was observed that at 15% wheat flour inclusion, intramuscular lipid reduced. Earlier reports indicate that water content and intra-muscular lipid content are the principal sources of juiciness in meat products [12]. The results showed that the higher the wheat flour inclusion, the lesser the juiciness of the sausage.

For overall acceptability, product A (5.00) was not significantly different ($p>0.05$) from other products. The addition of wheat flour resulted in higher and greater elasticity and increased acceptability due to higher scores for texture and colour. Earlier research [13] reported that smoke-drying as a processing method, does not have adverse effect on the quality and overall acceptability of meat products rather it enhances acceptance of products.

According to Malaysian Food Regulation -16 the amount of actual meat in manufactured meat

product like sausage should not be less than 65%. As a major ingredient, the percentage of meat used in the formulation of sausage in this study was the minimum permissible limit of 70% [14].

3.2 Proximate Composition of Smoke-Dried Sausage

The results from Table 3 showed the proximate properties of sausage with different levels of wheat flour inclusion. For moisture content, Product A (9.51%) had the lowest moisture content, this was followed by Product C (9.98%), next was Product B (10.64%) and the highest was Product D (11.39%). It was observed that the products decreased in moisture content as wheat flour inclusion was increased from 5% (10.64%) to 10% (9.98%) in products. The results showed that wheat flour inclusion could result to hardness in meat products.

The protein content showed that Product D (56.33%) had the lowest value, followed by Product B (58.23%), next was Product C (59.57%), and the highest was observed in Product A (60.42%). The highest value of protein observed in Product A could be attributed to its lowest moisture content. The lower the moisture content the more concentrated the other nutrients in the products. These results showed that the inclusion of wheat flour to sausage results in lower protein content compare to whole beef (100%). Although, the protein content for all the products was high, this could be as a result of the processing method (smoke-drying). Smoke component has preservative influence on crude protein due to reduction effect of pH [15]. Protein content in smoke-dried meat was significantly higher than protein content of meat obtained from other processing methods [16].

The ash content showed that sausage with 0% inclusion of wheat flour i.e. Product A had the highest ash content (13.24%) and was followed by Product C (13.11%), next was Product B (10.39%), the least was observed in Product D (9.22%). The ash content for the different products was high compared to the ash content of 4.23% for smoked snail [17].

The fat content showed that Product A (11.07%) had the highest fat content, followed by Product B (10.36%) next was Product C (10.27%), and the least was Product D (9.23%). The results showed that wheat flour inclusion in sausage product could help to decrease fat content.

There was significant decrease ($p<0.05$) in the fiber content of the products with wheat flour compared to product with 0% wheat flour.

Product C (2.94%) had the highest fiber, next was Product A (2.67%) followed by Product D (2.49%), the least was product B (2.21%). The fiber observed in these products was low and the presence of fiber could be attributed to the plant materials used as seasonings (ginger etc.) during the processing of sausage. Besides, wheat flour is high in insoluble fiber, and fiber helps to prevent constipation. Consumption of food rich in dietary fiber reduces the risk of diabetes mellitus, cardiovascular diseases, constipation, appendicitis, and colon cancer [18,19].

The highest carbohydrate was in Product D (11.34%) followed by Product B (8.1%) and then Product C (4.13%) and the least was Product A (3.09%). Naturally occurring red meat contains no carbohydrate. However, the carbohydrate seen in these products could be attributed to seasonings and wheat as plant materials used.

3.3 Mineral Composition of Smoke-Dried Sausage

There was significant difference ($p<0.05$) in the mineral content of products (Table 4). The product with the highest calcium content was B (5.72 mg/100g), followed by Product A (4.61 mg/100g) next was Product C (4.29 mg/100g), the least was Product D (3.65 mg/100g) calcium help in the formation of strong bones and teeth.

There was significant difference ($p<0.05$) among the products for potassium. The highest potassium content was in Product C (122.0 mg/100g), followed by Product A (118.33 mg/100g) next was Product B (98.90 mg/100g), the least was Product D (86.40 mg/100g). Potassium is necessary for the functioning of all living cells and it is present in all plant and animal tissues.

The results showed that there was significant difference ($p<0.05$) in the magnesium content of the products. The highest magnesium content was Product B (3.12 mg/100g) followed by Product A (2.63 mg/100g), next was Product C (2.24 mg/100g), while the least was Product D (1.34 mg/100g). Magnesium helps normal nerve to beat steady.

Table 2. Sensory evaluation of smoke-dried sausage

	Replacement levels of wheat flour				
Sensory Evaluation	**0%**	**5%**	**10%**	**15%**	**SED**
Colour	5.00[a]	4.80[ab]	4.50[b]	4.50[b]	0.19
Texture	1.90[b]	4.80[a]	4.90[a]	4.90[a]	0,23
Taste	5.00[a]	5.00[a]	4.40[b]	2.50[c]	0.25
Juiciness	5.00[a]	5.00[a]	4.90[a]	2.70[b]	0.12
Overall acceptance	5.00[a]	5.00[a]	4.80[a]	5.00[a]	0.18

Means with the same superscript along the rows are not significantly different (p>0.05)
NOTE: Product A= 0% replacement level of wheat flour, Product B= 5% replacement level of wheat flour, Product C =10% replacement level of wheat flour, Product D=15% replacement level of wheat flour
SED=Standard error of difference

Table 3. Proximate composition of smoke-dried sausage

	Replacement levels of wheat flour				
Parameters	**0%**	**5%**	**10%**	**15%**	**SED**
Moisture %	9.51[d]	10.64[b]	9.98[c]	11.39[a]	0.01
Protein %	60.42[a]	58.23[c]	59.57[b]	56.33[d]	0.02
Ash %	13.24[a]	10.39[c]	13 11[b]	9 22[d]	0.01
Fat %	11.07[a]	10.36[b]	10.27[c]	9.23[d]	0.02
Fiber %	2.67[b]	2.21[d]	2.94[a]	2.49[c]	0.01
Carbohydrate %	3.09[d]	8.17[b]	4.13[c]	11.34[a]	0.02

Means with the same superscript along the rows are not significantly different (p>0.05)

Table 4. Mineral content and pH of smoke-dried sausage

	Replacement levels of wheat flour				
Minerals (mg/100g)	**0%**	**5%**	**10%**	**15%**	**SED**
Calcium	4.61[b]	5.72[a]	4.29[c]	3.65[d]	0.02
Potassium	118.3[b]	98.90[c]	122.00[a]	86.40[d]	1.05
Magnesium	2.63[b]	3.12[a]	2.24[c]	1.34[d]	0.03
Phosphorus	9.27[c]	11.30[b]	13.40[a]	8.37[d]	0.32
pH	6.13[a]	6.17[a]	6.17[a]	6.07[a]	0.13

Means with the same superscript along the rows are not significantly different (p>0.05)

There was significant difference (p<0, 05) among the products in terms of phosphorus. The highest phosphorus content was Product C (13.40 mg/100g), followed by Product B (11.30 mg/100g), next was Product A (9.27 mg/100g), while the least was Product D (8.37mg/100g). Phosphorus is an essential mineral used for growth and it helps for repair of body cells and tissues. Okonkwo and Anyaene [7] reported that mineral contents increases due to absorption of sodium chloride.

3.4 pH of Smoke-Dried Sausage

The results for pH showed that there was no significant difference (p>0.05) in pH value of the products (Table 4). Product B and C had the same value (6.17), and were not significantly different (p>0.05) from the two products, next was Product A (6.13), the least pH was observed in Product D (6.07). The results showed that these products are low acid food and are shelf stable due to vacuum filling as well as appropriate packaging. A longer shelf life of sausage is achieved through vacuum filling (3). Packaging meat and meat products with appropriate plastic film and laminates plays significant role in retention of the quality and extension of shelf life during refrigerated storage [20].

4. CONCLUSION AND RECOMMENDATION

The results of this study showed that sausage is high in protein and mineral content at 10%

inclusion of wheat flour. The use of wheat flour in sausage as plant substitutes acts as binder which strengthens and make the sausage firm. Non- meat ingredients reduced the cost and improved the quality attributes and consumer acceptability of the meat products. The price of sausage is quite competitive when compared to other meat products. Sausage production as a norm utilizes meat left-overs, which are relatively cheap as raw materials. Sausage manufacture is a means of adding value to off-cuts and thereby increasing the utilization of carcass meat. The inclusion of wheat flour in sausage production for economic, higher nutritive content and sensory properties should be at 10%.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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