ID: 482

Quality of smoked-cooked chicken sausage with soy flour and oil

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Abstract
The study aimed to investigate the effect of different levels of soya flour and soya oil on the sensory attributes and nutritional qualities of smoked-cooked chicken sausages. The sausages were manufactured by replacing part of the chicken meat in four treatments with soya flour (T1 =0.0g; T2=94g; T3 =75g and T4 = 52g) and soya oil (T1=0.0ml; T2=56ml; T3=75ml; and T4= 98ml). The products were smoked, cooked and served to forty consumer panelists for sensory evaluation. Consumer panelists evaluated the appearance, texture, juiciness, flavor, taste and overall acceptability of the sausages using a 9-point hedonic scale. Other parameters determined were proximate composition, cooking yield and water holding capacity. The results from proximate composition showed no significant differences ($p>0.01$) in ash and moisture contents of all treatments. There were significant differences ($p<0.01$) in the protein contents, with T2 having the highest protein content and T4 having the lowest. It was observed that fat contents significantly increased ($p<0.01$) as the levels of inclusion of soy oil increased in sausage formulations, and T4 had the highest fat content. There were also significant differences ($p<0.01$) in water holding capacity, with T4 having the highest. No significant differences ($p>0.01$) were observed in the cooking yield and all the sensory attributes evaluated. It was concluded that using higher quantities of flour and lower oil levels resulted in higher protein contents of sausages. While incorporating lower quantities of flour and higher oil levels resulted in higher fat contents. But the levels of soya flour and soya oil used did not affect the sensory attributes of sausage. The best chicken sausage was obtained with 5.35% soya flour and 3.18% soya oil in product formulations.

Keywords: Chicken sausage, sensory attributes, nutritional quality, soya flour, smoked-cooked sausage.

Introduction

The consumption of meat and meat products have long been regarded as an essential part of human diets since they are important sources of a wide range of nutrients that are essential for optimal growth and development. According to You *et al*. (2020) global developments and industrialization have induced a worldwide increase in meat-based diets, including differently processed meat. Such meat-based diets including sausages contain several nutrients in high quantities and quality, however, the contents of protein (amino acids), vitamins, minerals and fatty acids may vary depending on the animal species and processing methods.

A sausage is a meat product obtained from the formulation of different meat ingredients and spices in different proportions to satisfy consumer demands in different regions. According to Carballo (2021) there are varieties of sausages produced worldwide each with outstanding socio-cultural and economic significance, and each local variety is a reflection of the availability and type of raw materials, the climatic influences of the geographical environment, cultural and religious conditions, as well as the knowledge of manufacture passed on from one generation to another. Among the various types of meat, chicken is a popular source of protein due to its low fat, high protein, and balanced amino acid contents. It is therefore recognized by modern consumers as an ideal protein source for healthy eating (Kawecki *et al*., 2021; Hwang *et al*., 2020). According to Barbut (2001) chicken sausages are considered one of the popular foodstuffs among food products and it is consumed across the world. However, during storage, quality attributes of products deteriorate due to lipid oxidation, microbial growth, and also due to chemical reactions (Moawad *et al.,* 2020). Their perishable nature is due to high moisture content, minerals, fat and proteins, which may favour microbial activity leading to a loss in sensory attributes. As a result, the incorporation of some ingredients may maintain the product quality and shelf life (Pagthinathan and Gunasekara, 2021). Thus, food industry experts are continuing to explore innovative means to obtain foods that can meet consumer acceptance for nutritional and sensory characteristics with better storage life based on careful selection and formulation of ingredients available.

According to Zhang *et al*. (2021) soy flour helps to reduce cooking loss, prevent fat separation, and increase yield in meat products. Aside from its use in sausage making, soy protein in particular could have health benefits since it contains essential amino acids that the body needs to function properly. The use of soy flour can also increase the protein contents of other products, which can be beneficial for consumers who require more protein in their diets (Zhang *et al*., 2021).

Thus, many research reports are available on the effects of the addition of soy flour or protein concentrate in sausage making, but there is paucity of work done specifically on effects of using both soy flour and oil on the quality of chicken sausages.

The main objective of this study was to evaluate the quality of chicken sausage through the incorporation of both soy flour and soy oil. The specific objectives included assessments of the impact of soy flour and oil on the physicochemical, nutritional, and sensory attributes of smoked-cooked chicken sausages.

Materials and methods

Study location

This study was conducted at the Meat Science and Processing Unit, Department of Animal Science Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

Source of experimental materials

10kg of frozen chicken drumsticks were obtained from a local meat shop and spices and seasonings used were obtained from the Kumasi Central Market. Soy oil was purchased from Vester Oil Mills Limited while the soy flour was from ABI'S Special, both located in Kumasi. The chicken drumsticks were thawed overnight at 2°C and deboned, after which the boneless obtained was minced using a table-top mincer with 5mm sieve diameter (MADO Super wolf, Germany).

Sausage production

The total of 6.5kg minced chicken obtained was divided into four portions of 1.754kg, 1.604kg, 1.604 and 1.604kg, each labelled as T1, T2, T3 and T4 respectively (Table 1). The same quantities of spices (20g curing salt, 5g black pepper, 4g garlic powder, 6g nutmeg powder,10g phosphate, 500g ice, 8g chili pepper in each of the minced meat) were added to each treatment. Soy oil and soy flour were added at different levels for T2, T3, and T4 except T1 (control).

Table 1 Ingredients used in product formulations

Ingredients (g)	Treatments			
	Control T1	T2	T3	T4
Meat Sample	1754	1604	1604	1604
Soy flour	0.0	94	75	52
Soy oil (ml)	0.0	56	75	98
Cure Salt	20	20	20	20
Black pepper	5	5	5	5
Garlic powder	4	4	4	4
Phosphate	10	10	10	10
Nutmeg powder	6	6	6	6
Ice and Water	500	500	500	500
Chili pepper	8	8	8	8

The minced meat with all the ingredient was placed in an electric meat mixer and chopped into a consistent paste (meat batter), which was filled into edible cellulose casings and liked to 6cm lengths for hot smoking in a traditional smoke oven. Smoked sausages were cooked in hot water at 80ºC to obtain internal temperature of 65ºC. The cooked sausages were cooled in ice water, packaged in labelled transparent bags for storage at -18ºC for further studies.

Parameters measured

Sensory properties

Sensory evaluation of the sausages was carried out the following day and repeated after 7 days by 35 consumer panellists. The panelists comprised of members and research fellows of the Department of Animal Science. Each sausage treatment sample evaluated was cut into equal sizes of 2cm, after which it was warmed and served to the panel members. Each sample was coded with 3-digit random numbers for the evaluation of sensory attributes for appearance, flavor, texture, juiciness and overall acceptability using 9-point hedonic scale (where 1 is dislike extremely and 9 means like extremely). Drinking water was provided to all panel members to rinse their mouth before and between tasting each sausage sample to avoid carry-on effects.

Proximate analyses and pH of sausages

The crude protein, crude fat, moisture, and ash contents of the products were determined according to AOAC (2023) methods. The pH of sausage samples which were homogenized in deionised distilled water was determined using a digital pH meter (Precisa pH 900-9050, Switzerland).

Thiobarbituric acid reactive substances value (TBRS)

Lipid oxidation in the chicken sausages was measured as TBARS value, according to the procedures described by Alina *et al.* (2012) and Xiong *et al.* (2015). Briefly, 5g of sausage sample without casing was mixed thoroughly with 25 mL of aqueous solution containing 5 mL ≥99.0% trichloroacetic acid, then with 20 mL of deionised water.

The resulting mixture was placed in a 100 mL beaker for 1 h at room temperature, after which it was filtered through a Whatman No.1 filter paper. The filtrate obtained was diluted to 50 mL with deionized water. A mixture of 5 mL of 0.02 M aqueous solution of 2-thiobarbituric acid (TBA) and 5 mL of diluted filtrate was heated in a water bath at 95 °C for 20 min for the formation of a pink colour. The sample absorbance was recorded at 532 nm on a UV/Vis 3200 spectrophotometer and expressed as mg malondialdehyde (MDA) equivalent/ kg sample.

Statistical Analysis

All data generated from the study were analyzed using SPSS version 20.0 using one-way analysis of variance (ANOVA) and significant differences between treatment means were determined using Duncan's test of homogeneity at 1%.

Results and discussion

Sensory characteristics of smoked-cooked chicken sausages

Sensory scores of sausages incorporated with or without soy flour and soy oil are presented in Table 2. The sensory evaluation results showed no significant differences among the samples in terms of appearance ($p = 0.619$), flavor ($p = 0.809$), taste ($p = 0.222$), juiciness ($p = 0.619$), texture ($p = 0.136$), and overall acceptance ($p = 0.897$). These results suggest that all the samples were similar, no matter the type treatment formulation used. Appearance scores ranged from 5.85(T1) to 6.35(T2), flavour was between 6.15(T2) and 6.50(T4), taste ranged from 6.025(T2) to 6.775(T3), juiciness was scored between 5.77(T3) and 6.300(T2), texture ranged from 5.575(T1) to 6.275(T4), and Overall acceptance was scored between 6.425(T1) and 6.700(T2).

Table 2 Sensory characteristics of chicken sausages with or without soy flour and soy oil

Parameters	Type of sausage				Sem	p-value
	T1	T2	T3	T4		
Appearance	5.850	6.350	6.250	6.300	0.147	0.619
Flavor	6.200	6.150	6.250	6.500	0.135	0.135
Taste	6.625	6.025	6.775	6.450	0.133	0.222
Juiciness	6.275	6.300	5.770	6.150	0.156	0.619
Texture	5.575	6.250	6.225	6.275	0.124	0.136
Overall Acceptance	6.425	6.475	6.700	6.550	0.133	0.897

Sensory scale: 1=Dislike extremely; 2=dislike slightly; 3=dislike moderately; 4= dislike; 5=neither like nor dislike; 6=like; 7=like slightly; 8=like moderately; 9=like extremely; Sem=standard error of means

The panel evaluation in this study suggested that all the sensory properties of chicken sausages were not influenced by the addition of soy flour or soy oil at the different levels studied. However, Choi *et al.* (2014) reported that the addition of brewer's spent grain fibre decreased the sensory scores for appearance, flavour, tenderness, juiciness as well as overall liking of chicken sausages. Malav *et al.* (2015) also reported decreased sensory properties for mutton patties produced with cabbage powder. But Fang *et al.* (2019) observed no significant differences in the sensory properties of chicken sausages produced with 3% sugar fibre.

Proximate composition of chicken sausages

The results for the proximate composition of the chicken sausages are presented in Table. 3. All the proximate components considered were significantly different ($p<0.01$) among the various formulations except for the crude ash and moisture contents. The fat content was highest in T4 (23.252%) and lowest in T1 (14.052%), while the protein content was highest in T2 (23.765%) and lowest in T3 (18.289%). Sausages with or without soy flour and oil were similar in moisture contents but significantly higher ($p<0.01$) fat and lower protein contents ($p<0.01$) were observed in soy-treated chicken sausages. These differences are related to the different composition of soy flour and oil ingredients used. Soy flour has higher protein content but lower fat content than soy oil. Chicken sausages with higher oil levels showed differences ($p<0.01$) in fat content compared to the control: the higher the added level, the higher the fat content. Also, the lower the flour added, the lower the protein contents observed. These trends regarding the changing fat and protein levels in meat products depending on the percentages of added ingredients agree with the reports of other authors for several meat products (Trout *et al.,* 1992; Biswat *et al.,* 2007; Peña-Saldarriaga *et al*., 2020).

Moisture contents ranged from 66.395%(T3) to 69.230%(T2) while percentage ash was between 1.480%(T4) and 1.855%(T3), and these were not statistically different ($p<0.01$) among treatments. These observations were similar to results reported by Peña-Saldarriaga et al. (2020) for chicken sausages produced with different chicken by-products as replacement for chicken fat.

Table 3 Proximate composition of the Smoked-cooked sausage

Parameter (%)	Type of sausage				Sem	p-value
	T1	T2	T3	T4		
Moisture	69.079	69.230	66.395	67.690	0.446	0.056
Ash	1.569	1.827	1.855	1.480	0.097	0.527
Fat	14.052[a]	17.745[a]	21.790[b]	23.252[b]	1.386	<0.001
Protein	21.692[b]	23.765[c]	18.289[a]	19.464[a]	0.803	<0.001

[abc]Means in the same row with different superscript are significantly different (p<0.01); soy flour (T1 =0.0g; T2=94g; T3 =75g and T4 = 52g); soy oil (T1=0.0ml; T2=56ml; T3=75ml; and T4= 98ml); Sem=standard error of means

Cooking yield, water holding capacity, and pH

No significant differences (p>0.01) were found among the cooking yield of the four sausage types studied. The mean cooking yields were 82.745% (T1), 86.605% (T2), 78.565% (T3), and 85.145% (T4). These results suggest that the different treatments of soy flour and oil did not potentially have any significant impact the yields of chicken sausages. However, Fang et *al.* (2019) reported significant differences in the cooking yield of chicken sausages. The observed differences in cooking yields reported by Fang *et al.* (2019) could be attributed to the different ingredients used in the different treatments. Where as Fang *et al.* (2019) used different levels of sugarcane fibre and water, the current study utilized soy flour and oil in the manufacture of the sausages.

Table 4 Percentage Cooking Yield, Water Holding Capacity, and pH

Parameters	Type of sausage				Sem	p-value
	T1	T2	T3	T4		
Cooking Yield	82.745	86.605	78.565	85.145	2.016	0.627
Water Holding Capacity	21.200[a]	23.700[b]	34.100[c]	37.100[d]	2.547	<0.001
pH	6.015[c]	5.695[a]	5.890[b]	6.210[d]	0.071	<0.001

[abcd]Means in the same row with different superscript are significantly different. (p<0.01); soy flour (T1 =0.0g; T2=94g; T3 =75g and T4 = 52g); soy oil (T1=0.0ml; T2=56ml; T3=75ml; and T4= 98ml); Sem=standard error of means

There were significant differences (p<0.01) in both pH and water holding capacity among the four chicken sausage types produced. The mean water holding capacities were 34.100% (T1), 37.100% (T2), 23.700 %(T3), and 21.200% (T4). It was observed that higher pH levels in T1(6.105) reduced significantly to 5.89(T3) in the soy-treated sausages. Both pH and water holding capacity have important functions in meat and meat products. Whereas water holding capacity influences juiciness, pH has significant effects of microbial activity and food texture development. The results in this study suggest that the significantly higher water holding capacity in soy-treated sausages could result in more juicier sausages, while their lower pH values may limit microbial activity to cause spoilage in the sausages during storage.

Effects of soy flour and oil usage on lipid oxidation in chicken sausages during storage Thiobarbituric acid-reacting substances (TBARs) value is commonly used to indicate the extent of lipid oxidation in food products. A higher TBAR value suggests a higher level of oxidative spoilage during storage. The observed TBARS values in both control and soy-treated chicken sausages were not significantly different during the entire 3 weeks of refrigerated storage though the levels seem to increase in absolute terms (Table 5). The recorded values during the first, second and third weeks of storage ranged from 0.585(T1) to 0.635(T3), 0.615(T2) to 0.620(T1) and 0.612(T3) to 0.641(T4) respectively.

Table 5 TBARs values in chicken sausages with or without soy flour and oil

Storage Duration	Treatments TBARs				SEM	p-value
	T1	T2	T3	T4		
Week 1	0.585	0.635	0.625	0.630	0.147	0.564
Week 2	0.620	0.615	0.625	0.650	0.135	<0.021
Week 3	0.630	0.613	0.612	0.641	0.137	0.072

Sem=standard error of means; TBARS=thiobarbituric acid reactive substance value in mg malonaldehyde equivalent/kg sample

There were reported reduced TBARS values in sausages (mortadella) with citrus fibre incorporated (Viuda-Martos *et al.,* 2010), goat meat nuggets with incorporation of broccoli powder extracts (Banerjee *et al.,* 2012), and mutton patties with the addition of cabbage powder (Malav *et al.,* 2015). These reductions in TBAR values earlier reported could be due to differences in phenolic contents of soy flour and oil as used in the production of chicken sausages in this study compared to citrus fibre, broccoli powder or cabbage powder used in the production of mortadella, goat meat nuggets and mutton patties respectively. Color of chicken sausages with or without soy oil

The results obtained for colour profile analysis of sausages are shown in Table 6. According to Kamani *et al.* (2017) colour is regarded, first, as a qualitative criterion in meat products and it plays a significant role in consumer's perception and overall product acceptability. There were no significant differences (p>0.01) for all the colour coordinates analysed. L* (Lightness) coordinate ranged from 57.453(T1) to 58.001(T4), a* (redness) value was between 17.256(T2) and 18.916(T1) while b* (yellowness) was from ranged from 7.400(T1) to 7.980(T3). Different findings were reported for L*, a* b* values by Peña-Saldarriaga *et al*. (2020) when chicken sausages were formulated with and without chicken fatty-byproducts. Overall, the L* a* b* analysis in this current study suggests that the incorporation of soy flour and soy oil in chicken sausage did not potentially affect the colour of sausages and thus, the consumers were not able to detect any differences in the appearance and acceptability scores during sensory evaluation (Table 2).

Table 6 Color profile of chicken sausages with or without soy flour and oil

Parameters	Treatments				Sem	p-value
	T1	T2	T3	T4		
L*	57.453	57.933	58.000	58.001	0.525	0.012
a*	18.916	17.636	17.256	17.330	0.330	0.031
b*	7.400	7.516	7.980	7.433	0.243	0.021

Means in the same row are not significantly different (p>0.01). Sem=standard error of means

Conclusions and recommendation

The use of soy flour and soy oil as ingredients did not affect the sensory characteristics, cooking yield, TBARs and colour of the smoked-cooked chicken sausages. But using higher flour levels resulted in higher protein contents while the incorporating higher oil levels gave higher fat contents in the sausages. The best chicken sausage was obtained with 5.35% soy flour and 3.18% soy oil in the formulation of smoked-cooked chicken sausages. Further study is recommended using soy flour and oil in the formulation of other types of sausage.

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