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Effect of Cooking Methods and Temperature on Proximate and Amino Acid Composition of Breakfast Sausage

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Authors' contributions

This work was carried out in collaboration among all authors. Author DOO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OOO and OAO managed the analyses of the study and read through the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The effect of cooking method and temperature on amino acid composition of breakfast sausage (BS) was undertaken in this study.
Methodology: Three batches of prepared BS from beef, were randomly allotted to three cooking methods (CM): (boiling, grilling and frying) each at cooking temperatures (CT) of 80, 90 and 100°C to attain internal temperature of 72°C in a completely randomized design. Samples from each treatment were oven-dried and assayed for amino acid and proximate composition using standard procedures. Data obtained was analysed using descriptive statistic and ANOVA at $\alpha_{0.05.}$
Results: Results showed that grilled sausage at 80°C had highest total amino acid profile (3.2%). Grilled sausage at 80°C had highest crude protein (25.58%). Grilled BS at 80°C recorded least fat content (15.99%). Grilled sausage at 80°C had the higher ash (6.66%) and least (1.40%) in boiled sausage at 90°C.
Conclusion: Therefore, breakfast sausage could be best grilled at 80°C due to maintain high amino acid profile, crude protein, ash and lower fat content.

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Keywords: Cooking methods; amino acid; breakfast sausage; cooking temperatures.

1. INTRODUCTION

Meat can be consumed fresh, cured, dried or otherwise processed. About one third of all meat is processed, which means it has been changed from its original fresh cut [1]. Ham and sausage are the most popular processed meat products [1]. Sausages are made from chopped or comminuted lean meat and fat mixed with salt, spices and other ingredients, and then filled into a casing made of animal intestine or cellulose. Sausages can be classified based on country of origin or types of spices added [2]. An example of this is breakfast sausage, categorised under fresh sausage type.

Meat and its products become more edible and digestible when subjected to cooking [3]. During cooking, meat undergoes both physical and chemical changes, such as a decrease in the nutritional value, which are strongly dependent on protein denaturation and water loss Mora et al. [4] and Tornberg [5]. Heating time, temperature, cooking method and muscle composition are all important variables, which may influence the final desirable characteristics of the meat Alfaia et al. [6] and Christensen et al. [7]. It is well known that an increase in core temperature in meat will promote collagen shrinkage, reduce water holding capacity and increase cooking loss that influences its final quality and acceptability [8]. Although meat changes induced by cooking have been studied for many years and extensively discussed Offer [9] and Tornberg [5], only few reports have specifically dealt with the influence of different cooking conditions on the amino acid and mineral contents [10]. Therefore, the effect of three cooking methods (frying, boiling and grilling) and three cooking temperatures (80, 90 and 100°C) on proximate and amino acid profile of breakfast sausage was evaluated in this study.

2. MATERIALS AND METHODS

2.1 Experiment Site

The experiment was carried out at the Animal Product and Processing (Meat Science) Laboratory, Department of Animal Science, University of Ibadan, Ibadan.

2.2 Meat Source and Sausage Preparation

Semi-membranous muscle from mature bull was purchased from the University abattoir, immediately after slaughter. The large intestine of pig was also collected from the Pig slaughter slab at the Piggery Unit of the University Teaching and Research Farm while lard was purchased from Bodija market (Pig Unit) abattoir. The meat was cleaned; connective tissues and fat were properly trimmed out and was kept in the refrigerator 4 ±1°C overnight prior to sausage preparation. Meat and fat were run separately through an automated meat mincer, the meat through 6 mm plate and the fat through 4 mm plate. Then the rest of the meat and the other ingredients were thoroughly mixed and reground through a 4 mm plate.

Salt, sodium nitrite, phosphate and sugar were dissolved in iced water, added to facilitate the mixing. The blended lard, soybean used as binder and dry spice (Table 2) were mixed. The green spices onion, ginger and garlic in ratio of 3:1:1 (Table 3) were finely chopped and ground for the preparation of green spice mixture. Green spice and dry spice mixture were poured simultaneously into the mixing bowl. All meat and non-meat ingredients were mixed together and ground again to desired consistency.

Table 1. Sausage composition

Ingredient	Composition %
Beef	65.00
Lard	20.00
Binder	3.50
Curing salt *	2.00
Sugar	1.00
Phosphate	0.30
Ice water	4.00
Dry spices **	2.00
Green spices ***	2.20
Total	100.00

** Sodium chloride and Sodium nitrite(99% and 1% respectively); ** Table 2; *** Table 3*

The prepared sausage was stuffed into presoaked natural casing (pig intestine) that was presoaked in brine using an automated stuffer. The stuffed casings were divided into links (units) by twisting; each sausage link was 10 cm in length. The finished sausages were then packaged in Ziploc bags and frozen at -4°C.

2.3 Cooking Methods

Sausages were subjected to three cooking methods which were grilling using gas grilling machine, frying (using oil)and boiling using

water bath at three cooking temperature; 80, 90, and 100°C until internal temperature of 72°C was reached.

Table 2. Composition of dry spices for breakfast sausage

Spice	Inclusion level %
Black pepper	20.00
Nutmeg	7.00
Calabash nutmeg	3.00
Red pepper	20.00
Monosodium glutamate	15.00
Thyme	20.00
Curry powder	10.00
Total	100.00

Table 3. Composition of green spices for breakfast sausage

Spices	Inclusion level %
Onion (*Allium cepa*)	60
Ginger (*Zingiberofficinale)*	20
Garlic (*Allium sativum*)	20
Total	100

2.4 Amino Acid Composition

Essential amino acids were determined by the spectrophotometric method using Ninhydrin chemical reaction according to Moore and Stein [11].

2.5 Determination of Proximate Composition

Proximate composition was done according to the procedure of [12].

2.6 Experimental Design

3 X 3 factorial arrangement in complete randomized design.

2.7 Statistical Analysis

Data were subjected to analysis of variance using [13]. Means were separated using Duncan's Multiple Range Test option of the same software.

3. RESULTS AND DISCUSSION

3.1 Essential Amino Acid Score of Breakfast Sausage

Presented in Figs. 1 to 12 was the essential amino acid profile of breakfast sausage cooked at different temperatures. From the result, it was observed that grilled sausage at 80°C had the highest total amino acid profile (3.2%), followed by fried sausage at 80°C (2.8%) while boiled sausage at 80°C had the lowest value (2.5%).

Grilled sausage had highest amino acid profile among the three different cooking methods (Fig. 2), followed by frying while boiling had the lowest rating. This could be due to higher water content found in boiled sausage. Water molecules are highly polar and attracted to the muscle proteins by ionisable basic and acidic groups such as arginine, histidine, lysine, glutamic acid. The meat protein was denatured by heat and a part of its ionized basic or acid groups were broken. The possible reason for this might be that the high temperature caused rapid denaturation of meat protein when compared with low temperature, resulting in loss of more water molecules [14]. Although, the boiling of meat at 90 and 100°C showed increased amino acid contents when compared with that of 80°C. Boiling resulted in denaturation of proteins in meat and the denatured meat proteins could be easily hydrolyzed. When dissolved in hydrochloric acid for determination of amino acids, the meat boiled for longer time with high content of denatured proteins easily hydrolyzed resulting in high amino acid contents than when boiled for shorter time. This perhaps accounted for the increased amino acid contents with increase in boiling time. However, prolonged boiling at 100°C resulted in more protein loss in meat and therefore the amino acid contents in meat boiled for 100°C were less than that of meat boiled for 90°C. This observation agreed with that of [15] that an endothermic transition at a temperature range of 59.6 to 68.4°C for collagen in chicken breast patties resulted in an increase of soluble protein. The soluble protein dissolved in water causing decrease in protein content of chicken breast patties.

The amino acid score of breakfast sausage decreased with increased grilling and frying temperature. The possible reason is that grilling and frying led to formation of heterocyclic aromatic amines [16] and a hard and dry surface on the meat [17], which made the meat proteins difficult to hydrolyze during amino acid analysis [18] and caused the meats fried for longer duration to have a low amino acid content.

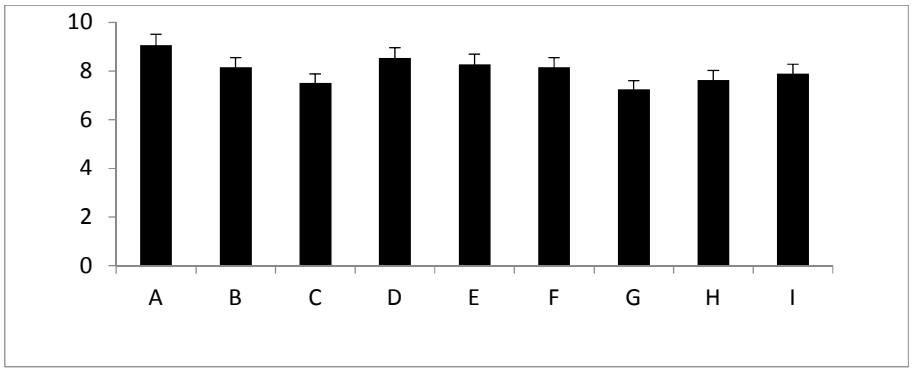

Fig. 1. Phenylalanine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

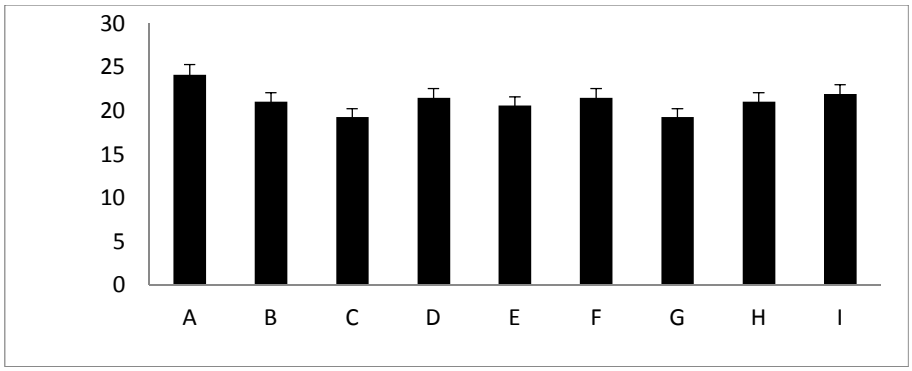

Fig. 2. Isoleucine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

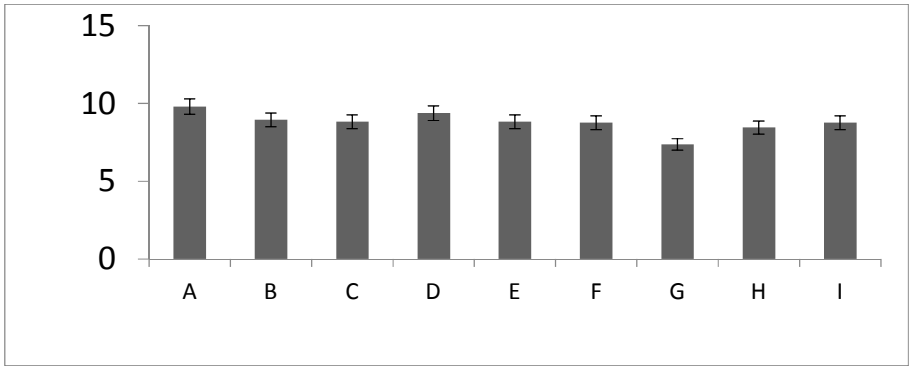

Fig. 3. Lysine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

3.2 Proximate Composition of Breakfast Sausage Cooked at Different Temperature

The summary presented in Table 4 gives the proximate composition of breakfast sausage cooked at different temperature. The moisture content ranged from 49.16% to 55.38%. Grilled sausage at 80^0C had the highest crude protein (25.58%) followed by fried sausage (21.36%) with least crude protein in boiling (10.59%). The fat content of proximate composition of breakfast

sausage cooked at different temperature revealed significant differences in fat content but was not following a consistent pattern. The least fat content was recorded for sausage grilled at 80°C (15.99%).The ash content were statistically ($p<0.05$) different. Grilled sausage at 80°C had the highest ash content (6.66%) with least ash content in boiled sausage at 90°C (1.40%).

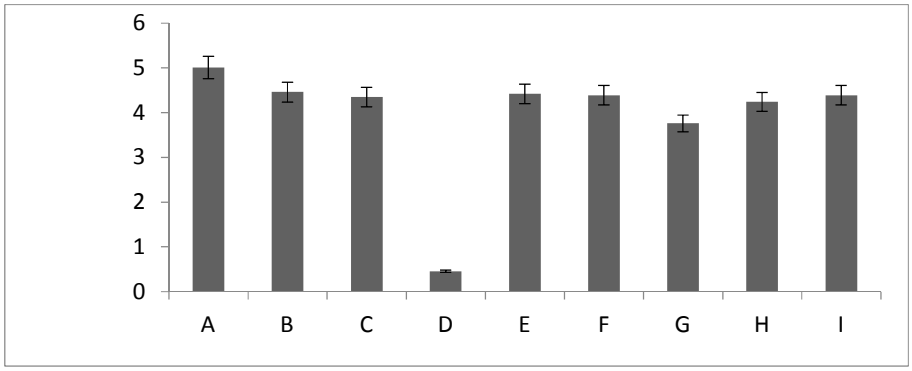

Fig. 4. Histidine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

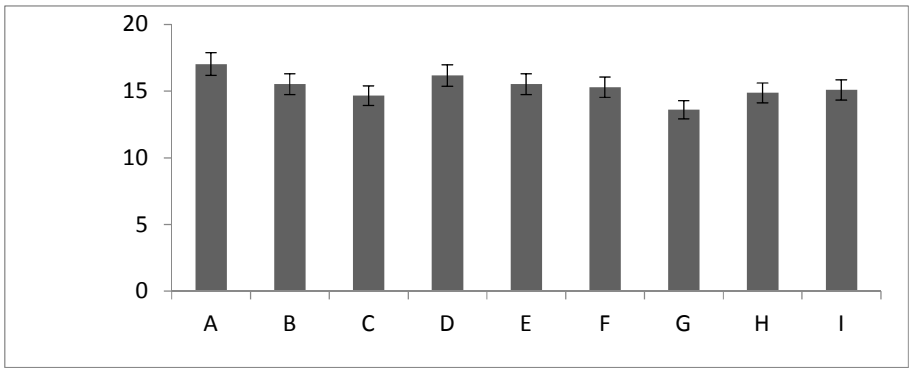

Fig. 5. Methionine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

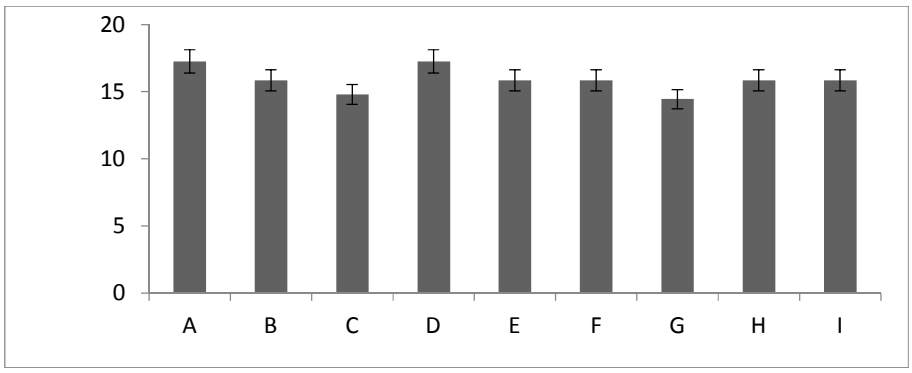

Fig. 6. Leucine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

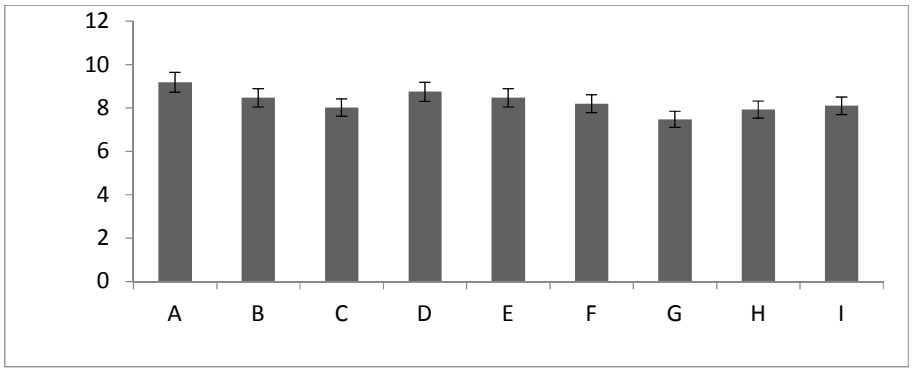

Fig. 7. Valine in percentage
A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

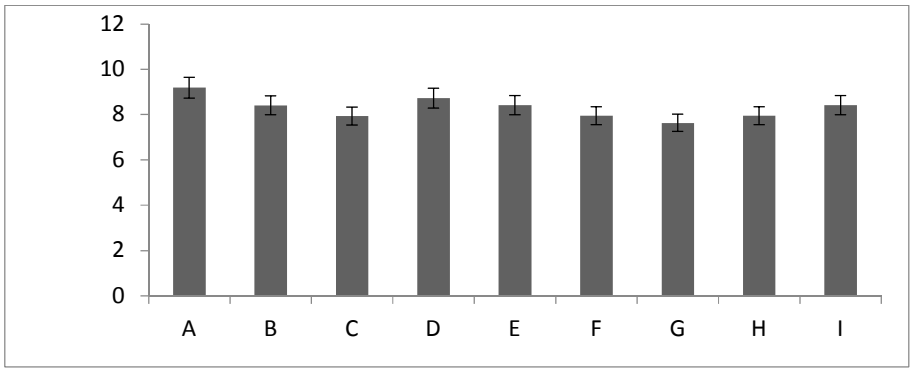

Fig. 8. Tryptophan in percentage
A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

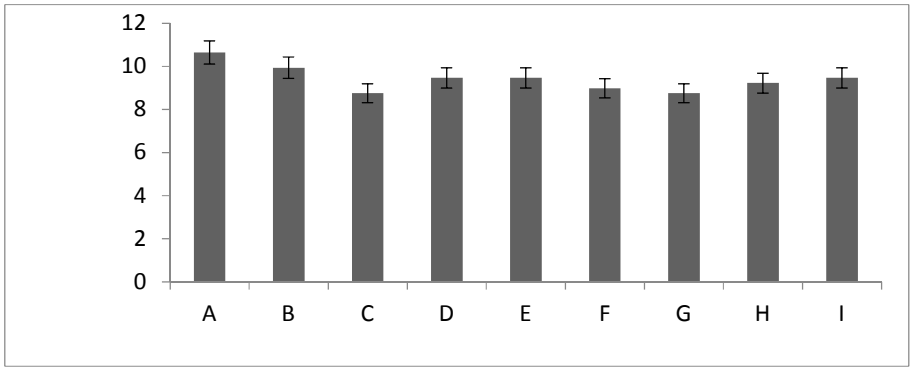

Fig. 9. Alanine in percentage
A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

3.2.1 Moisture content

The moisture content of breakfast sausage at 80 and 90°C across the cooking methods was significantly higher at 54.76 and 53.33%, respectively while grilled sausage recorded highest moisture content at 100°C as shown in Table 4. This revealed that boiling had less influence on moisture content of breakfast sausage cooked at difference

temperature compared to grilling and frying that resulted in severe moisture loss depending on the temperature and cooking time.

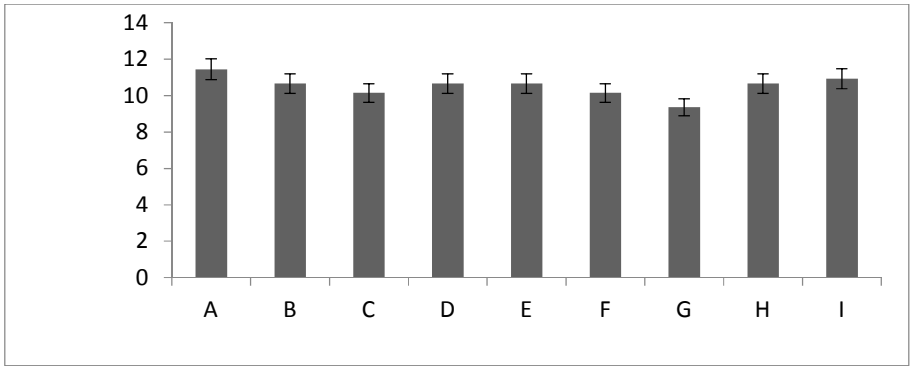

Fig. 10. Threonine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

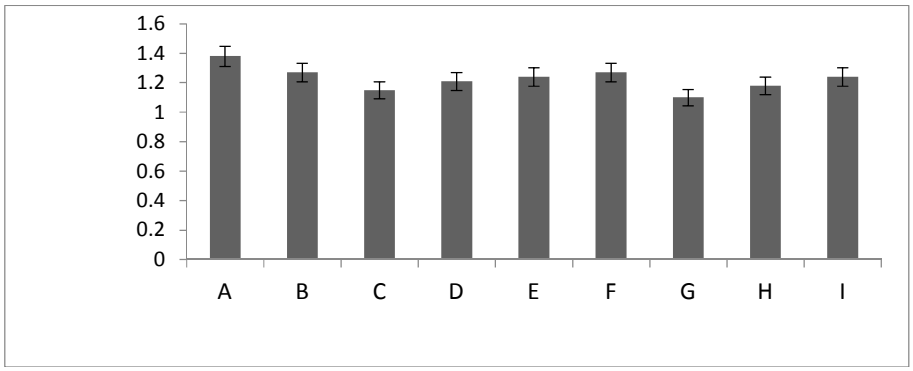

Fig. 11. Cycteine in percentage

A= Grilling 80°C, Grilling B= 90°C, C= Grilling 100°C, D= Frying 80°C, E= Frying 90°C, F= Frying 100°C, G= Boiling 80°C, H= Boiling 90°C, I= Boiling 100°C

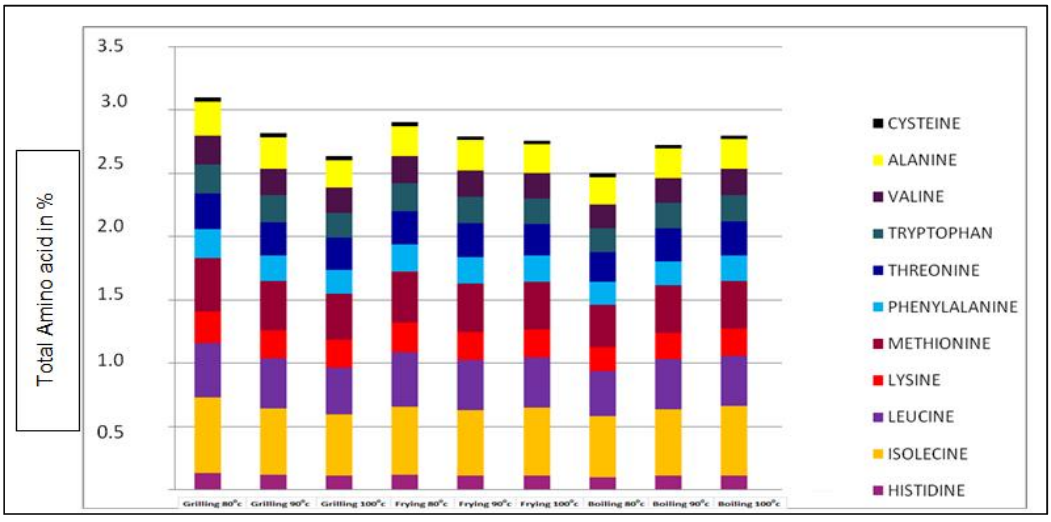

Fig. 12. Essential amino acid score of breakfast sausage cooked at different temperature

Table 4. Proximate composition of breakfast sausage cooked at different temperature

Parameters (%)	Temperature (°C)	Grilling	Frying	Boiling	SEM
Moisture content	80	50.58^{cz}	52.19^{by}	54.76^{ax}	0.51
	90	51.75^{by}	49.16^{cz}	53.33^{cx}	0.61
	100	55.38^{ax}	52.81^{az}	54.50^{by}	0.38
	SEM	0.62	0.56	0.22	
Crude protein	80	25.58^{ax}	21.36^{ay}	10.59^{cz}	2.75
	90	20.27^{bx}	18.59^{by}	12.29^{bz}	1.21
	100	16.86^{cy}	18.32^{bx}	13.78^{az}	0.66
	SEM	1.91	0.48	0.46	
Ether extract	80	15.99^{cz}	17.50^{cy}	26.24^{ax}	1.31
	90	27.99^{ax}	24.91^{az}	26.14^{by}	0.45
	100	20.53^{bz}	22.65^{by}	24.57^{cx}	0.58
	SEM	1.29	1.11	0.27	
Ash	80	6.66^{ax}	4.73^{bz}	5.66^{ay}	0.31
	90	4.82^{bx}	1.53^{cy}	1.40^{cz}	0.58
	100	4.46^{by}	5.66^{ax}	2.73^{bz}	0.64
	SEM	0.34	0.63	0.58	

$^{xyz...}$Means on the same column with different superscripts are significantly different (p<0.05); $^{abc...}$ Means on the same row with different superscripts are significantly different (p<0.05); SEM: standard error mean

3.2.2 Crude protein

Crude protein of breakfast sausage cooked at different temperature revealed that, sausage grilled at 80°C had the highest value (25.58%) as shown in Table 4, followed by frying (21.36%) with least value observed for boiling (10.59%). The crude protein values revealed that as the cooking temperature increased, there was decreased crude protein in grilled and fried breakfast sausage while the reverse was the case for boiling. This could be as a result of protein denaturation ability of high temperature, time and the amount of water loss during cooking.

3.2.3 Ether extract and ash content

The fat content of breakfast sausage cooked at different temperature revealed significant differences but did not follow a consistent pattern. The least fat content (15.99%) was recorded for grilled sausage at 80°C while ash content was ($p<0.05$) different as shown in Table 4, which followed the same pattern with crude protein. Grilling at 80°C had the highest value for ash which could be as a result of water loss, impact of temperature and cooking time. Since microwave cooking and grilling proceed in the absence of water (dry cooking methods), these cooking methods allowed for a high retention of ash than boiling (wet cooking method). Dal et al. [19] also found a decreased in ash content of rabbit meat after boiling and roasting. Similar ash values for cooked meat (1.3 to 1.9 g/100 g) were reported by Farfán and Sammán [20].

4. CONCLUSION

Breakfast sausage grilled at 80^0C had the highest essential amino acid scores, crude protein and ash.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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