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The differential effects of cooking methods on the nutritional properties and quality attributes of meat from various animal sources

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ABSTRACT

This study investigated the various effects of two food product processing methods (boiling and grilling) on the nutritional composition (fatty acid, amino acid profiles) of meat from cows, goats, and rabbits. Freshly slaughtered animals were cleaned and subjected to boiling and grilling. Cooking loss varied with cooking methods; grilling resulted in the highest cooking loss, especially in cow meat (52.95%). Data from the proximate composition analysis revealed that both raw and grilled meat samples of rabbit meat contained the highest amount of protein (22.93 and 22.20 %, respectively) when compared to the corresponding samples from the other two animal sources. Additionally, rabbit meat contained a low level of fat (1.85%), which was not significantly different than the boiled samples (1.75, 1.76 %). Boiling and grilling significantly increased the in *vitro* protein digestibility of meat. The meat showed significant sources of both essential and non-essential amino acids. Rabbit meat showed a higher proportion of essential amino acids and a higher protein efficiency ratio. Boiled goat meat had a lower proportion of saturated fatty acids (SFA), boiled meat had higher polyunsaturated fatty acids (PUFA) than its grilled counterpart. Goat meat showed a favourable fatty acid profile. Thus, goat and rabbit meat are healthier alternatives to beef, and both boiling and grilling are useful in maintaining the nutritional qualities of meat.

Introduction

Consumers' perception of meat quality affects their choices of meat types and processing methods. Meat is important in human nutrition as it is a well-known protein and energy source for daily diets. Moreover, meat is an all-round balanced diet because of its nutritional richness (Pathare and Roskilly, 2016) and is considered the food of choice by many due largely to its nutritional value. It is a nutrient-dense food and provides major nutritive contributions to the diet relative to the amount of calories contained. Heat processing techniques are commonly used to improve the quality and safety of food products, as well as to achieve shelf life extension (Talab, 2014). Cooking is a very critical step in food preparation as it affects organoleptic properties, nutritional value as well as consumer acceptance; common cooking methods include frying, oven cooking, and microwave cooking. Cooking, including boiling and grilling of meat and meat products, is a common household preparation technique, generally carried out to inactivate pathogenic microorganisms, as well as enhance flavour and palatability. Edibility and digestibility of meat also improves as a result of cooking (Alfaia et al., 2013). However, meat undergoes both physical and chemical changes during cooking which includes decreased nutritional value, protein denaturation, etc. (Mora et al., 2011).

The meat consumption trend varies globally depending on religious beliefs, socio-economic factors, or nutritional inadequacies. Recent studies have related beef consumption to the development of disease conditions such as coronary heart disease and cancer (Kaluza et al., 2014; Bouvard et al., 2015). Consequently, consumers are now more health-

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conscious, thus, there is an increased preference for the consumption of meats with lower fat and cholesterol levels. This has spurred research interest regarding the nutritional composition of meat from other animal species other than cow, especially lean meats, to evaluate their safety as a healthier alternative.

Rabbit meat is a lean meat routinely consumed in most countries, China, Italy, Spain, and France being the major producers (FAOSTAT, 2010). Rabbit meat provides excellent nutritional properties, including high protein content, high essential amino acid levels, as well as a proportionate mineral content (Zotte and Szendró, 2011). Moreover, the low fat content of rabbit meat makes it a healthy delicacy for health-conscious consumers.

Goat meat has also been adjudged to be leaner than other red meats; it possesses favourable nutritional properties with a distinctive taste. Goat meat is lower in calories, total fats, saturated fats, and cholesterol than other traditional meats.

Heat processing methods are major determinants of physical properties and sensory quality, such as the tenderness of meat, moreover, meat processing requires cooking prior to consumption and there is no sufficient documentation regarding the effect of household cooking techniques on meat nutrients. Other researchers have reported the effect of cooking on the comparative chemical composition and quality of different meat types subjected to refrigeration or freezing storage. These studies evaluated camel and veal (Nikmaram et al., 2011; Lopes et al., 2015), rabbit (Zhang et al., 2014), drake (Omojola et al., 2014), and chicken (Hong et al., 2015). These studies have also considered other heat processing techniques, such as microwaving, roasting, and frying. However, scanty reports exist on a comparative nutritional composition of meat from animals abundantly domesticated in Nigeria and the evaluation of the effect of two most common household meat processing methods. Thus, this study comparatively evaluates the influence of two major heat processing techniques on the nutritional quality of meat from different animal species.

Materials and methods

The samples were obtained from a cow thigh (red bororo, male, around 30 months old), goat (West African dwarf, 4 months old), and the rabbit (New Zealand, male, 18 wks. old) was sourced from Oba market, Akure and Federal University of Technology Teaching and Research Farm, Akure, Ondo State, Nigeria. The muscles from the choice part (thigh) from ten different animal carcasses were randomly selected and divided into three portion sizes (each portion weighing approximately 80 g). The reagents used were of analytical grade, except for the HPLC and gas chromatography solvents, which were chromatographic grade.

The meat portion was either unprocessed (raw), boiled (100 °C for 15 mins), or grilled in an electric oven (170 °C for 15 mins). The resulting product was ground to a homogenous mass in a Cuisinart grinder (DCG-128CC (FA)), then it was packaged and stored at 4 °C prior to further analyses.

Evaluation of quality attributes

Cooking loss was measured according to the method of Niamnuy et al. (2008) and calculated as the difference in sample weight before and after cooking, and was expressed as the percentage of the weights of samples before cooking.

$$\text{Cooking loss (\%)} = \frac{\text{Weight of meat before cooking} - \text{weight of meat after cooking}}{\text{weight of meat before cooking}} \times 100$$

Total Volatile Basic Nitrogen (TVB-N) was determined as described by the Conway micro diffusion method (PSQ, 1980). Ten (10) grams of meat muscle was homogenized with 20 mL of 20% trichloroacetic acid (TCA) in a blender. The homogenate was filtered through Whatman no.1 filter paper into a 100 mL standard flask. The residue was diluted with 1% TCA and made up to 100 mL. 25 mL of the filtrate was pipetted into a distillation flask with 6 mL of 10% NaOH. Steam distillation was then carried out using a Kjeldahl-type distillator (Struer TVN) and the TVB-N was collected in 10 mL of 4% boric acid (containing 40 μL of methyl red and bromocresol green) indicator, which turned green when alkalized by the TVB-N. The solution was then titrated with 0.05 M sulphuric acid until there was a complete neutralisation of the base, which was indicated by a colour change to pink.

The thio-barbutric acid (TBA) value was measured and expressed as mg of malonaldehyde equivalents per kg of sample (Tarladgis et al., 1960). Absorbance was determined using a spectrophotometer (Thermo Scientific, U.K. Model UV 4.1) at 532 nm against a blank containing distilled water and a TBA solution. The TBA values were calculated by multiplying the sample absorbance by 100 and expressed in mg/g solid. Peroxide value was measured as described in the AOCS methods (1997).

Determination of the chemical composition

Proximate composition of the meat samples was measured according to the standard AOAC methods (2012). Crude protein was determined using a Foss Tecator Kjeltec 2300 Nitrogen/Protein Analyzer. Fat was determined by Soxhlet extraction of the dry sample, using petroleum ether. Ash content was determined by dry ashing samples in a muffle furnace at 550 °C for 24 hr, crude fibre was determined by acid and alkali hydrolysis, and moisture content was determined by the oven dry method. The in vitro protein digestibility of meat was evaluated using the multienzyme technique as described by Hsu et al. (1977). Three (3) enzymes were used for the assay, α-Chymotrypsin (38 units/mg solid; Sigma, St. Louis, MO, USA), trypsin (13,390 BAEE units/mg solid; Sigma), and peptidase (Streptomyces griceus, 46 units/mg solid; Sigma). The reference protein used was Animal Nutrition Research Council casein.

Digestibility was calculated as follows:

Digestibility (%, three enzymes) = 210.64 - 18.103**x**, where x is the pH of sample at 10 mins incubation time.

Determination of the amino acid composition

The amino acid profiles were determined using the HPLC Pico-Tag system after samples were digested with 6 M HCl for 24 hr (Bidlingmeyer et al., 1984). The cysteine and methionine contents were determined after performic acid oxidation (Gehrke et al., 1985) and the tryptophan content was determined after alkaline hydrolysis (Landry and Delhaye, 1992). The total essential amino acids (TEAA), the percentage of the total essential amino acids in the total amino acids (%TEAA), the total non-essential amino acids (TNEAA), and the ratio of essential to non-essential amino acids were calculated and the predicted protein efficiency ratio (P-PER) was determined using one of the equations of Alsmeyer et al. (1974) (i.e. P-PER = - 0.468 + 0.454(Leu) - 0.105(Tyr)).

Chemical score of the amino acids

Once the amount of amino acids in the different muscles was determined, the chemical score (CS) of the essential amino acids (CSEAA), or CS, was calculated in relation to the reference on pattern protein proposed by FAO/WHO/UNU (2007) applying the following equation:

$$\text{CSEAA} = \frac{\text{g EAA in tested protein}}{\text{g EAA in pattern protein}} \times 100$$

Determination of the fatty acid composition

Crude fat was extracted as described by AOAC (2012). About 50 mg of the extracted fat content of the sample was saponified for 5 mins at 95 °C with 3.4 mL 0.5M KOH in dry methanol. The mixture was neutralized using 0.7M HCl. 3 mL of the 14% boron trifluoride in methanol was added. The mixture was heated for 5 mins at 90 °C to achieve complete methylation. Fatty Acid Methyl Esters (FAME) were extracted thrice from the mixture with redistilled n-hexane. The content was concentrated to 1 mL for Gas Chromatographic analysis and 1 µL was injected into the injector port. The FAME were analysed using an HP6890A gas chromatograph (Hewlett–Packard, Avondale, PA, USA) equipped with a flame-ionization detector (GC-FID), using an HP INNOWax fused-silica capillary column (CP-Sil 88; 30 m × 0.25 mm i.d., 0.25 µm film thickness) as described by Bessa et al. (2007). The quantification of muscle lipids FAME was done using nonadecanoic acid (19:0) as the internal standard. Nitrogen was used as the carrier gas and the injector split ratio was 1:20. After injection (1 µL), the initial column temperature of 100 °C was held for 15 mins, increased to 150 °C at 10 °C/min and held for 5 mins. Then, it was increased to 158 °C at 1 °C/min, held for 30 min, and finally increased to 200 °C at a rate of 1 °C/min, and maintained for 60 mins. The injector and detector temperatures were 250 and 280 °C, respectively. FA was expressed as a percentage of the sum of detected FAME (g/100 g FAME).

Sensory evaluation

The consumer acceptability and preference of cooked meat from the three animal sources was evaluated through sensory evaluation by thirty (30) semi-trained panellists. A predetermined list of seven (7) sensory attributes was used to describe the sensory characteristics of meats. A 30 min training session was conducted to evaluate the use of the attributes by the panellists during sensory analysis. The sensory attributes allowed the differentiation of samples in terms of appearance (colour), texture (tenderness, juiciness), flavour (flavour and aroma), taste (palatability), and overall acceptability. Samples were coded and served to the panellists for independent evaluation; all sensory attributes assessed by the panellists were rated using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely.

Statistical analysis

Data was generated in triplicate and subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS) v.17. Means

were separated by the Duncan's Multiple Range Test (DMRT) at 95% confidence level.

Results and discussion

Chemical composition of meat

The chemical composition of meat as affected by the cooking method is presented in Table 1. Cooking loss relates to the reduction in weight of meat as a result of a cooking operation. Even though the weight loss consists mainly of water, a significant loss of fat can also occur. Cooking loss measurement is a rapid method employed in assessing the impact of a heat treatment on meat, as this could influence the degree of its juiciness. In this study, the cooking loss ranged from 16.37 to 52.95 %. A more significant cooking loss was recorded when the meat was subjected to grilling (42-53 %) than boiling (16-36 %), this may be due to high temperatures involved in grilling, which might have led to the loss of fat. The cooking loss data for both treatments correspond to those of previous reports, ranging between 15 and 43 % (Sheard et al., 1998; Alfaia et al., 2010; Omojola et al., 2014). Goat meat showed the lowest cooking loss for both cooking methods; this may be connected to the fact that chevon exhibited the highest water holding capacity when compared to other meat types. Lijalem et al. (2015) reported lower cooking loss for goat meat compared to beef, our result followed a similar trend, considering that in their report the meat sample with lower water holding capacity had higher cooking loss. In general, the cooking method employed affects the extent of cooking loss. Losses depend on the mass transfer process during the thermal treatment, which directly relates to the heat processing parameters (which includes heating rate, final cooking temperature, and time), as well as the properties of the raw meat. The variation observed in the different methods employed may be due to high temperature and slow cooking involved with the grilling process, which might result in a loss of excess water and shrinkage. The correlation between cooking loss and shrinkage of meat can be explained by the fact that the shrinkage resulting from grilling causes a loss of meat liquid, which results in a loss of weight. As previously reported, the lower the cooking loss, the better the juiciness of the meat (Jama et al., 2008). Chiavaro et al. (2009) reported that an increase in the core temperature of meat promotes collagen shrinkage, reduces water holding capacity, and increases cooking loss, thus influencing the final quality and acceptability of meat. The specific effect is dependent on the cooking method employed. In both cooking methods, chevon presented the lowest cooking loss for boiling and grilling (16.37; 42.98 %, respectively), thus suggesting that this meat type could be the juiciest when consumed. The pH value is a key determinant of meat quality as the ultimate pH of meat is important for its resistance to spoilage (Walker and Betts, 2000). In the present study, the pH value of the meat samples ranged from 6.10 to 6.77 which falls within range for the pH of the muscle of a living animal.

The effect of cooking on the chemical composition of meat was also evaluated (Table 1). The peroxide values were generally less than 5 meq/kg which suggests no onset of rancidity in the product. This is expected because the meat was processed immediately after slaughter and not subjected to post-mortem storage, thus there was no development of any oxidative rancidity products, as indicated by the low peroxide value. The highest TBA value (51-63 mg/g) was recorded in beef across the treatments (boiling and grilling), while chevon and rabbit meat had significantly lower values (12-24 and 5-21 mg/g, respectively). The total volatile basic nitrogen (TVB-N) is the chemical indicator of meat quality. In the present study, low TVB-N was observed for the raw meat samples (3.63-5.13 mg/100g), the result depicts that the meat evaluated was of high quality, attributable to freshness, since the meat used was from freshly slaughtered animals (6 h post-mortem).

Table 1. Effect of processing on the quality attributes of raw, boiled, and grilled meat

Samples	Cooking loss (%)	WHC (%)	pH	FFA	TBA (mg/g)	Peroxide (mgEq/kg)	TVB-N (mg/100g)
RCM	NA	62.22 ± 0.23^{f}	6.47 ± 0.05^{d}	1.73 ± 0.08^{d}	63.00 ± 0.01^{a}	1.47 ± 0.31^{g}	3.63 ± 1.71^{e}
RGM	NA	63.28 ± 0.29^{f}	6.77 ± 0.06^{a}	1.26 ± 0.14^{g}	24.10 ± 0.01^{d}	1.60 ± 0.69^{cd}	5.13 ± 0.81^{de}
RRM	NA	66.80 ± 0.03^{de}	5.87 ± 0.06^{g}	1.68 ± 0.14^{e}	21.00 ± 0.01^{f}	1.60 ± 1.04^{cd}	5.13 ± 2.14^{de}
BCM	35.87 ± 1.37^{d}	71.70 ± 0.58^{c}	6.33 ± 0.06^{e}	1.73 ± 0.08^{d}	51.20 ± 0.58^{c}	2.07 ± 0.50^{b}	4.67 ± 1.62^{de}
BGM	16.37 ± 1.40^{f}	84.70 ± 0.06^{a}	6.53 ± 0.06^{c}	1.69 ± 0.50^{e}	14.00 ± 0.01^{g}	2.80 ± 0.69^{e}	6.07 ± 0.81^{de}
BRM	28.55 ± 2.37^{e}	74.50 ± 0.26^{b}	6.47 ± 0.06^{d}	1.41 ± 0.50^{f}	22.20 ± 0.01^{e}	2.67 ± 0.12^{f}	5.60 ± 1.40^{de}
GCM	52.95 ± 0.31^{a}	64.73 ± 0.06^{e}	6.10 ± 0.02^{f}	3.70 ± 0.26^{b}	60.00 ± 0.00^{b}	2.28 ± 0.16^{a}	13.07 ± 2.33^{b}
GGM	43.93 ± 0.44^{c}	67.95 ± 0.11^{d}	6.32 ± 0.02^{e}	2.52 ± 0.05^{c}	12.00 ± 0.00^{h}	2.58 ± 0.02^{d}	14.47 ± 0.47^{a}
GRM	50.47 ± 0.16^{b}	65.00 ± 0.06^{e}	6.58 ± 0.11^{b}	4.12 ± 0.01^{a}	5.00 ± 0.03^{i}	1.37 ± 0.03^{h}	10.27 ± 0.47^{c}

Values are means ± standard deviation of replicate determinations. Values with different letters on the same column are significant ($P \leq 0.05$).
WHC: Water holding capacity; FFA: Free fatty acid; TBA: Thiobarbituric acid value; TVBN: Total basic volatile nitrogen; RCM: Raw Cow Meat; RGM: Raw Goat Meat; RRM: Raw Rabbit Meat; BCM: Boiled Cow Meat; BGM: Boiled Goat Meat; BRM: Boiled Rabbit Meat; GCM: Grilled Cow Meat GGM: Grilled Goat Meat; GRM: Grilled Rabbit Meat

However, heat processing generally affected the TVB-N, with grilling causing a significant increase (54.23-72.23 %). The lowest TVB-N values were observed in rabbit meat; boiling showed an 8% increase while grilling resulted in a 54% increase. Given that the result obtained in this study is below the specified maximum acceptable value of 20 mg/ 100 g recommended by the United State Dietary Allowances Food Safety and Inspection Service (2000), it is logical to consider the meat types and processing methods employed in this study are healthy and safe.

Chemical composition

The effect of cooking methods employed on the proximate composition of meat from different animal sources is presented in Table 2. Raw meat had a high moisture content (64-73 %). The high-water content will support its susceptibility to rapid deterioration and spoilage, which necessitates the need for heat processing to prolong the shelf life and promote the edibility of the product. Similar to the present finding, a high moisture value of about 70% was reported for chicken by Hong et al. (2015). Heat processing (cooking and grilling) caused a significant reduction in the moisture content, however, grilling showed a higher moisture reduction ability (49-87 %), whereas boiling caused a lower moisture reduction (11-30 %). Low moisture reduction (39%) has been previously reported for roasted camel meat (Nikmaram et al., 2011). Zhang et al. (2014) on the other hand reported significantly higher moisture reduction in rabbit meat by frying than by boiling, but observed similar moisture reduction (11.66-12.98 %) for the varied duration of boiling. This significant moisture reduction (especially in grilled meat) may help delay deterioration and spoilage which could result from high proliferation of micro-organisms and biochemical reactions associated with high a moisture content and water activity. Cow meat had the highest fat content (12%) with a slight reduction (2.74-2.90 %) observed in the cooked products; goat meat had a fat content of 9.73%, while rabbit meat had the least fat content (1.85%). The low fat content of rabbit meat may be attributed to it being a lean meat. Cooking resulted in a slight reduction in fat and a higher fat loss was observed in grilled meat than in boiled meat products. Thus suggesting grilled meat products may be less susceptible to oxidative and hydrolytic rancidity. Other researchers (Omojola et al., 2014) have reported a reduction in fat content of meat products as a result of grilling. Protein contents of cow and rabbit meat were not significantly different. However, heat treatments (boiling and grilling) resulted in a loss of protein content of meat, especially cow (3.85; 6.62 %) and rabbit meat (6.45; 3.18 %) respectively. Nonetheless, a slight protein increase (2.31%) was observed for cooked goat meat. In a previous study, Zhang et al. (2014) reported similar loss (7.75%) of protein content for rabbit meat after boiling. Also, Adam and Abugroun (2015) reported a 4.91% protein loss after boiling cow meat, while Wilkinson et al. (2014) reported a higher decrease (18%) in protein content of pork subjected to a lower cooking temperature (75 °C). The reduction in protein content may be a result of protein denaturation occurring due to the introduction of high temperatures during cooking. Ash content is an indicator of total mineral content; cooking resulted in a significant increase in the ash content. The ash content of cooked meats significantly increased (100%), which suggests that the meat could be a good source of mineral elements. Chevon possessed the highest ash content; this may not be unconnected to the composition of feed the animal grazed on. Grilled meats had significantly improved ash contents (about a 138-268 % increase); grilling process (dry cooking method) occurred in the absence of water, which allows for a high retention of mineral matter (6.81-13.84 %), whereas boiling (wet cooking method) does not retain as much quantity as in the former (5.77-7.36 %). Omojola et al. (2014) reported about 240% increase in the percentage ash content of roasted drake meat. A past study showed that microwaving and grilling increased the ash content of veal meat, while boiling caused a decrease in ash content (Lopes et al. 2015).
Protein digestibility has been described as a more realistic indicator of the nutritional value of protein-rich food products. Processing methods (boiling and grilling) increased the in *vitro* protein digestibility (I*V*PD) of the meat products significantly. Increased protein digestibility may be attributed to the inactivation of enzyme inhibitors (such as cathepsins and calpains) and the denaturation of protein, which might expose new sites to digestive enzyme action. Both heat processing techniques significantly increased protein digestibility, with grilled meat having a slightly higher digestibility (75-82 %) than its boiled counterpart (78-80 %). Grilling improved protein digestibility of cow meat while boiling promoted the I*V*PD of goat and rabbit meat. Cow and rabbit meat had the highest increase in protein digestibility, with boiling causing an increase of 8.23% in rabbit meat and grilling resulting in an 8.15% increase for cow meat. The present result implies that rabbit meat is a good source of protein with improved digestibility achieved through the grilling process.

Table 2. Effect of cooking on the proximate composition and protein digestibility of cow, goat, and rabbit meat

	Composition (%)					
Samples	Moisture	Fat	Protein	Ash	Crude fibre	*IV*PD
RCM	64.64±0.01^{b}	12.03±1.64^{a}	22.36±0.05^{a}	2.84±0.94^{g}	0.88±0.09^{e}	75.53±0.10^{f}
RGM	73.34±0.91^{a}	9.73±0.58^{c}	18.63±0.01^{b}	3.76±0.06^{f}	1.06±0.21^{d}	78.79±0.10^{d}
RRM	64.24±1.50^{b}	1.85±0.29^{e}	22.93±0.03^{a}	3.33±0.45^{g}	1.32±0.18^{b}	72.45±0.10^{g}
BCM	57.77±0.13^{c}	11.70±0.9^{b}	21.50±0.09^{a}	5.77±0.77^{e}	0.79±0.16^{f}	77.82±0.10^{e}
BGM	58.03±0.34^{c}	9.89±0.00^{c}	19.06±0.05^{ab}	7.36±2.73^{c}	1.24±0.25^{c}	80.24±0.18^{b}
BRM	44.99±0.38^{d}	1.75±0.08^{e}	21.45±0.01^{a}	5.91±0.27^{e}	1.35±0.40^{b}	78.79±0.18^{d}
GCM	13.57±1.31^{f}	11.68±0.3^{b}	20.88±0.01^{ab}	6.81±0.30^{d}	1.01±0.12^{d}	75.59±0.10^{f}
GGM	9.66 ±0.11^{g}	8.62±0.70^{d}	18.40±0.01^{b}	13.84±0.71^{a}	1.31±0.00^{b}	79.82±0.18^{c}
GRM	32.19±0.54^{e}	1.76±1.48^{e}	22.20±0.02 ^{a}	11.74±1.56^{b}	1.42±0.53^{a}	81.63±0.10^{a}

Values are mean ± SD of replicate determinations. Values with different letters on the same column are significant ($P \leq 0.05$). *IV*PD: In vitro protein digestibility; RCM: Raw Cow Meat; RGM: Raw Goat Meat; RRM: Raw Rabbit Meat; BCM: Boiled Cow Meat; BGM: Boiled Goat Meat; BRM: Boiled Rabbit Meat; GCM: Grilled Cow Meat GGM: Grilled Goat Meat; GRM: Grilled Rabbit Meat

Table 3a. Effect of cooking methods on the amino acid composition (g/100g) of cow, goat, and rabbit meat

	RCM	RGM	RRM	BCM	BGM	BRM	GCM	GGM	GRM	FAO/WHO (2007)
Glycine	4.72±0.02^{b}	5.04±0.04^{a}	4.71±0.05^{b}	4.15±0.03^{d}	5.03±0.02^{a}	4.72±0.03^{b}	4.30±0.04^{c}	5.09±0.05^{a}	4.34±0.08^{c}	
Alanine	7.11±0.01^{b}	5.86±0.13^{c}	5.64±0.03^{d}	7.13±0.06^{b}	5.85±0.03^{c}	5.65±0.03^{d}	7.33±0.15^{a}	5.91±0.06^{c}	5.39±0.06^{e}	
Serine	4.46±0.12^{c}	4.55±0.04^{c}	4.15±0.04^{d}	4.02±0.02^{e}	4.54±0.05^{c}	4.16±0.01^{d}	4.48±0.03^{c}	4.61±0.07^{b}	4.81±0.03^{a}	
Proline	4.18±0.02^{b}	4.02±0.00^{c}	1.28±0.01^{e}	3.62±0.04^{d}	4.02±0.04^{c}	1.28±0.00^{e}	4.70±0.03^{a}	4.05±0.05^{c}	1.26±0.00^{e}	
Valine	5.13±0.03^{b}	4.81±0.05^{d}	6.19±0.13^{a}	5.06±0.04^{c}	4.81±0.05^{d}	6.19±0.13^{a}	5.06±0.08^{c}	4.84±0.16^{d}	6.10±0.03^{a}	3.9
Threonine	3.96±0.04^{c}	4.70±0.00^{b}	4.86±0.03^{a}	3.72±0.05^{d}	4.70±0.01^{b}	4.86±0.03^{a}	3.96±0.06^{c}	4.73±0.05^{ab}	4.81±0.06^{a}	2.3
Isoleucine	4.62±0.02^{d}	4.39±0.01^{e}	5.45±0.20^{a}	5.51±0.06^{a}	4.38±0.03^{e}	5.46±0.05^{a}	4.81±0.05^{c}	4.43±0.06^{e}	5.41±0.05^{ab}	3.0
Leucine	7.76±0.13^{b}	7.76±0.03^{b}	9.43±0.16^{a}	7.76±0.03^{b}	7.76±0.05^{b}	9.44±0.11^{a}	7.79±0.06^{b}	7.80±0.06^{b}	9.38±0.15^{a}	5.9
Aspartic acid	8.79±0.02^{c}	8.96±0.13^{b}	8.99±0.04^{b}	9.10±0.00^{a}	8.96±0.06^{b}	9.00±0.06^{b}	9.11±0.10^{a}	9.00±0.08^{b}	8.95±0.04^{b}	
Lysine	8.86±0.09^{c}	8.01±0.07^{e}	9.18±0.05^{a}	8.88±0.09^{c}	8.01±0.06^{e}	9.18±0.15^{a}	8.88±0.04^{c}	8.09±0.09^{d}	9.11±0.02^{b}	4.5
Methionine	2.76±0.01^{d}	2.91±0.00^{c}	1.67±0.03^{f}	3.09±0.03^{b}	3.19±0.00^{a}	1.71±0.02^{f}	3.09±0.02^{b}	3.23±0.03^{a}	1.87±0.00^{e}	1.6
Glutamic acid	14.61±0.16^{d}	14.29±0.24^{f}	15.75±0.09^{b}	14.79±0.16^{c}	14.42±0.27^{e}	15.76±0.09^{b}	14.73±0.11^{c}	14.66±0.08^{cd}	16.27±0.19^{a}	
Phenylalanine	4.56±0.03^{b}	4.35±0.02^{c}	3.35±0.04^{d}	4.97±0.06^{a}	4.34±0.06^{c}	3.36±0.04^{d}	4.95±0.03^{a}	4.40±0.06^{c}	3.31±0.03^{d}	3.8
Histidine	3.25±0.01^{c}	3.22±0.03^{c}	4.35±0.25^{a}	3.43±0.02^{b}	3.22±0.05^{c}	4.35±0.03^{a}	3.41±0.05^{b}	3.26±0.06^{c}	4.30±0.06^{a}	1.5
Arginine	6.09±0.03^{c}	6.29±0.15^{b}	5.89±0.05^{e}	5.98±0.04^{d}	6.29±0.16^{b}	5.90±0.04^{e}	5.96±0.06^{d}	6.41±0.07^{a}	5.80±0.10^{f}	
Tyrosine	3.25±0.03^{e}	3.37±0.04^{d}	4.76±0.02^{a}	2.92±0.01^{f}	3.37±0.04^{d}	4.77±0.04^{a}	2.91±0.03^{f}	3.46±0.04^{c}	4.66±0.06^{b}	
Tryptophan	1.32±0.02^{b}	1.15±0.03^{c}	1.40±0.01^{a}	1.13±0.01^{c}	1.29±0.03^{b}	1.40±0.03^{a}	1.12±0.02^{c}	1.32±0.02^{b}	1.40±0.00^{a}	0.6
Cystine	1.00±0.00^{c}	1.00±0.01^{c}	1.14±0.01^{b}	0.63±0.00^{d}	1.00±0.00^{c}	1.14±0.03^{b}	0.63±0.01^{d}	1.05±0.02^{c}	2.23±0.07^{a}	0.6

Values are mean ± SD of replicate determinations. Values with different letters on the same row are significant ($P \leq 0.05$). RCM: Raw Cow Meat; RGM: Raw Goat Meat; RRM: Raw Rabbit Meat; BCM: Boiled Cow Meat; BGM: Boiled Goat Meat; BRM: Boiled Rabbit Meat; GCM: Grilled Cow Meat GGM: Grilled Goat Meat; GRM: Grilled Rabbit Meat

Amino acid composition of meat as influenced by heat processing

The amino acid profile of raw and processed meat samples expressed as g/100 g of protein is presented in Table 3a. Comparatively, rabbit meat exhibited a higher content of essential amino acids (EAA) such as valine, threonine, isoleucine, leucine, lysine, histidine, tryptophan and cystine. The contents did not change significantly after boiling; however, a slight decrease was observed in the grilled samples, this may be attributed to partial degradation (protein denaturation) as grilling proceeded at higher temperatures. Heating significantly affected the amino acid content of cow meat, as lower values were observed for six non-essential amino acids (NEAAs) (alanine, serine, proline, valine, arginine, tyrosine) and four EAAs (valine, threonine, tryptophan, cystine) in both boiled and grilled cow meat. This agrees with the report by Sobral et al. (2018) that cooking meat at 100-140 °C reduced the amino acid content of meat. Less than 90% amino acid retention was reported by Wilkinson et al. (2014) for pork longissimus muscle cooked at 75 °C for 90 mins. Overall, the essential amino acids of the meats exceeded the FAO/WHO/UNU (2007) standard for both children and adults. Adoption of the

studied heat processing methods for the meat types is significant because the abundant EAA present in the processed meats is important for body repair and cell regeneration in adults as well as growth and development in children (Bohrer, 2017). Heat treatments slightly increased methionine content in all meat samples; moreover, phenylalanine, lysine, histidine, and isoleucine also increased in beef samples. However, no significant change was observed in chevon and rabbit meat. The high content of essential amino acids in rabbit meat is in agreement with other reports (Hernàndez et al., 2010).

The influence of the heat processing technique on the nutritional quality of the three meat types evaluated is summarized in Table 3b. The Total Amino Acid increased with both boiling and grilling, the increase may be a result of water loss. Consequently, boiling also showed positive influence on the total essential amino acid (TEAA). Similar increase in the TEAA values after boiling was reported by Oduro et al. (2011). The amino acid score (AAS) estimates protein quality, and in this case, it ranged from 70.1 to 77.7 among the meat samples. The AAS is above 70, which infers that the meat types investigated possess good protein quality. The AAS followed this order: rabbit meat > cow meat > goat meat; and boiling significantly increased the AAS of beef. The protein efficiency ratio (PER) is an index for measuring protein quality of food. The higher the predicted protein efficiency ratio (P-PER), the better the physiological utilization of the protein-rich food product. Eggs were used as a standard protein reference since they are a by-product from animals and are usually considered a complete protein food with excellent quality. Rabbit meat had the highest P-PER, contributing about 85% (3.31) of the PER of an egg (3.90). Thus, rabbit meat may be better utilized when consumed to produce optimum metabolic efficiency than the other meat types (beef and chevon). However, among the heat processing techniques employed, there was a slight difference in the P-PER of the individual meat samples. For instance, BCM had a P-PER of 70.26% compared to the standard reference (egg), while GCM had 71.02%. Also, BGM and GGM possessed 69% of P-PER when compared to egg PER, while protein efficiency in BRM and GRM showed 85% of the PER reported for an egg. Heat processing technique employed did not significantly affect the P-PER of the meats. Hernández et al. (1996) reported PER values of 2.87, 3.30, and 3.41 for pork, chicken and beef, respectively. Overall, the results were generally higher than the values (2.32 to 2.52) earlier reported for duck (Adeyeye, 2018).

Fatty acid composition of meat as influenced by heat processing

Fatty acid composition is significant for health as it affects plasma lipids. The fatty acid profile mainly exhibited two classes; saturated fatty acids (SFAs) and monounsaturated fatty acids (MUFAs), as the sum of the contents of these acids increased in processed meats while the sum of the PUFA decreased. The fatty acid compositions of the meats were in the range of 36-49 % for SFAs, 36-54 % for monounsaturated fatty acids (MUFAs), and 3-26 % for PUFAs (Table 4). The highest proportions observed were palmitic (C16:0, 23-31%), stearic (C18:0, 5.94-15.52 %), palmitoleic (C16:1, 4.09-5.92 %), and oleic acids (C18:1, 14.11-20.13 %). These results corroborate the findings from previous studies on farm animal species (Padre et al., 2006). Boiling and grilling significantly increased the content of C14:0 and C18:0 of the meat, but reduced the C16:0 across all the meat samples, however, not all SFAs have equivalent effects.

Table 3b. Nutritional quality of heat processed cow, goat, and rabbit meat

	RCM	RGM	RRM	BCM	BGM	BRM	GCM	GGM	GRM	Reference -Egg (USDEC, 1999)
TEAA	40.90±0.14^{c}	40.15±0.09^{c}	44.48±0.19^{a}	43.47±0.10^{ab}	40.41±0.13^{c}	44.52±0.21^{a}	42.95±0.13^{b}	40.78±0.22^{c}	44.29±0.16^{a}	57.30
%TEAA	42.41±0.23^{b}	42.40±0.18^{b}	45.30±0.25^{a}	44.86±0.11^{a}	42.46±0.23^{b}	45.28±0.16^{a}	43.73±0.26^{ab}	42.33±0.10^{b}	44.56±0.21^{a}	
TNEAA	55.53±0.16^{a}	54.53±0.31^{ab}	53.71±0.38^{ab}	53.42±0.25^{ab}	54.77±0.35^{ab}	53.81±0.18^{ab}	55.27±0.46^{a}	55.56±0.22^{a}	55.11±0.43^{a}	
%TNEAA	57.58±0.31^{a}	57.59±0.18^{a}	54.70±0.22^{b}	55.13±0.18^{b}	57.54±0.13^{a}	54.72±0.21^{b}	56.27±0.14^{a}	57.67±0.28^{a}	55.44±0.12^{b}	
EAA/NEAA	0.74	0.74	0.83	0.81	0.74	0.83	0.78	0.73	0.80	
AAS	71.4±1.42^{b}	70.1±0.93^{b}	77.6±1.61^{a}	75.9±1.40^{a}	70.5±0.88^{b}	77.7±1.00^{a}	75.0±0.54^{a}	71.2±1.15^{b}	77.3±0.65^{a}	100
P-PER	2.71±0.12^{b}	2.70±0.09^{b}	3.31±0.25^{a}	2.74±0.10^{b}	2.70±0.12^{b}	3.32±0.16^{a}	2.77±0.08^{b}	2.71±0.12^{b}	3.30±0.15^{a}	3.90

Values are mean ± SD of replicate determinations. Values with different letters on the same row are significant ($P \leq 0.05$). RCM: Raw Cow Meat; RGM: Raw Goat Meat; RRM: Raw Rabbit Meat; BCM: Boiled Cow Meat; BGM: Boiled Goat Meat; BRM: Boiled Rabbit Meat; GCM: Grilled Cow Meat GGM: Grilled Goat Meat; GRM: Grilled Rabbit Meat; TEAA: Total Essential Amino Acids; TNEAA: Total Non-Essential Amino Acids; AAS: amino acid score; P-PER: Predicted Protein Efficiency Ratio

Table 4. Effect of heat processing on the fatty acid profile of cow, goat, and rabbit meat

Fatty acid (%)	RCM	RGM	RRM	BCM	BGM	BRM	GCM	GGM	GRM
C10:0	0.01±0.00	0.01±0.00	0.00±0.00	0.02±0.00	0.02±0.00	0.05±	0.02±0.00	0.02±0.00	0.02±0.00
C12:0	0.01±0.00	0.01±0.00	0.01±0.00	0.15±0.00	0.16±0.00	0.22±0.03	0.16±0.02	0.14±0.00	0.11±0.03
C14:0	3.57±0.12	3.39±0.00	3.64±0.02	3.84±0.06	3.77±0.00	3.88±0.09	3.98±0.02	3.44±0.00	4.14±0.09
C16:0	27.97±0.03	26.83±0.13	28.87±0.11	23.35±0.09	24.76±0.09	25.44±0.00	28.44±0.15	28.25±0.00	30.88±0.11
C18:0	5.94±0.00	5.68±0.03	6.18±0.05	13.31±0.00	12.34±0.06	15.52±0.06	11.24±0.00	11.15±0.05	13.57±0.13
C20:0	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.02±0.00	0.03±0.00	0.01±0.00	0.01±0.00	0.01±0.00
C22:0	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.02±0.00	0.03±0.00	0.01±0.00	0.01±0.00	0.01±0.00
C24:0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Σ SFA	**37.52±0.09**	**35.94±0.10**	**38.72±0.15**	**40.69±0.10**	**41.09±0.13**	**45.17±0.16**	**43.86±0.15**	**43.02±0.03**	**48.63±0.20**
C14:1c9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
C16:1c9	4.83±0.00	5.62±0.05	4.51±0.00	5.92±0.10	6.01±0.06	4.22±0.04	4.95±0.00	5.20±0.12	4.09±0.03
C18:1t6	BDL	BDL	BDL	BDL	0.01±0.00	0.01±0.00	BDL	BDL	BDL
C18:1c6	17.45±0.17	18.37±0.12	16.72±0.00	15.86±0.08	15.25±0.08	14.11±0.03	19.49±0.12	20.13±0.07	18.64±0.00
C18:1c9	13.52±0.09	14.30±0.10	13.68±0.00	24.37±0.12	25.24±0.08	21.35±0.15	27.05±0.08	27.82±0.10	24.14±0.00
C18:1t9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
C18:1t11	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.03±0.00	0.01±0.00	0.01±0.00	0.01±0.00
C20:1c11	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00	0.14±0.00	0.11±0.01	0.12±0.00	0.13±0.00
C22:1c13	0.78±0.03	0.66±0.00	0.66±0.00	1.04±0.02	0.66±0.03	0.77±0.03	0.70±0.00	0.60±0.02	0.39±0.03
C24:1c15	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Σ MUFA	**36.69±0.20**	**39.06±0.21**	**35.68±0.00**	**47.30±0.18**	**47.28±0.14**	**40.63±0.20**	**52.31±0.10**	**53.88±0.13**	**47.40±0.03**
C18:2c9,13	19.12±0.10	18.42±0.00	19.01±0.05	9.79±0.00	9.46±0.02	11.34±0.00	2.31±0.00	2.50±0.00	3.04±0.00
C18:2t9,12	BDL	BDL	BDL	0.01±0.00	0.01±0.00	0.01±0.00	BDL	0.01±0.00	0.01±
C20:2c11,14	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
C22:2c13,16	0.12±0.00	0.13±0.00	0.08±0.00	0.17±0.02	0.12±0.00	0.22±0.00	0.12±0.00	0.02±0.00	0.02±0.00
C18:3c6,9,12	2.34±0.05	2.31±0.00	2.40±0.05	0.27±0.03	0.27±0.00	0.35±0.03	0.01±0.00	0.02±0.00	0.02±0.00
C18:3c9,12,15	2.77±0.00	2.79±0.03	2.82±0.09	0.31±0.00	0.31±0.00	0.39±0.00	0.01±0.00	0.01±0.00	0.01±0.00
C20:3c11,14,17	0.01±0.00	0.01±0.00	0.00±0.00	0.01±0.00	0.01±0.00	0.02±0.00	0.01±0.00	0.01±0.00	0.01±0.00
C20:3c8,11,14	0.17±0.00	0.18±0.00	0.17±0.00	0.16±0.00	0.18±0.00	0.23±0.00	0.19±0.00	0.16±0.02	0.10±0.00
C20:4c5,8,11,14	1.00±0.05	0.94±0.03	0.89±0.03	1.02±0.11	1.14±0.02	1.25±0.15	0.25±0.00	0.07±0.00	0.38±0.00
C20:5c5,8,11,14,17	0.24±0.00	0.23±0.00	0.21±0.00	0.22±0.00	0.12±0.00	0.29±0.00	0.89±0.03	0.25±0.00	0.23±0.00
C22:6c4,7,10,13,16,19	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00	0.03±0.00	0.01±0.00	0.01±0.00	0.01±0.00
Σ PUFA	**25.78±0.04**	**25.02±0.02**	**25.59±0.08**	**11.97±0.09**	**11.63±0.00**	**14.13±0.08**	**3.80±0.01**	**2.96±0.00**	**3.83±0.00**
PUFA/SFA	**0.69±0.04**	**0.70±0.04**	**0.66±0.08**	**0.29±0.08**	**0.28±0.06**	**0.31±0.10**	**0.09±0.03**	**0.07±0.00**	**0.08±0.00**
n-3 PUFA	5.29±0.01	5.29±0.01	5.39±0.05	0.75±0.00	0.77±0.00	0.99±0.00	0.22±0.00	0.20±0.00	0.14±0.00

Values are mean ± SD of replicate determinations. SFA: saturated fatty acids; PUFA: polyunsaturated fatty acids; MUFA: monounsaturated fatty acids; BDL: below detection level

Table 5. Consumer acceptability of heat processed cow, goat, and rabbit meat

Samples	Flavour	Tenderness	Juiciness	Aroma	Taste	Appearance	Overall acceptability
BCM	7.60±1.09^{b}	6.85±1.21^{a}	7.40±0.99^{a}	7.35±0.93^{ab}	7.60±0.83^{a}	7.95±0.29^{a}	7.80±0.95^{a}
BGM	7.40±0.94^{ab}	7.60±0.99^{a}	7.45±1.05^{a}	7.40±0.10^{ab}	7.60±1.16^{a}	7.55±0.97^{a}	7.60±0.99^{a}
BRM	7.55±0.89^{ab}	6.95±1.17^{a}	7.40±0.99^{a}	7.30±1.11^{ab}	7.30±1.05^{a}	7.40±0.99^{a}	7.50±1.00^{a}
GCM	8.05±0.94 ^{a}	7.15±0.91 ^{a}	7.50±1.05^{a}	7.85±0.93^{a}	7.95±1.22^{a}	7.35±0.95^{a}	7.90±0.75^{a}
GGM	6.70±2.00^{c}	7.05±1.29 ^{a}	6.50±1.40^{b}	6.70±1.38^{b}	6.50±1.02^{b}	6.30±1.23^{b}	6.65±0.99^{b}
GRM	7.45±1.31^{ab}	7.30±1.27 ^{a}	7.25±1.02^{ab}	7.45±1.00^{a}	7.85±1.05^{b}	7.55±1.05^{a}	7.80±1.00 ^{a}

Values are means ± standard deviation of replicate determinations. Values with different superscript on the same column are significant ($P \leq 0.05$). BCM: Boiled Cow Meat; BGM: Boiled Goat Meat; BRM: Boiled Rabbit Meat; GCM: Grilled Cow Meat GGM: Grilled Goat Meat; GRM: Grilled Rabbit Meat

Predominant meat fatty acids, such as oleic (C18:1cis-9) and stearic (C18:0) acid, appear to be essentially neutral in their effects on cholesterol levels. Rabbit meat had the highest SFA (38.72%) content, while chevon had the highest unsaturated fatty acid (64.08%) content. Lauric (C12:0), myristic (C14:0), and palmitic acids (C16:0) are hypercholesterolemic; whereas the saturated stearic (C18:0) acid does not raise blood cholesterol levels and is considered 'neutral' (Banskalieva et al., 2000). A similar trend of increased content was observed for MUFAs, except for C18:1c6 which reduced in boiled samples and C22:1c13 in grilled meat. The present result is in agreement with the previous report by Zotte and Szendró (2011) which says meat lipids usually contain less than 50% SFA and up to 65% unsaturated fatty acids (MUFA and PUFA). Boiling and grilling caused a reduction (45-54 % and 85-88 % respectively) in PUFAs, with rabbit meat having the lowest reduction level for both heat processing techniques. Oliveira et al. (2015) and Rant et al. (2019) reported a 52% and 55% reduction in PUFA contents of roasted beef and microwaved lamb, respectively. The decrease in PUFA contents may not be unconnected to the presence of double bonds, which is more susceptible to oxygen attack, hence, the increased susceptibility to oxidative degradation compared to other fatty acids.

Variations in the fatty acid composition of raw and cooked meats have already been reported by Echarte et al. (2003), who observed significant differences in the fatty acid profile of both chicken and beef patties. Several mechanisms, such as water loss and lipid oxidation, diffusion, and exchange, often associated with cooking may result in relative changes in some fatty acids (Dal Bosco et al., 2001). The percentages of individual trans-fatty acids (TFA) were insignificant for the cooking treatments. A significant increase was observed in the relative proportion of the SFA, as well as the MUFA, with the grilled meats having higher values than their boiled counterparts. Chevon had the lowest SFA content, while rabbit meat had the lowest MUFA content across the treatments. In general, grilling resulted in higher contents of FA and a significant reduction of the PUFA in all the meat samples, which likely resulted from the higher moisture loss. The n-3 PUFA is an essential fatty acid because it cannot be synthesized by the body and it is important for metabolic integrity. The mean content of the health promoting n-3 PUFA in heat processed meats was 0.75 - 0.99 g/100 g and 0.14 - 0.22 g/100 g of muscle for boiled and grilled portions, respectively. The values obtained for the boiled meat cuts exceeded the adequate intake (250 mg/day) sufficient for the primary prevention of cardiovascular disease in healthy subjects as recommended by EFSA (2010). The PUFA/SFA ratio in human diets should be above 0.45. In the present study, cooked samples (boiled and grilled) showed significantly lower PUFA/SFA ratios, with values close to the lower recommended limit. The PUFA/SFA ratio for boiled meats was higher than the values (0.10, 0.12) reported for either microwaved or roasted lamb meat.

Sensory attributes of meat as influenced by heat processing

The effect of two heat processing techniques (boiling and grilling) on consumer preference for the different animal species was evaluated and presented in Table 5. It can be deduced from the result of sensory evaluation that boiled and grilled rabbit meat compared favourably with conventional beef in terms of all parameters measured (tenderness, juiciness, aroma, taste, and appearance), as there was no significant difference between the two meat samples, while grilled goat meat presented significant differences in all parameters evaluated, including overall acceptability. Goat meat, like the meat from other wild animals, is characterized by a strong gamy aroma, an attribute weak or absent in other animals including chicken, rabbit, turkey, and lamb (Rodbotton et al., 2004), moreover, the taste of meat from these animals is almost indistinguishable. Boiling is suitable for the preservation of many flavouring (heterocyclic) compounds such as pyrazines, thiazoles, and oxazoles (Mottram and Whitfield, 1994). The moist heat employed in boiling solubilizes meat collagen and produces natural meat flavours; in addition, the leaching of meat flavour compounds into cooking medium occurs in this way, creating a delicately flavoured meat. Grilling on the other hand is a dry-heat cooking technique carried out at high temperatures, the processing is accompanied by the loss of flavour compounds.

Conclusion

Rabbit and goat meat showed better nutritional composition, with cooking contributing positively to meat properties. Boiling and grilling retained and or improved the nutritional properties of meat, hence, they may be adopted as major meat processing techniques. Moreover, chevon showed better quality attributes in terms of protein digestibility, lower cooking loss, and superior polyunsaturated fatty acid content. Boiling improved the amino acid and fatty acid profile, as well as protein digestibility. However, grilling is an appropriate heat processing technique for beef, on the other hand, boiling is appropriate for chevon, as the nutritional composition of meat was retained and improved for the individual cooking methods overall.

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