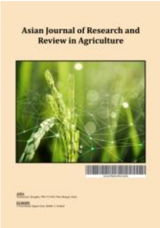

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Physicochemical Properties and Microbiological Evaluation of Sausage Prepared from Different Proportion of Chicken and Beef

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The development of meat industry and meat processing has shifted from marketing of live animals and adopt value added chain in meat products. This study accessed different proportion of beef and chicken breast in sausage production. Twenty kilograms of Pectoralis major and Adductor muscle mixture using five mixing ratio between breast meat and beef. Physicochemical, microbiological and

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sensory properties were analyzed in this study. The analyses were carried out using SAS software while the means were separated with LSD at 5%. The influence of meat mixture on sausage was significant ($P<0.05$) among the treatment: proximate composition indicated that treatment I (70 % chicken breast) had the highest percentage of crude protein (31.77±0.65 %) compared to the lowest percentages in treatment V (70% Beef) (27.57±0.55%); pH values were within the range of 6.16± 0.59 (III) to 6.55± 0.21 (V) ($P<0.05$). Total Aerobic Counts for raw sausages was highest in treatment V (4.63± 0.39 cfu/g) while the lowest value was recorded in I (1.38± 0.08 cfu/g). This study confirmed that pectoralis major can be successfully used in the production of sausage with preference to the consumer acceptability and would also enhance cooking yield and nutritional values.

Keywords: Pectoralis; Adductor; Aerobic; chicken; sausage, microbiological aspects.

1. INTRODUCTION

“Sausage production is a simple process of allowing meat to undergo series of controlled structural and chemical changes. These are basic to all cultures but the changes rely on varied methods of preparation to achieve desired distinctive characteristics. The increasing trend in consumption of sausages in Africa is just a reflection of a global consumer interest in processed meat products. Technologies in the animal industry is meat product value addition and meat processing, the focus of the poultry industry has shifted from marketing live birds as commodity to value added products to facilitate trade in poultry products. In terms of economic conditions, chicken meat is preferred more than beef and because the price of the chicken meat is relatively cheaper” [1,2,3]. “The potential of beef and chicken meat in value addition technologies has not been explored. Suitable meat ingredients are vital to produce blends and mixture of meat and fat particles, resulting in sausages that are consistent in quality. Most processed meat is prepared from beef and pork or a combination of both. Chicken meat is considered a highly nutritious food because it contains relatively high protein and low fat percentages” [4]. “The popularity of poultry meat among consumers is due to the healthy image of poultry meat, sensory properties such as desirable texture and colour, and the mild flavour profile allowing consumers to impart desired flavours to the meat” [5].

“It is becoming more acceptable to purchase alternative sources of red meat, as opposed to meat of only the traditional species of red meat producing animals. The type and the amount of meat in formulations of meat products are the most important factors for product quality” [6]. “Beef is used extensively in meat products; however, the scientific properties of white meat have generated interest among processors. Different sources of meat have different protein characteristics and different physicochemical properties. Moisture, crude protein, crude fat, and ash ratio constitute the chemical composition of meat. It is varied according to the species of animal and muscle structure of the animal”, (Ketoon et al. 2014). “In studies based on red meat consumption levels, the most consumed red meat is beef mutton and chevon” (Kaygısız et al. 2022). “The crude protein (20.67%) value reported for beef was lower than the protein (27.60%) reported value for chicken” [7]. “As the highest protein content in chicken, it could be preferred for making different kinds of meat products and by-products consumed by the majority of people” [7]. “Industrialization of food processing increases the apparent consumer interest in the quality of meat products with emphasize on microbial, nutritional and sensory attributes are important consideration determining acceptability and choice of a product to potential consumers” [8]. “Broiler is a fast growing breed of poultry and has a different physiology than other poultry” [9]. “The proximate and physical properties of muscle tissue and the associated connective tissue are very important when considering the usefulness of meat as food” [10]. Hence, it is important to evaluate the effects of the incorporation of different ratios of beef and chicken meat on the physicochemical, proximate composition, microbiological properties and sensory evaluation of the breakfast sausage.

2. MATERIALS AND METHODS

2.1 Preparation of Broiler Breast Meat and Beef

Two hundred broilers were raised for six weeks to harvest the breast muscles for sausage production. The materials used in this study were broilers and within the age of 40-50 days, average weight of 2.25kg. These birds were reared under intensive system at the Teaching and Research Farm, University of Ibadan, Ibadan. They were slaughtered and dressed conventionally at the slaughter house of the Department of Animal Science, University of Ibadan. Ten kilograms of Beef (*Adductor* muscle) of 3-4 years aged cattle obtained from the slaughter house of The Department of Animal Science while Lard fat and small intestine of sheep and other ingredients such as *soy* bean flour, refined salt, sugar, ice water, ginger, onion, garlic powder and dry spices STPP (Sodium Tri Polyphosphate) were procured on weight basis at Bodija market. Ten kilograms of *Pectoralis major* and ten kilograms of *Adductor* muscles) obtained were cleaned, trimmed of visible fats, connective tissues and wrapped separately in a polyethylene bag before placed in a cold room (4°C) for 24 hour at meat laboratory for further study.

2.2 Preparation of Sausage

The lean meat (*Adductor* and *Pectoralis major* muscles) and fat were separately ground in the chopper (TC, 12E, SIRMAM, Venezia, Italy) with 4mm diameter sieve at a low speed setting to obtain a homogenous mass. The formulation for each treatment was according to those ingredients in Table 1. The ground meat and fat was transferred to a bowl cutter and chopped in a food processor (BZBJ-15, Expro Stainless Steel Mechanical and Engineering Company Hangzhou, China) for two minutes with a half quantity of ice and 2% of salt. Then, lard, and other ingredients were added together with the reminder ice and the batter was chopped at high speed for three minutes. The sausage links were twisted and tied manually and kept at 4°C for thirty minutes. Three batches of each formulation were performed and the batter temperature did not exceed 12°C. Immediately after chopping, the batter formulated was stuffed into natural casing (sheep intestine). Stuffed samples were hand linked and heated in food processor (Fessmann, GmbH und Co KG, 71364 Winneden) to an internal temperature of 72°C. Approximately 150-200 g of raw batter samples from each treatment was vacuum-packaged and stored in cooler at 4°C for further analysis.

2.3 Proximate Analysis and Nutrient Retention

The pH of cooked the sausage was determined using a digital probe pH meter (Hanna, Italy) [11]. Moisture, ether extract, ash and protein content of raw and cooked samples were analyzed according to procedure described by AOAC, 2000 methods [11]. Development of oxidative rancidity was determined by using the 2-thiobarbituric acid (TBA) test according to the procedure of Tarladgis et al. [12] as modified by Rhee [13]. Results were expressed as milligrams of malonaldehyde per kilogram of sample. Three samples per each batch were performed in triplicate. The results from the laboratory were used to calculate cooking yields and true nutrient retention values. The nutrient retention value (%) for each nutrient in the sausages was calculated according to Murphy et al. [14] using the following formula:

Equation 1

$$\left\{ \frac{\left[\text{Nutrient Content of Cooked Product}) \times (\text{Weight of Product after Cooking})\right]}{\left[\text{Nutrient Content in Raw Product}) \times (\text{Weight of Product before Cooking})\right]} \right\}$$

Equation 2 & Equation 3

$$\text{TR}(\%) = \left\{ \frac{\left[\text{Nutrient Content of Cooked Product}) \times (\text{Weight of Product after Cooking})\right]}{\left[\text{Nutrient Content in Raw Product}) \times (\text{Weight of Product before Cooking})\right]} \right\} \times 100$$

$$\text{YF} = \frac{(\text{Weight of Cooked Meat})}{(\text{Weight of Raw Meat})}$$

Yield factor (YF) for this study was calculated as described Vásquez-Caicedo et al. 2017 and Bognár, 2017.

2.4 Determination of Cooking Properties

The following parameters were performed in all the raw and cooked samples: cooking yield, cooking loss, shear force, and dimensional shrinkage. All cooking measurements were performed in three replicates of each treatment as reported by Naveena et al. [15].

2.5 Cooking Loss

Cooking loss was determined as described by Honikel [16]. Raw sausages were weighed and placed into a sealed polyethylene bags before heating in water bath at 80°C. Samples were cooked until define internal temperature 75°C.

Table 1. Sausage formulation with different ratios of chicken and beef meat Percentage proportion of Ingredient composition

Ingredient (g)	Proportional Ratio of Chicken and Beef				
	I (100/0)	II (75/25)	III (50/50)	IV (25/75)	V (100/0)
Chicken	70.00	52.50	35.00	17.50	0.00
Beef	0.00	17.50	35.00	52.50	70.00
Fat (Lard)	15.00	15.00	15.00	15.00	15.00
Soya Bean Flour	4.00	4.00	4.00	4.00	4.00
Refined salt	2.00	2.00	2.00	2.00	2.00
Sugar	1.00	1.00	1.00	1.00	1.00
$NaNo_3$	0.01	0.01	0.01	0.01	0.01
STPP	0.30	0.30	0.30	0.30	0.30
Ice water	3.00	3.00	3.00	3.00	3.00
Dry Spices	2.00	2.00	2.00	2.00	2.00
Onion	1.31	1.31	1.31	1.31	1.31
Garlic	0.69	0.69	0.69	0.69	0.69
Ginger	0.69	0.69	0.69	0.69	0.69
Total	100.00	100.00	100.00	100.00	100.00

$NaNo_3$: Sodium Nitrate; STPP: Sodium tripolyphosphate

The cooked sausages were cooled at room temperature; reweighed and cooking loss was reported as a percentage and calculated as follows:

Cooking loss % = [{Raw weight - Cooked weight}/{Raw weight}] ×100 Eq. 4

Product yield (%): = [{Weight of cooked sausage samples}/{Weight of raw sausage samples}] ×100 Eq.5

Dimensional shrinkage % (DS%) was calculated using the following equation as reported by Murphy et al. [17]

D S%= {Raw sausage- Cooked sausage (diameter)}/ {Raw sausage diameter} × 100 Eq. 6

2.6 Microbiological Analysis

The microbiological assessment of the sausage was carried out using three parameters: Total Aerobic Counts (TAC), Total Coliform Counts (TCC) and Total Fungal Counts (TFC). The TAC of the sausage samples from the two heat sources were determined following aseptic technique procedure and following the method described by (Gandi, 2014). Samples from each product (15g) were taken aseptically and homogenized in 0.1% (w/v) peptone solution for one minute. The homogenate was serially diluted and used for microorganism enumeration and nutrient agar was used for total bacteria counts after 48 hours incubation at 37°C. The population of bacteria was expressed as log CFUg-1.253. For TCC, the spread plate technique was used. One milliliter aliquot of each of the diluted samples was plated out on sterile MacConkey agar (MA). Incubation was at room temperature for 48 hours in an inverted position. Discrete colonies of coliform bacteria developed were counted and recorded.

“The media (Nutrient agar, Potato Dextrose Agar and MacConkey agar) for fungi were prepared according to the manufacturers’ instruction. The associated fungi were isolated using a standard pour plate technique. Ten grams of the dried meat products were homogenized in sterile distilled water. One milliliter of the homogenate was decimally diluted, and 1 ml of selected dilution (10^{-4}) was plated in duplicate on a sterile Sabouraud Dextrose agar containing 1% streptomycin. Inoculated plates were incubated at 28 ± 2°C for 5-7 days. Discrete colonies were isolated in pure culture by sub-culturing the cells” [18].

2.7 Sensory Evaluation

Sensory evaluation was conducted on freshly prepared sausage (day 0) as described by A. M. S. A. [19]. A total of twenty panellists with age ranging between 22 and 40 years were trained according to the British Standard Institution (7) guidelines to evaluate the product. The panellist evaluated the products for colour, juiciness, flavour, tenderness, pungency and overall acceptability on a nine-point hedonic scale (1 for extremely dislike and 9 extremely like). The sausages were sliced to approximately 1.5cm and wrapped in kitchen foil, blind coded with 3-digit random number and oven warmed at 180ºC for 5 minutes before serving. The panellists were seated in individual cubicles in a temperature and light-controlled room, receiving a set of five samples served in a complete randomised order. The samples were served on a plate covered with a lid. Cracker biscuit and distilled water were used to cleanse the palate between samplings.

2.8 Statistical Analysis

Data collected were analyzed using statistical analysis system [20]. One–way analysis of variance (ANOVA) was used and LSD was used for comparison of mean values to identify significant differences at P<0.05.

3. RESULTS AND DISCUSSION

3.1 Cooking Properties

The effect of mixing ratio between chicken breast and beef on pH value and physicochemical parameters of breakfast sausages are shown in Table 2. The pH values of samples from treatments I and II were 6.42±0.14 and 6.00±0.05, respectively. The pH value increased after cooking in all the treatments (P<0.05). The pH values of meat products are greatly associated with water retention and textural properties of the final product [21]; thus, our result is expected to cause an improvement in the properties of meat homogenates with added chicken breast due to the alkali value of chicken breast meat. The lowest cooking loss was found in sausage from treatment I (24.69±1.86) followed by II (27.45±1.32) and III (29.45±1.24). No significant difference was observed for cooking loss among samples from treatments IV (31.05±1.32%) and V (31.95±0.84%) but showed highest cooking loss among the treatments. An increase in chicken breast added in meat homogenates reduced cooking loss. The cooking losses decreased with the increasing level of breast muscle and reached a decrease of 31.05% at a proportion of 25%, even though there was no significant difference between concentrations of 0% and 25%. A decrease in cooking losses at higher levels of breast muscle gave a positive result that the concentration level decreased cooking losses which would have implications for the increase in yield of meat and processed meat products. At the same time, meat that does not lose its water depending on the cooking methods and is able to keep its content is evaluated quality meat [22,23]. This was in line with water holding capacity (WHC) which tended to increase with increasing proportion of breast meat. Therefore, the sausage prepared with only chicken breast showed the lowest cooking loss among all treatments (P<0.05). Leygonie et al. [24] reported that cooking loss is influenced by the changes in muscle cellular and extracellular components of the meat used during the processing. The product yield of sausage from treatment I (75.32±1.86) displayed highest product yield while the lowest was recorded in treatment V (68.05±0.84). The product yield decreases as the proportion of the breast muscle decreased across the treatments. Yield values are related to the changes in protein structure during the cooking process. The effects of chicken meat and beef on the diameter reduction values were found to be lowest in treatment I (13.34±0.58%) and highest in treatments IV (15.48±0.28%) and V (15.71±0.21%), which may be attributable to higher water-holding capacity [25]. During heating, shrinkage of fibres, aggregation, and gelling of myofibrillar and sarcoplasmic proteins, and shrinkage and solubilization of connective tissue caused loss of connections between muscle fibres [21,26]. The oxidation of lipids in meat products is a key problem that reduces shelf life of meat products. The TBARS values of cooked sausages were also significantly affected by the proportion of breast meat to beef. Cooked sausage samples from treatment I (0.01±0.01) had significantly lowest TBARS values than sausages from treatments II (0.02± 0.02), III (0.02± 0.01), IV (0.04± 0.01) and V (0.04±0.01). Lipid oxidation leads to a decrease in shelf life, loss of nutrient value, and formation of toxic compounds in meat products [27]. Lipid deterioration could be related to oxidation of fat tissues, shelf life and flavour [11,28,29], considering that in the present study sausage samples consists of meat from different species of animals. The increasing amounts of chicken meat in the mixtures increased TBARS values. The normal resistance of meat to the development of rancidity depends on the balance between the presence of antioxidants in the animal tissues and the level of unsaturation and the concentration of the fatty acids present [30]. Poultry meat is composed of relatively high levels of unsaturated fatty acids thus poultry products are very susceptible to the development of off-flavours due to oxidative rancidity [31]. The pattern of TBARS appears to be consistent with other studies [32], which reported that beef was the most susceptible to lipid peroxidation among meats. Rymer et al. [33] suggested that the difference in heme pigment content, which is associated with catalase activity, could be responsible for the varying oxidative stability of meats from different animal species.

3.2 Proximate Composition

Proximate composition of the experimental sausages is presented in Table 3. Moisture contents of raw sausage samples ranged from 69.20±0.99% (I) to 73.39± 0.13% (V), with significant (P<0.05) differences between the samples. Raw sausage samples from treatment IV had moisture content of 73.09±0.43% and was not significantly different (P>0.05) from treatment V (73.39± 0.13%) sausage samples. Cooked sausages in treatments III (62.58±0.23), IV (62.54±0.2763) and V (62.41± 0.43) had higher moisture content than the samples in treatments I (60.86±0.63) and IV (61.89±0.43). It was found that samples in treatment V have the greatest capacity to retain water, while samples in treatment I having the least. The retention of water during further processing of meat is necessary to obtain a product that is juicy and breast muscle has low subcutaneous fat. Moisture content has been considered an important property of sausage, particularly as it relates to sensory characteristics and final weight which is directly associated with commercial value to manufacturers (Ahmad et al. 2010. Crude protein was significantly (P<0.05) higher in raw samples in treatments II (22.35±0.13) and III (22.02±0.44) compared to I (21.09±0.93) IV (21.57±0.05) and V (21.59± 0.01). Crude protein and ether extract in cooked sausages decreased significantly (P<0.05) as the inclusion of beef increased in the formulation; this might be due to higher moisture content. The results of the ash content indicated that the ash increased has the incorporation of breast muscle decreased across the treatments. Ash content in cooked sausages from treatments IV (5.49± 0.16) and V (5.40± 0.29) was significantly (P<0.05) higher than I (4.46±0.33), II (4.78±0.01) and III (5.09±0.19), respectively. These differences are related to the different proportion of meat and connective tissues in meat, beef has higher intramuscular fat and connective tissues than chicken meat [34].

Table 2. pH and Physicochemical properties of breakfast prepared from different proportion of Chicken and Beef

Treatments	I	II	III	IV	V
Variable	**I (100%)**	**II (75%)**	**III (50%)**	**IV (25%)**	**V (0%)**
Ph	6.42± 0.137[ab]	6.49± 0.05[a]	6.16± 0.59[b]	6.28±0.228[ab]	6.55± 0.21[a]
Cooking Yield	75.32 ±1.86[a]	72.55± 1.32[b]	70.55±1.24[c]	68.95±1.32[d]	68.05±0.84[d]
Cooking Loss	24.69 ± 1.86[d]	27.45± 1.32[c]	29.45±1.24[b]	31.05±1.32[a]	31.95± 0.84[a]
Dimensional Shrinkage	13.34± 0.58[c]	14.44± 0.45[b]	14.73±0.08[b]	15.48±0.28[a]	15.71±0.21[a]
Tbars	0.01± 0.01[c]	0.02± 0.02[bc]	0.02± 0.01[b]	0.04± 0.01[a]	0.04±0.01[a]

abcd: Means on the same row with different superscripts are statistically significant (P< 0.05); TBARS: Thio-Barbituric-Acid–Reactive Substances

Table 3. Proximate composition of sausage prepared from different proportion of Chicken and Beef

Treatment		Proportion of chicken and beef meat				
Variable	**Sample**	**I (100%)**	**II (75%)**	**III (50%)**	**IV (25%)**	**V (0%)**
Moisture Content	Raw	69.20±0.99[d]	70.44±0.07[c]	71.61±0.95[b]	73.09±0.43[a]	73.39± 0.13[a]
	Cooked	62.54±0.27[a]	62.58±0.23[a]	61.89±0.43[b]	60.86±0.63[c]	62.41± 0.43[a]
Crude Protein	Raw	22.35±0.13[a]	22.02±0.44[a]	21.59± 0.01[b]	21.57±0.05[b]	21.09 ±0.93[c]
	Cooked	31.77±0.65[a]	29.96± 0.79[b]	28.98± 0.43[c]	28.20±0.41[d]	27.57±0.55[e]
Ether Extract	Raw	3.33±0.16[a]	2.86± 0.51[b]	2.45±0.54[c]	1.76±0.03[d]	1.79± 0.01[d]
	Cooked	4.46±0.33[d]	4.78±0.01[c]	5.09±0.19[b]	5.49± 0.16[a]	5.40± 0.29[a]
Ash	Raw	3.13±0.31[a]	2.64± 0.09[b]	2.64±0.16[b]	2.68±0.07[b]	2.55± 0.05[b]
	Cooked	2.37±0.31[a]	2.28±0.19[a]	2.17±0.43[a]	1.88±0.18[b]	1.86± 0.12[b]
NFE	Raw	3.45±0.32[a]	1.72± 0.56[b]	1.38±0.26[b]	1.41±1.32[b]	0.68± 0.14[c]
	Cooked	3.06±0.06[a]	1.48± 0.44[b]	0.89±0.41[c]	0.74±0.19[c]	1.35± 0.23[b]

abcde: Means on the same row with different superscripts are statistically significant (P<0.05); NFE: Nitrogen Free Extract

3.3 Nutrient Retention

Nutrient retention is defined as the measure of the proportion of the nutrient remaining in the cooked food in relation to the nutrient originally present in the raw food [35]. Values for nutrient retention for cooked sausage are presented in Table 4. Average moisture retention values were significantly higher in treatment I (67.42± 2.94 %) when compared to treatments II (64.45± 1.36), III (60.94± 1.35), IV (57.27± 0.98) and V (57.76± 0.45). Moisture retention was similar between treatments IV (57.27± 0.98) and V (57.76± 0.45). However, moisture retention decreased across the treatment based on the levels of different proportion of meat types. True Retention of moisture followed the same trend as product yield values for the treatments, suggesting that product yield was mostly a function of moisture loss, although fat probably might also contributed to the variation. Crude Protein retention was significantly higher ($P<0.05$) in treatments I (97.67± 4.59) and IV (97.61± 1.58) followed by III (94.69± 3.44), V (91.67± 1.88) and (91.63± 1.18), respectively. Wilkinson et al. [36] and Smith et al. [37] reported an increase in protein content after cooking for all meat products; however, collagen-rich muscles have a lower nutritional value for crude protein retention. Highest Fat retention was recorded in treatment V (174.68±6.45) followed by IV (154.89±11.85), II (143.17±24.96), III (137.48±18.54) and the lowest was recorded in treatment I (99.99±10.13). Although no significant effects of different proportion of chicken and beef meat on the sausage was found in treatments II (143.17±24.96), III (137.48±18.54) and IV (154.89± 11.85) were found for ether extract. Luchak et al. [38] reported an increase in ether extract and a decrease in moisture with an increase in cooking time. A plausible explanation for the lower fat retention in treatment I, would be due to high proportion of breast muscle, the effect was found to be significant, improving fat retention across the treatments. This explanation could be applied to the low level of intramuscular fat in breast muscle was lower than that in beef. Kempster et al. [39] also reported that intramuscular fat is later developing than subcutaneous fat and therefore it can be expected that a larger proportion of the fat of beef was located within muscles than in breast muscle. Intramuscular fat tends to be retained during cooking, while subcutaneous fat is prone to be lost as fat drip. Similarly, Harris et al. [40] found percent fat increased and percent moisture decreased as degree of doneness increased regardless of fat treatment. Ash had highest retention in treatment V (85.65± 6.14) followed by treatment IV (70.62± 5.81), III (66.91± 3.17) and II (62.63± 5.55) and the lowest retention value was in treatment I (57.94±14.35). Different proportion of chicken and beef meat did not have significant effects on true retention values in ash for treatments I (57.94±14.35), II (62.63± 5.55), III (66.91± 3.17) and IV (70.62± 5.81).

3.4 Sensory Evaluation

The scores of the preference exhibited more informative answers about the differences between the samples of sausages. The average scores assigned by panelists for the colour, flavour, juiciness, tenderness and overall acceptability attributes of fresh sausages are shown in Table 5. Focusing on panel preference for sausage types, most of the sensory quality attributes were highly rated. This implies that their characteristics were more appealing and acceptable to the panel. Though, there were variations among the sensory attributes. The results revealed that colour, flavour, juiciness and tenderness were the most liked sensory quality attribute of sausages to influence panel preference. Sausage formulated with 100% of chicken meat (4.74± 1.49) significantly recorded lowest scores for colour compared to other treatments ($P<0.05$), but no significant differences was observed between samples in treatments II (5.83± 0.41) and III (6.53± 0.25). Treatments IV (7.35± 0.57) and V (7.84± 0.83) had highest significant values than all other sausages for colour. These differences could be due to the low myoglobin content of chicken meat. “Beef sausages were perceived to be more superior to other sausages premised on colour and increased the sensory quality attributes of the products. This probably explains the observed superiority in appearance of the types of sausages. It is known that juiciness is determined by the level of fat content and moisture contents of meat, which, in turn influence tenderness of the product. Perhaps this explains the empirical results of low rating of juiciness for chicken sausages. This is consistent with another study which found that poultry meat has low moisture content” [17]. The combined breast meat and beef sausages also had improved sensory quality attributes as reflected by the increased odds. Therefore, the findings suggest that combining the beef and breast meat has a positive impact on improving the sensory quality of the processed sausages, while samples from treatment V were the most acceptable by the panellist.

Table 4. True nutrient retention of sausage prepared from different proportion of Chicken and Beef

Treatments	I	II	III	IV	V
Variable	**I (100%)**	**II (75%)**	**III (50%)**	**IV (25%)**	**V (0%)**
Moisture Content	67.42± 2.94^{a}	64.45± 1.36^{b}	60.94± 1.35^{c}	57.27± 0.98^{d}	57.76± 0.45^{d}
Crude Protein	97.67± 4.59^{a}	91.63± 1.18^{c}	94.69± 3.44^{b}	97.61± 1.58^{a}	91.67± 1.88^{c}
Ether Extract	99.99±10.13^{d}	143.17±24.96^{bc}	137.48±18.54^{c}	154.89± 11.85^{b}	174.68±6.45^{a}
Ash	57.94±14.35^{d}	62.63± 5.55^{cd}	66.91± 3.17^{bc}	70.62± 5.81^{b}	85.65± 6.14^{a}

abcd: Means on the same row with different superscripts are statistically significant (P<0.05)

Table 5. Sensory evaluation of sausage prepared from different proportion of Chicken and Beef

Treatments	I	II	III	IV	V
Variable	**I (100%)**	**II (75%)**	**III (50%)**	**IV (25%)**	**V (0%)**
Colour	4.74± 1.49^{c}	5.83± 0.41^{b}	6.53± 0.25^{b}	7.35± 0.57^{a}	7.84± 0.83^{a}
Flavour	5.31± 0.09^{d}	5.65± 0.22^{b}	5.73± 0.11^{ab}	5.78± 0.10^{a}	5.44± 0.14^{c}
Juiciness	4.25± 0.20^{c}	4.50± 0.24^{bc}	4.67±0.28^{b}	4.69±0.28^{b}	5.18± 0.35^{a}
Tenderness	5.34± 0.13^{b}	5.59± 0.08^{a}	5.22± 0.08^{c}	5.16± 0.13^{cd}	5.07± 0.10^{d}
Pungency	4.70± 0.05^{c}	4.90± 0.03^{a}	4.84± 0.06^{b}	4.81±0.06^{b}	4.71± 0.08^{c}
Overall Acceptability	5.52± 0.19^{c}	5.57± 0.07^{c}	5.80± 0.09^{b}	5.78± 0.13^{b}	6.29± 0.31^{a}

abcde: Means on the same row with different superscripts are statistically significant (P< 0.05)

3.5 Microbial Quality Evaluation

Microbial growth in foods results in food spoilage with the development of undesirable sensory characteristics and in certain cases the food may become unsafe for consumption. The microbial characteristics of breakfast sausages are presented in Table 6. The sausage products in all the five treatments were observed for Total Aerobic Count (TAC), Total Anaerobic Count (TANC) and Total Fungal Count (TFC) immediately after processing, TAC count for the raw samples observed in treatment were I (1.38± 0.08), II (3.33± 0.36) , III (4.22± 1.00), IV (2.35± 0.38) and V (4.63± 0.39). The highest levels of TAC in cooked samples were observed in treatment V (3.95±0.30 Log cfu/g) and the lowest in treatment IV (1.95± 0.30Log cfu/g). TANC in all the raw samples ranged from 1.24± 0.08 to 4.31± 0.11 with treatment II (4.31± 0.11) having the highest values while the lowest was recorded in treatment I (1.24± 0.08), TANC in processed samples ranged from 2.06± 0.32 to 3.67± 0.33 while the highest value and lowest value were recorded in treatment III (3.67± 0.33) and II (2.06± 0.32), respectively. Total Fungal Count (TFC) ranged from 1.32±0.17 to 3.11± 0.70 with the highest and lowest values recorded in treatments V (3.11± 0.70) and III (1.44± 0.2). The cross contaminations might have come from poor quality ingredients such as: non-meat materials, wrapping materials and equipments used [41,42]. All the standard plate count (SPC) were within acceptability limits (2–4 log 10^{6} cfu/g) prescribed by Colombian legislation [43]. It should also be mentioned that total aerobic count (APC) can predict the shelf life of the food products and are used mainly as indicators of process hygiene and

Table 6. Microbial assessment of sausage prepared from different proportion of Chicken and Beef (log 10^{2}cfu/g)

Microbes		I	II	III	IV	V
Variable	**Sample**	**I (100%)**	**II (75%)**	**III (50%)**	**IV (25%)**	**V (0%)**
TAC	Raw	3.38± 0.08^{b}	3.33± 0.359^{b}	4.22± 1.00^{a}	2.35± 0.38^{c}	4.63± 0.39^{a}
	Cooked	1.38± 0.23^{d}	2.31± 0.14^{b}	1.43± 0.22^{d}	1.95± 0.30^{c}	3.95± 0.30^{a}
TANC	Raw	3.52± 0.09^{b}	4.31± 0.11^{a}	3.67±0.33^{b}	2.76±0.41^{c}	3.02±0.54^{c}
	Cooked	3.32± 0.15^{a}	2.06± 0.32^{c}	1.29± 0.067^{d}	2.45± 0.17^{b}	1.24± 0.08^{d}
TFC	Raw	5.74± 0.13^{a}	3.32± 0.47^{b}	3.34± 0.38^{b}	2.68± 0.08^{c}	3.11±0.70^{a}
	Cooked	2.01± 0.23^{c}	2.38± 0.38^{b}	1.44± 0.20^{d}	1.32±0.17^{d}	0.74± 0.40^{d}

abcde: Means on the same row with different superscripts are statistically significant (P< 0.05); TAC: Total Aerobic Count; TANC: Total Anaerobic Count; TFC: Total Fungal Count quality [32,44-47]. Handling of foods during processing and distribution may lead to ultimate reduction of shelf life, which might be an index of good environmental conditions created during processing. The results show that using poultry and beef in sausage production is possible, from the stand point of microbiological characteristics [48,49].

4. CONCLUSION

Incorporating chicken meat resulted in reduced moisture content and reduced cooking loss with minimal effects on pH of the breakfast sausage. The lower fat content in I and II group than V indicated the leanness of *pectoralis major*, which could be the beneficial outcome of the present study. Hence, breast muscle of broiler chicken has great potential for utilization in sausages. Generally, the sensorial attributes of breakfast sausages in treatment V are more appealing to consumers and beef sausages being extremely liked. The panellists could have been influenced by the light colour and juiciness of meat from broiler chicken. Further research is recommended to study the shelf life and in-depth studies along distribution and marketing levels to establish the sources of contamination and probably the critical control points are important.

DATA AVAILABILITY

All datasets generated and analysed during the current study are available on request from the corresponding author

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Poławska E, Cooper RG, Jóźwik A, Pomianowski J. Meat from alternative Species-Nutritive and dietetic value, and its benefit for human health-A review. CyTA-Journal of Food. 2013;11(1):37–42. Available:https://doi.org/10.1080/19476337.201 2.680916
2. Saygın Ö, Demirbaş N. Türkiye de Kırmızı Et Tüketimi: Sorunlar ve Öneriler. Selcuk Journal of Agricultural and Food Sciences. 2018;32(3):567–574. Available:https://doi.org/10.15316/sjafs. 2018.138
3. Saygin Ö, Demirbaş N. Türkiye'de Kırmızı Et Sektörünün Mevcut Durumu ve Çözüm Önerileri. Hayvansal Üretim. 2017;58 (1):74–80.
4. Jung S, Nam KC, Jo C. Detection of malondialdehyde in processed meat products without interference from the ingredients. Food Chem. 2016;209:90–94.
5. Petracci M. Mudalal S. Bonfiglio A, Cavani C. Occurrence of white striping under commercial conditions andits impact on breast meat quality in broiler Chicken Poultry Science. 2013;92(6):1670-1675
6. Zorba Ö, Kurt Ş. Optimization of emulsion characteristics of beef, chicken and turkey meat mixtures in model system using mixture design. Meat Sci. 2006;73:611–618.
7. Büşra Y, Muhittin Z, Makbule G, Özlem VABB, Postacı Ç, Emre O. Chemical composition of meat from different species of animalsnternational Journal of Agriculture, Environment and Food Sciences. 2023;7(3):581-587. Available:https://doi.org/10.31015/jaefs.20 23.3.12
8. Bhattacharyya D, Sinhamahapatra M, Biswas S. Preparation of sausage from spent duck- an acceptability study. International Journal of Food Science and Technology. 2005;42:24-29.
9. Ali MS, Kim GD, Seo HW, Jung EY, Kim BW, Yang HS, Joo ST. Possibility of Making Low-fat Sausage from Duck Meat with Addition of Rice Flour. Asian Australian J. of Anim. Sci. 2008;24: 421-428
10. Ahhmed AM, Kuroda R, Kawahara S, Otha K, Nakade K, Aoki T. Dependence of microbial transglutaminase on meat types in myofibrillar proteins cross-linking. Food Chemistry. 2007;112: 354−361.
11. Heck RT, Fagundes MB, Cichoski AJ, de Menezes CR, Barin JS, Lorenzo JM, Wagner R, Campagnol PCB. Volatile compounds and sensory profile of burgers with 50% fat replacement by micro particles of chia oil enriched with rosemary. Meat Sci. 2019;148:164–170.
12. Tarladgis BG, Watts BM, Younathan MS, Dugan LJR. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc. 1960;37:44–48.
13. Rhee KS, Anderson LM, Sams AR. Comparison of flavour changes in cooked

and refrigerated beef, pork and chicken meat patties. Meat Sci. 1978;71:392–396.
14. Murphy EW, Criner PE, Gray BC. Comparisons of methods for calculating retentions of nutrients in cooked foods. J Agric Food Chem. 1975;23(6):1153–1157.
15. Naveena BM, Muthukumar M, Sen AR, Babji Y, Murthy TRK. Quality characteristics and storage stability of chicken patties formulated with finger millet flour (*Eleusine coracana*). Journal of Muscle Foods. 2006;17(1):92–104.
16. Honikel KO. Reference methods for the assessment of physical characteristics of meat. Meat sci. 1998;49:447–457.
17. Murphy RY, Marks BP, Marcy JA. Apparent specific heat of chicken breast patties and their constituent proteins by differential scanning calorimetry. J. Food Sci. 1998;63:88–91.
18. Gandi BR. Quality characteristics and microbial status of beef smoked with different plant materials and suya produced from round muscles. A thesis submitted to the school of post graduate studies, ahmadu bello university, zaria, nigeria in partial fulfilment of the requirements for the award of a master's of science degree in Animal Science. 2014:1-94
19. A.M.S.A. American Meat Science Association. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh beef. Chicago, IL, USA; 1995.
20. SAS. User's Guide Statistics. SAS Institute, Inc. Cary, N.C., USA; 2000.
21. Tornberg E. Effect of heat on meat proteins- implications on structure and quality of meat products: A review. Meat Sci. 2005;70:493–508.
22. Belichovska D, Belichovska K, Pejkovski Z. Effect of genotype on physico-chemical characteristics of rabbit meat. Meat Technology. 2017;58(1):10–15.
23. Lima LP, Cruz CL, Farias TJ, Wanderley Júnior MA, Junqueira RS, de Oliveira ARA, Cordeiro CF, Filho JDG. Physicochemical characteristics of lamb meat fed with cottonseed associated with calcium lignosulphonate. Acta Scientiarum-Animal Sciences. 2022;44:1–10.
Available:https://doi.
org/10.4025/actascianimsci.v44i1.54682
24. Leygonie C, Britz TJ, Hoffman LC. Meat quality comparison between fresh and frozen/thawed ostrich m. iliofibularis. meat sci. 2012;91:364–368
25. Parlak Ö, Zorba Ö, Kurt Ş. Modelling with response surface methodology of the effects of egg yolk, egg white, and sodium carbonate on some of the physical-chemical and sensory properties of beef patties. Int. J. Food Eng; 2011.
DOI: 10.2202/1556-3758.2004
26. Yu TY, Morton JD, Clerens S, Dyer JM. Cooking-induced protein modifications in meat. Comprehensive Rev Food Sci. And Food Safety. 2017;16(1):141–159.
27. Falowo AB. Fayemi PO. Muchenje V. Natural antioxidants against lipid–proteinoxidative deterioration in meat and meat products: A review. Food Res. Int. 2014;64:171–181.
28. Vargas-Ramella M, Pateiro M, Barba FJ, Franco D, Campagnol PCB, Munekata PES. Tomasevic I, Domínguez R, Lorenz JM. Micro encapsulation of healthier oils to enhance the physicochemical and nutritional properties of deer pâté. LWT. 2020;125
29. Domínguez R, Pateiro M, Gagaoua M, Barba FJ, Zhang W, Lorenzo JM. Acomprehensive review on lipid oxidation in meat and meat products. Antioxidants. 2019;8:429.
30. Enser M. What is lipid oxidation. Fd Sci. Technol. Today. 1987;1:151-3.
31. Nkukwana TT, Muchenje V, Masika PJ, Hoffman LC, Dzama K, Descalzo AM. Fatty acid composition and oxidative stability of breast meat from broiler chickens supplemented with Moringa oleifera leaf meal over a period of refrigeration. Food Chemistry. 2014;142: 255-261.
32. Kim JH, Yim DG. Assessment of the microbial level for livestock products in retail meat shops implementing HACCP system. Korean Journal for Food Science of Animal Resources. 2016;36: 594-600.
DOI: 10.5851/kosfa.2016.36.5. 594
33. Rymer C, Givens DI. n-3 fatty acid enrichment of edible tissues of poultry: A review. Lipids, 2005;40(2):121-140.
Available:http://dx.doi.org/10.1007/s11745-005-1366-4
34. Peña-Saldarriaga LM, Fernandez Lopez J, Sayas-Barberá E, Pérez-Alvarez JA. Broiler chickens: Characterization of abdominal and gizzard fat. In Proceedings of the 1st World Congress of Food Safety

andSecurity, Leiden, The Netherlands. 2019;24–28:76

35. USDA. Table of Nutrient Retention Factors, Release 6. Prepared by Nutrient DataLaboratory, Beltsville Human Nutrition Research Center (BHNRC), Agriculture Research Service (ARS), U. S. A., Department of Agriculture (USDA); 2007.
36. Wilkinson BHP, Lee E, Purchas RW, Morel PCH. The retention and recovery of amino acids from pork *longissimus* muscle following cooking to either 60 °C or 75 °C. Meat Sci 2014;96:361–5.
37. Smith MO. Parts yield of broilers reared under cycling high temperatures. Poultry Science. 1993;72:1146-1150.
38. Luchak GL, Miller RK, Belk KE. Hale DS. Michaelswen SA. Johnson DD, West RL, Leak FW, Cross HR, Savell JW. Determination of Sensory, Chemical and Cooking Characteristics of Beef Cuts Differing in Intramuscular and External Fat. Meat Science. 1998;50:55-72
39. Kempster AJ, Croston D, Jones DW. Tissue growth and development in crossbred lambs sired by ten breeds.Livest Prod Sci. 1987;16:145–162
40. Harris KB, Harberson TJ, Savell JW, Cross HR, Smith SB. Influences of Quality Grade, External Fat Level, and Degree of Doneness on Beef Steak Fatty Acids. Journal of Food Composition and Analysis. 1991b;5:84-89
41. Walker SJ, Betts G. Factors affecting the microflora of chilled foods. In: Chilled Foods, Stringer, M. and C. Dennis (Eds.) wood head publishing. London. 2000;157-178
42. Syne SM, Ramsubhag AA, Adesiyun AA. Microbiological hazard analysis of ready-to-eat meats processed at a food plant in Trinidad, West Indies. Infection Ecology and Epidemiology. 2013;3:20450 Available:http://dx.doi.org/10.3402/iee.v3i0.20450
43. NTC. 1325 Norma Técnica Colombiana Para La Industria Alimentaria: Productos Cárnicos Procesados no Enlatados; ICONTEC: Bogota, Colombia; 2008.
44. A.O.A.C. Official Methods of Analysis. Association of Official Analytical Chemists, 17th edition. Washington, DC, USA; 2000
45. APHA. American Public Health Association Compendium of Methods for the Microbiological Examination of Foods, 4th edition. Washington D. C., USA. 2002;7-97:239-250 and 325-422.
46. Bendall JR. In: Bourne GH. (Ed). Structure and function of muscle, 466 Academic Press, New York, 2nd Edition. 1973;2(2):243-309.
47. Federal Register. Substances for use in meat and poultry products. 1979;44 (151,Ang.3), 45606-7.
48. ICMSF. Sampling plans for fish and shellfish. In: Microorganisms in Foods. Sampling for Microbiological Analysis: Principles and Scientific Applications (edited by ICMSF), 2nd Edition. Toronto, Canada: University of Toronto Press; 1986:181–196.
49. Jung E, Joo N. Roselle (*Hibiscus sabdariffa* L.) and soybean oil effects on quality characteristics of pork patties studied by response surface methodology. Meat Science. 2013;94:391-401.

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