Nig. J. Anim. Prod. 2018, 45(4):210 - 221 Nigerian Journal of Animal Production

Quality attributes and safety of processed meat products in Ibadan, Nigeria

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Abstract

Consumption of processed meat products has greatly increased due to availability and accessibility of ready to eat meat products. Despite increased patronage of ready to eat meat products, food safety implication of processed ready-to-eat-meat products is of global concern. Against this background, this study was aimed at assessing the quality and safety of processed ready to eat meat products sold in Ibadan. Samples of asun, suya and kundi were randomly collected from four selected markets in Ibadan metropolis and subjected to chemical analyses. The total cholesterol content in suya (1538.00 mg/100mg) was significantly higher (P<0.05) than in asun (1277.60 mg/100mg) and kundi (1277.60 mg/100mg). Kundi had significantly (P<0.005) higher crude protein (70.66 %) and ether extract (23.42 %) than asun with 20.17 % and 10.85 % ether extract, respectively. Lipid peroxidation of suya (6.18 mg/MDA/kg) at day 28 was significantly higher (P<0.05) than kundi (4.50 mg/MDA/kg) and asun (4.19 mg/MDA/kg). The total polycyclic aromatic hydrocarbon (TPAH) was 5.31µg/kg in suya, 2.02µg/kg in asun and 1.55µg/kg in kundi. The total heterocyclic aromatic amine (THAA) was 51.66 ng/g in suya, 28.12 ng/g in asun and 23.70 ng/g in kundi. The total heterotrophic bacteria count in suya (28.17 $\times 10^{-3}$ cfu/g) was higher than in kundi (11.19 $\times 10^{-3}$ cfu/g) and asun (3.99$\times 10^{-3}$ cfu/g). Therefore, safe keeping and quality of suya in Ibadan metropolis was low based on the above parameters measured.

Keywords: *Asun, Suya, Kundi*, meat quality and safety.

Introduction

Effort to preserve and make meat more desirable for consumption has heightened the demand for meat processing. Consumption of processed meat products has greatly increased due to availability and accessibility of ready to eat meat products. Despite increased patronage of ready to eat meat products, food safety implication of processed ready-to-eat-meat products is of global concern (Sofos, 2008). Meat processing is essentially needed for the formation of desirable meat flavours and also to kill harmful organisms. The doneness of processed meat products varies from very rare to well done (Oz *et al*., 2007). The doneness of meat is equivalent to the internal temperature, which is assessed with a meat thermometer. There are so many ready to eat meat products in Nigeria such as suya, asun, fried meat, barbecue, kilishi, balangu, danbunama and kebab (Jegede, 2018).

Consumption of processed meat products have been associated with cardiovascular diseases and cancers (Christine, 2003) which could be linked with the type of fat, oxidative stability of the meat product and cholesterol. According to Addis (1986), the saturated fatty acids have been established as the most important of the dietary risk factors in coronary heart disease. Epidemiological studies have found that an increased consumption of processed meat is associated with an increased risk of colorectal cancer due to certain cooking conditions such as precursors like fat, creatinine and temperature (Cross and Sinha, 2004; Haggar *et al*., 2009; WHO, 2015). Fat oxidation, mostly at frying temperatures, could lead to compounds that break down to short chain carboxylic acids, aldehydes, alcohols and esters, with unlikeable flavours (Sinha *et al*., 2005). It was noted that the heart illness danger when saturated fatty acids are consumed could be ameliorated when replaced by polyunsaturated fatty acids and monounsaturated fatty acids (USDHHS, 2005). Production of these products was done with hurry due to the purchasing edginess of the consumers even as the residual was put aside, uncovered as well as cool expecting consumer (Ologhobo *et al*., 2010). Consequently, not well done *suya* was produced and placed in an unhygienic state for consumption (Edema *et al*., 2008).

Harmful microbes have been incriminated in processed meat products (Abdullahi *et al*., 2004; Edema *et al*., 2008; Fakolade and Omojola, 2008; Ogbonna *et al.,* 2012) Igene and Mohammed (1983) showed mean full dish counts with coliform levels 6.24×10^7 - 1.4×10^9 as well as 8.5×10^2 - 2.0×10^3/g, correspondingly inside *suya* product. Also, full dish count with coliform level 6.5×10^6 - 8.0×10^6 and 3.0×10^6 - 3.62×10^6 cfu/mL were found inside roasted meat (Idio, 1995). Ologhobo *et al.* (2010) surmised that beef *suya* with chicken having microbial count were at stages which could cause health risk to customers. The total viable bacterial and fungal counts found in suya at Markudi and Bauchi metropolis were 3.7×10^5- 24×10^6 cfu/g 2.88-9.49×10^3 cfu/g, respectively (Inyang *et al*., 2005; Abubakar *et al*., 2011)

There is no adequate documentation on the safety and the keeping quality of ready-to-eat-meat products in Ibadan. Thus, there is need to assess the safety and keeping quality of ready-to-eat-meat products in Ibadan.

Materials and methods

Suya, Asun and *Kundi* were procured from four randomly selected markets in Ibadan metropolis. Each of the products collected represented a treatment and each treatment was replicated six times in a completely randomised design. The laboratory analyses were carried out at Animal Products and Processing Laboratory, Department of Animal Science, University of Ibadan, Ibadan, Nigeria located in the derived savanna vegetation belt of Southwest. The total cholesterol quantification in *asun, suya* and *kundi* was carried out as described by Weyant *et al*. (1976). The meat samples were assayed for proximate composition according to AOAC (1990). The fatty acids composition of the meat products was determined (Lowry and Tinsley, 1976). The lipid oxidation of selected meat samples was determined using thiobarbituric acid reactive substances quantified as malonaldehyde at days 1, 7, 14, 21 and 28 of storage using Witte *et al*. (1970) method. The microbial analysis was undertaken in triplicates following the techniques illustrated by ICMSF (1986) and AOAC (2000) while PAH and HAA were quantified using gas chromatography mass spectrophotometry (GCMS) according to Duedahl-Olesen *et al*. (2010).

Statistical analysis

Data were subjected to analysis of variance (SAS, 2002), while means were separated by Duncan multiple range test option of the same software at α0.05.

Results and discussion

The cholesterol composition of meat products in Ibadan metropolis is shown in Table 1. There were significant differences in the cholesterol content of meat products collected at different locations in Ibadan.

Suya (1538.00 mg/100 g) had the highest total cholesterol compared with *asun* (1277.60 mg/100 g) and *kundi* (268.57 mg/100 g). The total cholesterol of the three products sampled was above the recommended level of 240 mg/100g by American Heart Association (2011). The high total cholesterol content could be associated with the fatty ingredients used in the processing. Dietary cholesterol has inverse implications on internal cholesterol production while high saturated fatty acid ingestion reduces low density lipoprotein receiver- reconciled break down mechanism. However, the type of fatty acid, rather than the amount of dietary cholesterol is a powerful regulator for blood cholesterol concentration (Schaefer, 2016).

Table 1: Total Cholesterol i n Meat Products in Ibadan

Products	Cholesterol (mg/100mg) (n = 24)
Suya	1538.00[a]
Asun	1277.60[b]
Kundi	1277.60[b]
SEM	66.03

[a,b,c] Means with different superscripts along the same column are significantly different (P<0.05);
SEM= Standard of error mean

The proximate composition of the three meat products collected in Ibadan metropolis is shown in Table 2. The crude protein of *kundi* (70.66 %) was significantly higher (P<0.05) than *suya* (23.28 %) and *asun* (20.17 %). The crude protein of 70.66 % in *kundi* obtained in this study was similar to 66.79 % in *kundi* reported by Fakolade (2008). The concentration of the nutrient as a result of low moisture could be responsible for the increased protein which was analogous to the observation of Egbunike and Okubanjo (1999) that intermediate moisture meats have three to four times the raw protein equivalent and low moisture content. The crude protein (CP) of *suya* 23.28 % was lower than 33.44 % reported by Oyadeyi *et al.* (2014). This low value of CP could be due to the quantity of groundnut powder used. The 39.61 % CP reported by Apata *et al*. (2013) was higher than the CP obtained in this study, which may likely be due to the amount of coated groundnut powder used.

Kundi had the highest EE (23.42 %) and this value was higher than 5.43 % and 9.76 - 12.27 % reported by Fakolade (2008) and Adeyeye (2016), but similar to 20.06 % Fabianne *et al*. (2001) for cooked charqui meat flour. The ether extract of *suya* (15.15 %) obtained in this study was within the range 12.1-13.0 % (Abubakar *et al*., 2011) but higher than 8.50 % reported by Oyadeyi *et al.* (2014). This high level of ether extract could be linked to the quantity of oil existing inside defatted groundnut powder or as a result of the quantity of oil sprinkled over the *suya* while reheating.

The ash content in *suya* (3.27 %) was higher than in *asun* (2.82 %) and *kundi* (2.57 %). Apata *et al.* (2013) and Oyadeyi *et al.* (2014) reported that ash content of *suya* were 6.60 % and 5.76 %, respectively. Which were higher than the values obtained in this study. The ash content of *kundi* (2.57 %) was within the range of 1.86-4.82 % (Fakolade, 2008) and 0.98-1.76 % (Adeyeye, 2016). The high content of ash in kundi could be attributed to accumulated dirt on meat samples during drying in the various market floors as ealier remarked (Fakolade and Omojola, 2008; Adebayo-tayo *et al*., 2015). This indicates that the mineral content of suya sampled could be high. The product with highest moisture content (MC) was *asun* which contained 61.59 % MC. This was followed by *suya* which had 51.28 % MC. There seemed to be an inverse relationship between fat and moisture of the products which corroborates the report of Hedrick *et al.* (1994). Oyadeyi *et al.* (2014) also recorded higher moisture level of 46.68 % compared with 34.20 % by Apata *et al.* (2013). However, *kundi* contained 4.97 % which was the least MC in the products and this conformed to similar level of 4.7 % reported by Fabianne *et al.* (2001) for cooked charqui meat flour.

Table 2: Proximate composition of meat products in Ibadan

	Parameters (%) (n = 24)			
Products	Crude Protein	Ether Extract	Ash	Moisture
Suya	23.28^{c}	15.15^{b}	3.27^{a}	51.28^{b}
Asun	20.17^{b}	10.85^{c}	2.82^{b}	61.59^{a}
Kundi	70.66^{a}	23.42^{a}	2.57^{c}	4.97^{c}
SEM	2.78	0.63	0.06	2.93

^{a,b,c} Means with similar superscripts along the same column are not significantly different (P>0.05)
SEM= Standard of error mean

Figure 1 shows essential fatty acids of selected meat products in Ibadan metropolis. *Asun* (32.75 mg/100g) was highest in arachidonic acid followed by *kundi* (22.65 mg/100g) *and suya* (17.9 mg/100g). Arachidonic acid levels were within the range of 16.10-30.30 % reported by Hiza and Bente (2007). *Asun* appeared to contain higher amount of unsaturated fatty acids which could increase the marbling of the product. The low levels of these fatty acids in *suya* could be due to loss of fat during processing on direct heat. Linoleic acids composition had similar trend as arachidonic acid as it varied significantly (P<0.05) across three products. Linoleic acid of 29.50 mg/100g in *asun* was within 25-35 % recommended by American Heart Association (2007). Similarly, Oleic acid was significantly higher (P<0.05) in *asun* (29.65 mg/100g) than in *kundi* (20.55 mg/100g) and *suya* (16.25 mg/100g).

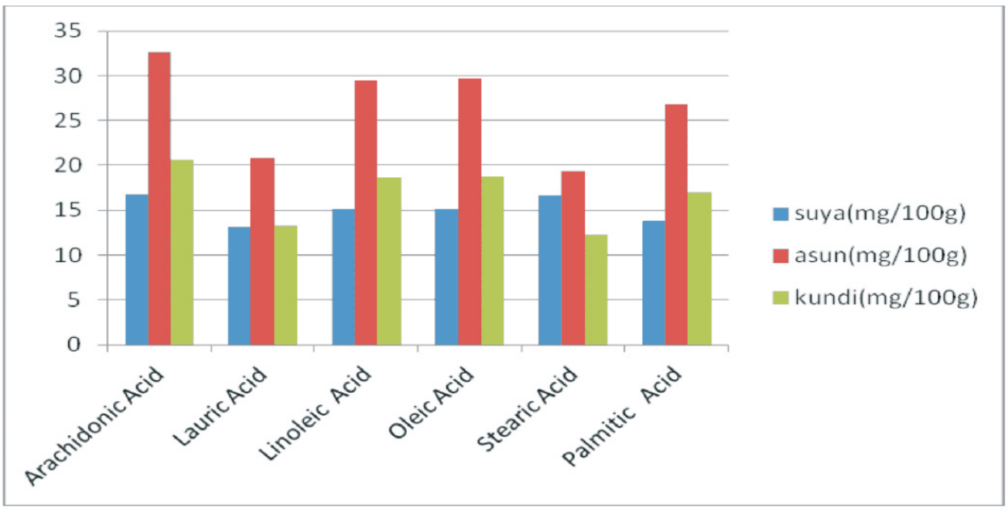

Figure 1: Essential fatty acid of meat products collected in Ibadan

It was observed that the total unsaturated fatty acid for a particular product was higher than that of saturated fatty acid and this agreed with the report USDA (2007) that less than half of all fatty acids in meat were saturated i.e. beef contained more of mono-unsaturated fatty acids than saturated and a small amount of poly-unsaturated fatty acids. *Asun* had significantly higher lauric acid level of 20.70 mg/100g compared with *kundi* which had 14.45 mg/100g and 13.95 mg/100g in *suya*. *Asun* contained the highest levels of stearic acid which ranged from 19.35 mg/100g, followed by *suya* (15.75 mg/100g) and *kundi* (13.4 mg/100g). Palmitic acid in *asun* (26.85 mg/100g) was significantly higher than in *kundi* (18.5 mg/100g) and *suya* (14.7 mg/100g). *Kundi* contained the highest fatty acids and this could be attributed to the oil used in cleaning the mould from *kundi*. Sheard *et al.* (1998) stated that high fat products tend to lose large amounts of fat during cooking whilst low fat in meat products lose relatively little fat.

Figure 2 shows the lipid peroxidation of meat products collected in Ibadan metropolis. There were significant variations in the lipid peroxidation across the products in weeks of storage. The rate of lipid peroxidation increased with days. *Suya* at 28 day (6.17mg/MDA/kg) had the highest value of malonaldehyde followed by *kundi* (4.50 mg/MDA/kg) and the least in *Asun* (4.19 mg/MDA/kg). The higher proxidation in *suya* could be attributed to the residual oil in the groundnut powder as well as the oil sprinkled on it during warming (reheating). The increased lipid peroxidation in *kundi* could be adduced to the usual cleansing with oil to make it attractive to the consumers.

Ogunsola and Omojola (2008) reported that the peroxidation of a shredded meat (*danbunama*) ranged from 0.38-0.81 between 6-9 weeks of storage. The malonaldehyde content of *Asun* was lower because the meat used was not that fatty. Apata *et al.* (2013) reported a range of 0.5-0.78 meq/kg/fat lipid oxidation in *suya* collected at four different zones within Ogun state which was lower than the 6.17mg/MDA/kg obtained in this study.

Malik and Sharma (2011) surmised that lipid peroxidation levels of a buffalo meat chunks were 0.36-1.93 mg/MDA/kg.

De Souza *et al* (2013) reported lipid peroxidation value found in charqui and jerked beef as 0.057 to 0.25 mg/MDA/kg and 0.023 to 0.05 mg/MDA/kg for *charqui* and jerked beef, respectively. There is an indication based on previous works and this study that as the days of storage increased the level of malonaldehyde in meat product also increased.

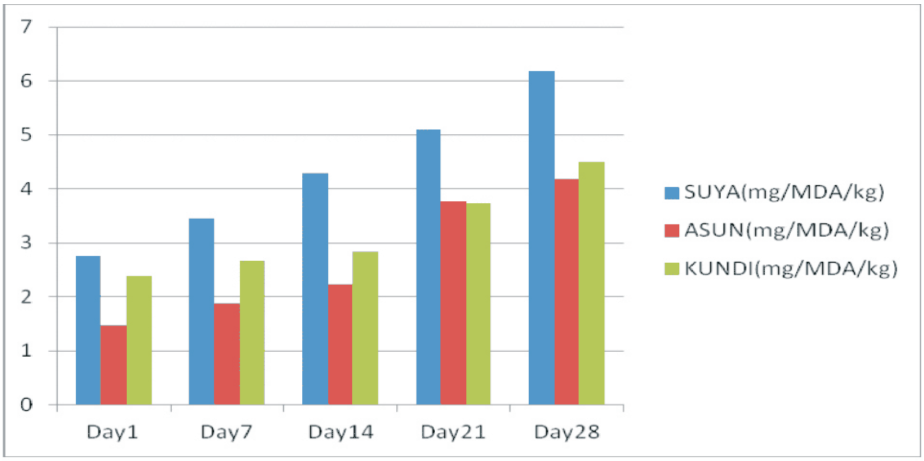

Figure 2: Lipid oxidation of meat products in Ibadan

The microbial load in the three meat products sampled in Ibadan metropolis is shown in Table 3. The total heterotrophic bacteria count in *suya* (28.17 $\times10^{-3}$cfu/g) was significantly higher (P<0.05) than in the other products. The total count was higher than 1.86 log/cfu/g reported by Apata *et al.* (2013) but lower than $2\times10^{6}/10^{5}$ cfu/g and 9×10^{5} cfu/g earlier documented (Ologhobo *et al.*, 2010; Afolabi and Okubanjo, 2015). Inyang *et al.* (2005) reported heterotrophic bacteria count of 3.7 x 10^{5} -2.4 x 10^{6} cfu/g for suya sampled in Markudi.

The increased microbial population in *suya* was an indication of excessive human handling of the product (Clarence *et al.*, 2009) and this also underscored the essence of proper sanitary conditions for the production of ready to eat meat products. *Kundi* (11.19 $\times10^{-3}$cfu/g) was next to *suya* followed by *asun* (3.99 $\times10^{-3}$cfu/g) in the content of total heterotrophic bacteria count. *Eshericia coli* were only found in *asun* (0.25 $\times10^{-3}$cfu/g). This result conformed to the findings of Ologhobo *et al.* (2010) that E.coli was not found in processed beef and chicken. The *staphylococcus* in *kundi* (2.89 $\times10^{-3}$cfu/g) and *suya* (2.19 $\times10^{-3}$cfu/g) in this study were significantly higher (P<0.05) than *asun* (0.85 $\times10^{-3}$cfu/g). This contradicts the assertion of Ologhobo *et al.* (2010) that *staphylococcus* was not found in *suya*. The level of Staphylococcus in *suya* was attributed to the ingredients used (Omojola, 2008). It could be noted that the raw or individually prepared meat products is a favourable environment for micro-organisms especially where hygiene and sanitary conditions are low

The *Coliform* bacteria load in *asun* (27.24$\times_{10}^{3}$ cfu/g) was significantly higher (P<0.05) than in *suya* (9.81$\times_{10}^{3}$ cfu/g) and *kundi* (1.03$\times_{10}^{3}$ cfu/g). The relatively high *coliform* bacteria count in *asun* and *suya* could be attributed to the improper handling of the product by the workers, which could be dangerous to consumer's health. Clarence *et al.* (2009) earlier advocated that improved hygiene and sanitary practises be employed during production of ready to eat food products.

There was no *Salmonella-shigella* in *kundi* but was found in *suya* (1.00 $\times_{10}^{3}$ cfu/g) and *asun* (0.25 $\times_{10}^{3}$ cfu/g). This observation was contrary to earlier report (Ologhobo *et al.,* 2010) that *Salmonella-shigella* was not found in *suya*. The *Salmonella-shigella* in *asun* and *suya* could be linked to the source of water and the utensils used during processing. The consumption of such meat products is hazardous to human health. However, the *fungal* count in *suya* (0.25$\times_{10}^{3}$ cfu/g) was not significantly higher (P>0.05) than in *kundi* (0.10 $\times_{10}^{3}$ cfu/g) but was not found in *asun*. The *fungal* count in *suya* and *kundi* could be due to the dirty environment where the products were processed and sold (Jegede, 2018).

Table 3: Microbial load of meat products in Ibadan

	Parameters ($\times10^{-3}$cfu/g) (n = 24)					
Products	THC	E. COLI	STAPHY-LOCOCCUS	COLIFORMS	SALMONELLA-SHIGELLA	FUNGAL COUNT
Suya	28.17^{a}	ND	2.19^{a}	9.81^{b}	1.00^{a}	0.25^{a}
Asun	3.99^{b}	0.25^{a}	0.85^{b}	27.24^{a}	0.25^{b}	ND
Kundi	11.19^{b}	ND	2.89^{a}	1.03^{c}	ND	0.10^{ab}
SEM	1.94	0.04	0.18	1.82	0.14	0.03

^{a,b,c} Means with similar superscripts along the same column are not significantly different (P>0.05);
SEM= Standard error of mean; THC= Total Heterotrophic Count; E.coli= Eshericia Coli; ND= Not dectected.

Table 4 shows the polycyclic aromatic hydrocarbon in meat products collected in Ibadan metropolis. In this study, it was observed that *suya* contained 5.31 µg/kg PAHs followed by *asun* (2.02 µg/kg) and *kundi* (1.55 µg/kg). This is an indication that smoking of *suya* on charcoals probably had a significant influence on the deposition of PAHs on the meat products; the high value of BaA for *asun* (1.14 µg/kg) could be attributed to smoking of the goat meat before stir frying. In the report of Minichini and Bocca (2003) on the survey of Spanish commercial smoked meat products for BaP was 0.3 µg/kg.

A smoked meat product was estimated to contain 0.6 µg kg-^{1} BaP (Andree *et al.*, 2010). The value reported by Minichini and Bocca (2003) for smoked meat products was lower to the BbF of *suya* (0.83 µg/kg) but higher than in *asun* (0.19 µg/kg) and *kundi* (0.12 µg/kg). The 0.65 µg/kg BaP in *suya* was similar to report of 0.6 µg/kg by Andree *et al.* (2010) for smoked meat. The high PAHs in *suya* could be associated with the smoke deposited on the meat from the wood charcoal during cooking and as the oil from the meat dripped on the wood charcoal at the temperature above 300 ^{0}C, which increased the liberated smoke. Therefore, the total PAH value for each product collected in this study was below the maximum acceptable level of 5 µg/kg recommended by European Commission, (2005) except *suya*.

Table 4: Polycyclic aromatic hydrocarbons content of meat products in Ibadan

Parameters	Products (µg/kg) (n = 24)			
	SUYA	*ASUN*	*KUNDI*	SEM
BaA	1.96^{a}	1.14^{b}	0.64^{c}	0.13
BbF	0.83^{a}	0.19^{b}	0.12^{c}	0.07
BaP	0.65^{a}	0.23^{b}	0.16^{c}	0.05
Pyrene	1.60^{a}	0.50^{b}	0.32^{c}	0.13
Chrysene	0.77^{a}	0.16^{b}	0.09^{c}	0.07
TPAH	5.31^{a}	2.02^{b}	1.55^{c}	0.40

^{a,b,c} Means with different superscripts along the same row are significantly different (P<0.05);
SEM= Standard error of mean; BaA=(Benzo (a)Anthracene), BbF=(Benzo(b) Fluoranthene), BaP=(Benzo (a)Pyrene)

The heterocyclic aromatic amines content of meat products sampled in Ibadan metropolis is shown in Table 5. The high value of IQ in *suya* (4.26 ng/g) could be attributed to the closeness of the meat product to the heat source at a temperature greater than 150 ^{0}C and also probably, because of the reaction between the precursors in *suya* such as creatine, creatinine and the groundnut powder used in coating the meat sample. Jinap *et al.* (2013) reported an IQ of 29.68±373 nglg for a charcoal medium grilled beef satay and 73.96±0.8 ng/g for a well done charcoal grilled satay which were higher than values in this study. The IQ of ready to eat hot dog beef was estimated at 0.31±0.09 nglg and 0.2±0.09 ng/g in Deli roast beef (Puangsombat *et al.*, 2012). The high MeIQx in *asun* (3.86 ng/g) could be linked to the interaction among the creatine, creatinine and amino acid present in the meat coupled with high temperature. The low level of HAAs in *kundi* (23.70 ng/g) could be attributed to the short duration of cooking, the reaction between the precursors in the meat and temperature above 150 ^{0}C as postulated (Jegede, 2018). PhIP, the most abundant of all HAA, was highest in *suya* (5.40 ng/g). The PhIP has the highest concentrations across the meat products collected from Ibadan metropolis compared with IQ and MEIQx. This shows that the liberation of PhIP was more than the other HAAs. These findings corroborate with those of Siegfried and Michael (2002). Jinap *et al.* (2013) surmised no PhIP in medium charcoal grilled beef satay while 11.30±0.08 ng/g was found in a well done beef satay. The 35 nglg in cooked beef, 330 nglg in chicken and 15 nglg in pork were reported (Iwasaki *et al.*, 2010) which were higher than values in this study.

Table 5: Heterocyclic aromatic amines concentration of meat products in Ibadan

Parameters	Products (ng/g) (n = 24)			
	SUYA	*ASUN*	*KUNDI*	SEM
IQ	4.26[a]	3.70[b]	2.16[c]	0.21
MeIQx	3.67[b]	3.86[a]	2.21[c]	0.17
PhIP	5.40[a]	2.36[c]	2.89[b]	0.32
THAA	51.66[a]	28.12[b]	23.70[c]	2.97

[a,b,c] Means with different superscripts along the same row are significantly different ($P<0.05$)
SEM= Standard of error mean; 2-Amino-3-methyl-3H-imidazo [4,5-F]quinoline (IQ), 2-Amino-3,8-dimethyl imidazo [4,5-f] quinoxaline (MeIQx), 2-Amino-1-methyl-6-phenylimidazo(4,5-b) pyridine (PhIP), Total heterocyclic aromatic amines (THAA)

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Received: 14th September, 2018
Accepted: 21st December, 2018