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Nutritional and sensory implications of pig tripe as ingredient in fresh pork sausage production

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A B S T R A C T

This experiment was conducted to study the possibility of using pig tripe for producing fresh pork sausages. Three types of sausages, each weighing 2 kg, were produced using pig tripe or without pig tripe. A consumer panel used a 9-point hedonic scale to assess the sensory characteristics of sausages. All the sensory characteristics evaluated showed no significant (p>0.05) differences across treatments. The contents of fat significantly reduced (p<0.05) when pig tripe was increased in formulating the sausages (T1=36.32%, T2=33.14% and T3=29.90%) and protein contents ranged from 27.55% (T1) to 22.90 (T3). Increasing levels of pig tripe resulted in the reduction of protein contents, but protein in T1 was not different from T2. The observed differences in ash and moisture composition of fried sausages were not significantly different. These findings suggest that pig tripe is a viable offal in the production of fresh pork sausage. It was concluded that 34% pig tripe could be used as an ingredient in producing fresh pork sausages without compromising sensory attributes and protein contents, but with reduced fat contents.

Keywords: Panel of consumers, Protein contents, Filler meat, Sausage, Sensory characteristics, Chemical analysis

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Introduction

Sausages are ground meat products that are salted, and usually seasoned and stuffed into casings. They are mostly made with ground meat ingredients, which could be obtained from a single source, such as chicken meat, or obtained from two or more meat types, such as beef, goat and pork. It is a widely consumed meat product that is known for its sensory attributes, convenience and nutritional benefits. According to Manzoor *et al.* (2022), there are concerns with regard to consumer health and well-being, for which reason the food industry is interested in providing low-fat and high-protein foods. Some consumers perceive pig meat as a fatty food, for which reason they may shy away from its inclusion in their diets. According to Sharma *et al.* (2021), meat animal slaughter operation generate many by-products, some of which can be disposed of correctly or used in the manufacture of other products when well handled and properly treated. This offal, including organs such as the liver, kidneys, hearts, and lungs, offer diverse culinary possibilities and nutritional benefits. Despite their rich flavour and nutrient density, they are frequently overlooked in favour of more conventional cuts, leading to underutilization and potential waste in meat processing. Several amino acids, as well as vitamins, essential minerals, and other minute components are abundant in offal, and they are highly bioavailable compared to those components sourced from plants (Kim *et al.*, 2020; Biesalski, 2005). Furthermore, incorporating offal into meat products can improve the physicochemical properties like flavour, texture, and overall sensory experience due to their distinct characteristics. Furthermore, incorporating offal into meat products can improve the physicochemical properties like flavour, texture, and overall sensory experience due to their distinct characteristics. Thus, economic benefits can also be derived from using pig offal in sausage production through cost reduction, resource utilization, product diversification, and enhanced consumer appeal, as demonstrated by Ali *et al.* (2017) and Hansen (2018). Using pig offal in sausage production can be a sustainable and cost-effective practice by reducing waste and maximizing the use of edible, low-cost animal parts. In order to contribute to the discourse on innovative meat processing techniques and sustainable food production, Akwetey *et al.* (2022) recommended that the manufacture of value-added products must include the use of pig stomachs and some other pork by-products. This current study, therefore, explored the impact of substituting varying levels of lean pork with pig tripe on sensory attributes, nutritional composition, and overall acceptability of fresh pork sausages manufactured using pig tripe at graded levels.

Materials and Procedures

Study location

The study was undertaken at the Department of Animal Science's Meat Science and Processing Unit and the Laboratory of the Food Science and Technology Department, all at the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi Ghana.

Experimental materials

The materials used in this study included fresh pork, fresh pig tripe, salted hog casing, various spices and seasonings, ice, an electric mincing machine with a 13mm sieve, and a manual sausage filler. The fresh pork, pig tripe, and hog casings were acquired from the Kumasi Abattoir Company Limited. Both tripe and lean meat were obtained from a six-month old hog to ensure consistency in quality and freshness characteristics, and transported on ice to the location of the experiment. All spices used were obtained from Bantama Market in Kumasi.

Processing procedures

Preparation of tripe and lean meat

The pig tripe was trimmed of adhering fatty and connective tissues, after which it was washed and par-boiled for 5 minutes to ensure easy removal of the mucosa lining. Before sausages production, both lean pork and the tripe obtained were kept frozen overnight at -18℃.

Formulations used in sausage production

Frozen lean pork and tripe were sliced to obtain smaller pieces for grinding separately using a table top meat grinder (MADO Superwolf, Germany) fitted 13mm sieve. Both ground pork and tripe were allotted to different treatments (T1, T2, and T3) in appropriate ratios as shown in Table 1.

Table 1. Ingredients used in the formulation of fresh pork sausage.

Meat Ingredients (g)	Treatment		
	T1	T2	T3
Boneless pork	2000	1300	800
Pig tripe	0	700	1200
Total	2000	2000	2000
Non-meat Ingredients (g)			
Black pepper	6	6	6
White pepper	3	3	3
Chili pepper	10	10	10
Nutmeg powder	10	10	10
Onion	3	3	3
Garlic	3	3	3
Common salt	10	10	10
Ice Water	200	200	200
Total	2245	2245	2245

T1=2000g lean pork only; T2=1300g lean pork+700g tripe; T3=1200g lean pork+800g tripe

The spice-mix was dissolved in 200ml water, added to the different treatments and mixed with the hand for 5 min each to get a uniform mixture of desirable consistency.

The spice-meat mixture for different treatments was placed in a manual filler machine and stuffed into natural hog casings, and linked manually at equal sausage lengths of 6 cm each. The linked sausages were packaged in labelled transparent bags and stored at -18℃ for further studies.

Parameters studied

Sensory properties

Sensory evaluation was performed for fried sausages at the Department of Animal Science using a 9-point hedonic scale. Cooked sausages were served to a panel of 45 judges, comprising students from the Department of Animal Science, all of whom had some experience of evaluating sausages. The different treatments were randomly served using a single blind system to reduce bias, increase objectivity, and improve the accuracy of assessment. Panel members were tasked to evaluate appearance, flavour, taste, texture, juiciness, and overall acceptance of the sausages served. They were also provided with water to rinse their mouth after tasting each treatment to prevent carry-over sensory effects between treatment samples (Akwetey *et al.*, 2022).

Proximate analysis and pH

Proximate analysis for ash, moisture, fat, and protein contents was conducted using samples of the fried sausages, which were served during sensory evaluation, according to procedures prescribed by AOAC (2023). The pH was determined for samples that were homogenized in deionised distilled water using a digital pH meter (Precisa pH 900-9050, Switzerland).

Water holding capacity (WHC) and percentage cooking loss

WHC was determined as described by De Sousa Reis *et al.* (2023). Percentage loss during cooking loss was calculated as the difference in weight before cooking and weight after cooking, expressed as a percentage of the initial weight.

$$\text{Cooking loss, \%} = \frac{\text{Initial weight} - \text{Cooked weight}}{\text{Initial weight}} \times 100$$

Experimental design and statistical analysis

The design used in this study was a completely randomised design (CRD) with 3 treatments and 3 replications, each consisting of 2 kg of meat. The data generated were subjected to one-way analysis of variance (ANOVA) using SPSS for Windows. Significance between treatment means was determined using Duncan's test of homogeneity at 5%.

Results and Discussion

Sensory properties of fried sausages

Results obtained for the sensory parameters of the sausages with and without the use of pig tripe are shown in Table 2. All the sensory attributes determined were not significant ($p>0.05$) across treatments. The observed means ranged from 6.40 (T2) to 6.80 (T1) for appearance, 6.15 (T2) to 6.65 (T3) for flavour, 6.35 (T2) to 6.95 (T1) for taste, 6.10 (T2) to 6.80 (T1) for texture, 5.75 (T3) to 5.85 (T1 and T2) for juiciness, and 6.60 (T2) to 7.10 (T1) for overall acceptance. These observed sensory results show that the varying levels of pig tripe incorporation in producing the different sausages did not potentially change how the sausages were perceived by appearance, flavour, taste, texture, juiciness, and overall acceptance by all the panel of judges. Though the overall acceptance seemed to be higher for the control sausages (T1) without tripe compared to T2 and T3, the observed differences were not statistically different. Essentially, these results suggest that including pig tripe in the sausage recipe, even up to 58%, does not negatively impact how consumers assessed their sensory attributes. Akwetey *et al.* (2022) reported similar results for smoked pork sausages produced with pork stomach as filler-meat. Similarly, Lee *et al.* (2025) also reported no significant differences for sensory properties of goat sausages after evaluation of colour, flavour, tenderness, juiciness, goat-odour, appearance, and overall acceptability by fifteen trained individuals. The sausages in the current study were well-received regardless of the tripe content, making pig tripe a promising ingredient that would not compromise consumer satisfaction, as reported by Oladejo and Adetuyi (2012).

Table 2. Sensory properties of fried sausages.

Parameter	Treatments				
	T1	T2	T3	SEM	p-value
Appearance	6.80	6.40	6.70	0.16	0.59
Flavour	6.50	6.15	6.65	0.16	0.45
Taste	6.95	6.35	6.55	0.19	0.43
Texture	6.80	6.10	6.35	0.18	0.28
Juiciness	5.85	5.85	5.75	0.24	0.98
Overall acceptance	7.10	6.60	6.85	0.18	0.52

T1=2000g lean pork only; T2=1300g lean pork+700g tripe; t3=1200g lean pork+800g tripe; SEM=standard error of means

Proximate composition

Analysing the proximate composition of fried sausages was important for understanding the nutritional impact of incorporating varying levels of pig tripe into the fresh sausages. The results obtained from the proximate components of the fried sausages are shown in Table 3. It was observed that the fat and protein contents of sausages decreased significantly (p<0.05) as the percentage of pig tripe increased in their formulations. Specifically, the fat content reduced from 26.07% in T1 to 20.97% in T2 and to 19.44% in T3. Similarly, the protein content also showed a difference from 19.74% in T1 to 18.86% in T2, and to 16.18% in T3. However, the protein content in T1 did not differ significantly (p>0.05) from T2. These observations highlight the fact that both fat and protein contents diminished as more lean pork was replaced with pig tripe. These observations were attributed to the significantly increasing moisture contents with increasing use of the tripe in sausage formulations, due to the inverse relationship between moisture, fat, and protein contents in meat (Lawrie, 2006). The moisture contents increased with higher tripe levels, with T1, T2 and T3 scoring 41.19%, 52.61%, and 57.03%, respectively. These findings are consistent with existing literature, where similar trends have been reported in studies examining the inclusion of offal in meat products. Abdelmageed (2013) and Oladejo and Adetuyi (2012) found that incorporating offal such as tripe into sausage formulations generally leads to lower fat and protein contents compared to sausages made solely with lean meat. This is because offal parts like tripe are generally lower in these macronutrients than muscle meat. It also highlights that while offal can be a valuable addition for enhancing the vitamins and minerals profiles of sausages, it often may result in a low fat and less protein-dense products (Lee *et al.*, 2025). The ash contents in this study seemed to increase in the sausages produced with pig tripe; however, the observed differences were not significantly different (p>0.05). Treatment T1, T2 and T3 respectively had ash contents of 2.79%, 3.25% and 3.12%.

Table 3. Proximate composition of fried sausages.

Parameter	Treatments				
	T1	T2	T3	SEM	p-value
Ash	2.79	3.25	3.12	0.46	0.71
Moisture	41.19^{a}	56.61^{bc}	57.03^{c}	2.45	0.03
Fat	26.07^{b}	20.97^{a}	19.44^{a}	1.36	0.048
Protein	19.74^{c}	18.86^{bc}	16.18^{a}	1.21	<0.001

^{abc}Means in the same row with different superscripts are significantly different (p<0.05). T1= 2000g lean pork only; T2=1300g lean pork+700g tripe; T3=1200g lean pork+800g tripe; SEM = standard error of means

Water holding capacity (WHC), pH, and cooking loss of sausages

Table 4 shows WHC, pH, and cooking loss (CL) of the fried sausages. The results indicate that as pig tripe content increases, WHC reduced significantly (p<0,05) from 10.11% in T1 to 5.09% in T2 and 4.77% in T3. These observations agree with the findings by Lee *et al.* (2025), but were inconsistent with reports by Abdelmageed (2013), who observed that offal, such as tripe, can retain more moisture in processed meat products. The pH and cooking loss levels in this study did not differ significantly (p>0.05). It was observed that T1, T2, and T3 recorded pH values of 5.49, 5.66 and 5.74 while their cooking losses were 43.80%, 44.03% and 443.10%, respectively. It was observed that treatments that recorded lower water holding capacity tended to exhibit more weight loss after frying, though the observed weight losses were not statistically different. Thus, suggesting that the inclusion of tripe would potentially not negatively impact product stability during cooking, and therefore highlighting the potential benefits of using non-conventional meat parts like pig tripe in sausage production. Lawrie (2006) and Oladejo and Adetuyi (2012) reported improved moisture retention and enhanced pH in products enriched with offal to support the viability of pig tripe as an ingredient for value addition.

Table 4. Water holding capacity, pH and cooking loss of sausages.

Parameter	Treatment				
	T1	T2	T3	SEM	p-value
Water holding capacity	10.11[a]	5.09[b]	4.77[c]	1.48	0.002
pH	5.49	5.66	5.74	0.05	0.07
Cooking loss	43.80	44.03	44.10	0.43	0.85

[abc]Means in the same row with different superscripts are significantly different (p<0.05); T1=2000g lean pork only; T2=1300g lean pork+700g tripe; T3=1200g lean pork+800g tripe; WHC=water holding capacity; SEM=standard error of means

Conclusions and Recommendations

This investigation demonstrated how the incorporation of pig tripe as a substitute for lean pork in fresh sausages offers nutritional advantages. The inclusion of pig tripe reduced fat content and increased moisture retention, while maintaining acceptable sensory qualities in fried sausages. Notably, sausages with 34% tripe (T2) achieved a balance of high protein content and desirable texture, flavour, and overall acceptance. These findings suggest that pig tripe can be effectively used as a value-added ingredient without compromising the overall sensory appeal of fresh pork sausages. It is recommended that further research focus on investigating the microbial load and shelf life of tripe-enriched sausages to ensure safety and quality during storage.

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