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Relative Nutritional and Contaminant Status of Cowhide Meat and Fresh Cow Meat

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Abstract:

Although, hides from slaughtered cows are conventionally not meant for consumption, in many parts of West Africa, including Nigeria, they are often processed into a meat-like delicacy, and eaten like the regular cow beef. It is imperative to assess the contaminant and nutritional status of cowhide meat, relative to the regular cow beef. We assessed the relative nutritional and contaminants status of brown cowhide meat, white cowhide meat, and fresh cow meat obtained from selected markets in Lagos, Nigeria. Nutritional components were determined using the Official Methods of Analysis by AOAC. Polychlorinated biphenyls (PCBs) and metal levels were measured by Gas Chromatography/Mass Spectroscopy and Atomic Absorption Spectrometry, respectively. The percentage protein concentrations of white cowhide meat (5.65±0.03% to 6.37±0.03%) and brown cowhide meat (5.46±0.04% to 6.20±0.19%) were significantly lower (p<0.01), relative to the regular cow meat which recorded percentage protein concentrations of between 21.16±0.08% and 22.53±0.14%. Brown cowhide meat from Obalende, Oyingbo, and Mushin markets had the highest 2,3,3'-Trichloro-1,1'-biphenyl concentrations of 2.15±1.39, 1.04±0.99, and 5.21±7.02 µg/kg, respectively. Cadmium occurred in significantly higher (p<0.01) concentrations in brown cowhide meat from the three markets. The relatively low protein constituents of brown and white cowhide meats, and their relative higher loads of some contaminants, make them least recommendable for consumption.

Keywords: Cowhide meat, Contamination, Diets, Metals, PCBs

1- Introduction

Protein is a major constituent of any food that would pass for a balanced meal or diet. Although both meat and plants (e.g. cereals and whole grains) could be rich sources of proteins, plant proteins are, most times, deficient in one or more essential amino acids. Hence, a major reliable source of complete proteins and amino acids for human nutrition is meat (Reeds, 2000; FAO, 2014; Nunez, 2018). Globally, beef constitutes 22% of meat intake, of which cow meat accounts for a substantial part.

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Consumption of cattle and buffalo witnessed a rise of over 16% between 1990 and 2012 (FAO, 2014). In Nigeria, the cattle market is a thriving business, and cow meat is widely eaten as part of regular meals. A survey conducted by the Food and Agricultural Organization (FAO) indicated that as far back as 1992, the population size of cattle in Nigeria stood at about 14 million (Bourn et al., 1992). Of course, this figure is expected to have risen tremendously, in line with the global trend.

In order to ensure the supply of hygienic meat to consumers and reduce incidences of environmental contamination, there are usually designated slaughterhouses or abattoirs in every city, town and locality. In most cases, there are prescribed standards that operators of abattoirs and meat suppliers are expected to comply with. However, typical of many developing countries, the Nigeria meat supply system is confronted with some problems and challenges including inadequate enforcement of abattoir standards, poor abattoir facilities and practices, killing of obviously sick or poor grade of animals, lack of formal ante mortem and post mortem inspections (*Lawan* et al*., 2013;* Shima et al., 2015). These poor abattoir practices potentially threaten the health of meat consumers.

Beyond the foregoing, a remarkable aspect of abattoir practices in Nigeria is the parts of slaughtered cow that are eaten. According to the FAO, after a cow is slaughtered and skinned in the abattoir, the hide should either be disposed of by burying, or processed for sale to the leather industry (FAO, 1988). But, in Nigeria, when a cow is slaughtered, the hide is neither disposed of, nor processed for leathery; rather, it is dehaired and processed to cowhide meat for consumption. In many places in Nigeria, especially the South, the local name for cowhide meat is 'Ponmo'. There are two types of cowhide meat; white cowhide meat and brown cow hide meat. The white cowhide meat is processed by steam or soap shaving, while the brown cowhide meat is processed by singeing with wood, scrapped tyres and plastics, and kerosene. The names, white cowhide meat and brown cowhide meat, reflect their respective colours after processing (Dada et al., 2018a). While the general inadequate facilities and poor abattoir practices have called to question, the safety of meat production in Nigeria (*Lawan et al., 2013;* Shima et al., 2015), the habit of processing cowhide into meat for consumption calls for special attention. The nutritional value and safety of these cowhide meats are in doubt, as they are potentially exposed to contaminants deposition either from the shaving materials (polluted water and detergents), or the singeing substrates (wood, scrapped tyre and plastics, kerosene) (Obiri-Danso et al., 2008; Akwetey et al., 2013; Ekenma et al., 2014; Dada et al., 2018a). The present study therefore aimed to assess the relative nutritional and contaminant status of fresh cow meat, white cowhide meat and brown cowhide meat obtained from selected markets in Lagos, Nigeria.

2-Materials and methods

The fresh cow meat, white cowhide meat, and brown cowhide meat samples assessed in this study were obtained from the meat section of three major open markets located in Mushin, Oyingbo, and Obalende areas of Lagos, Nigeria (Figure 1). In each of the three markets, fresh cow meat, white cowhide meat, and brown cowhide meat samples were collected every day, for three consecutive days, making a total of 27 samples. About 1 kg of each sample was bought from meat butchers and cowhide meat vendors who typically displayed their ware openly (Figures 2, 3, 4), at between 9am and 10am local time, as this was a peak period for meat market activities. To ensure a wider coverage, meat samples were bought from a new set of butchers and vendors each day. The meat and cowhide samples were kept in labelled sterile polythene bags,

packed in a box embedded with ice packs, and immediately transported to the laboratory. The samples were kept in the freezer at -11^{o}C, pending analyses.

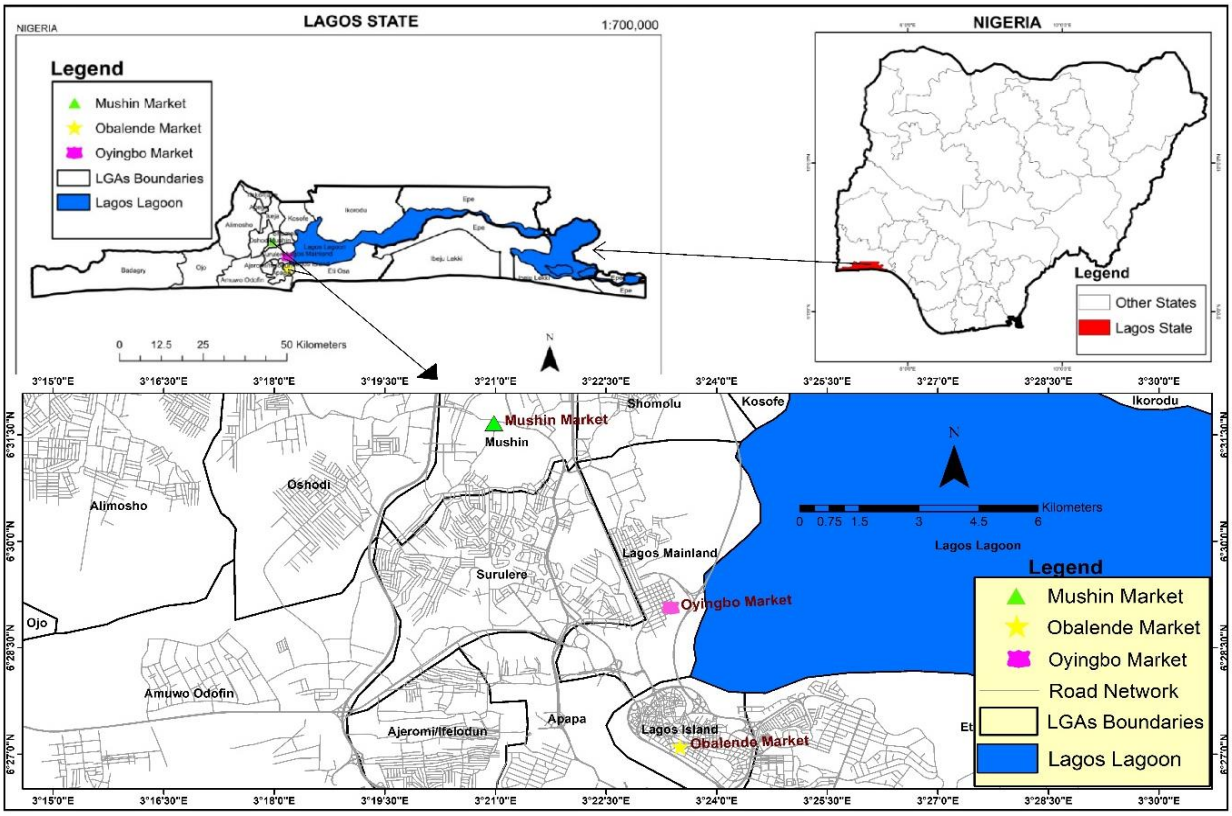

Fig. 1. Map showing location of Lagos State, in Nigeria (top right); Lagos State showing sampling markets (top left); locations of sampling point in the markets (below).

Fig. 2. Fresh beef

Fig. 3. White cowhide meat

Fig. 4. Brown cowhide meat

The meat samples, which had earlier been kept in a freezer, were allowed to thaw. They were separately sliced and washed with distilled water. From each sample, 500 g was oven dried to a constant weight at 105 ^{o}C. The dried sample was homogenized and made ready for analysis. Each dried homogenized sample was analysed for moisture, fat, ash, fibre, and free nitrogen extract (crude protein) using the procedures of the Official Methods of Analysis by AOAC (Horwitz & Latimer, 2005).

Fresh cow meat, brown cowhide meat and white cowhide meat samples were each analysed for PCB levels using Gas Chromatography/Mass Spectroscopy (GC/MS). All reagents used were of analytical grade. The glassware used for the tests were washed in 5% (v/v) analytical grade nitric acid, for 48 hours. Internal standard solution was prepared by adding 0.1 mL of decachlorobiphenyl to one liter of hexane. Surrogate solution was prepared by adding 50 µL of tetrachloro-m-xilene to one liter of hexane. Both solutions had a final concentration of 0.10 mg/L. Internal standard, surrogate reagents, and standards of PCB congeners were obtained from Sigma Aldrich (South Africa).

The meat samples were first extracted by a combined maceration/solid-phase extraction (SPE) method. Ten grams of the dried sample and anhydrous Na_2SO_4 were weighed into a 50 mL capacity amber glass bottle. Then, 40 mL of extraction solvent mixture (hexane and acetone) were added and agitated for 20 minutes on a mechanical shaker. The covered glass amber bottle was properly sealed and sonicated for 20 minutes using an ultra sonicator. The combined aliquot of both extractions were collected in a 250 mL beaker. A solid phase extraction was used to elute the cartridge in order to condition and equilibrate the cartridge.

The resulting extracts were eluted through the cartridge and collected into another small beaker while the residue/impurities were retained on the stationary phase, which is made of glass wool with combined Al_2O_3 and anhydrous Na_2SO_4 in ratio 2:3. The extract was evaporated to a volume of 2 mL using nitrogen concentrator to the final volume. The sample extracts were subjected to GC/MS analysis. Gas chromatography (Agilent Technologies model: 7890A) was interfaced with Mass selective Detector (model: 5975C MSD). Highly pure helium gas (99.9% purity) was used as a carrier gas (mobile phase) while HP-5 (30mm X 0.320um) was used as stationary phase.

Initial oven temperature: 60^{o}C (1 minute) at the rate of 30^{o}C/minute, increased to 180^{o}C (l minute) at the rate of 2.5^{o}C/minute, and ramped to 200^{o}C holding for 2 minutes at the rate of 5^{o}C/minute, further ramped to 280^{o}C (5 minutes) at the rate 10^{o}C/minute. The final temperature (300^{o}C) was held for 6 minutes. Injection temperature: 250^{o}C.

Mobile phase: Helium gas (99.9% purity) 0.5/mL/minute. Column: HP-5 (30mm X 0.25mm X 0.320um). Injection volume: 1u/L. Mode: splitless.

The constituent of the polychlorinated biphenyls was identified by comparing the mass spectra with the known standard.

The metal concentrations in fresh cow meat and cowhide meat samples were determined by Atomic Absorption Spectrometry (AAS) according to the methods of the AOAC (Horwitz & Latimer, 2005). Oven-dried, homogenized sample was first digested by wet digestion method. To digest the sample, 10 g of the ground meat sample was taken in digesting glass tube. Twelve millimetres (12 mL) of HNO_3 was added to the meat samples and the mixture was kept overnight at room temperature. Then, 4 mL perchloric acid ($HClO_4$) was added to this mixture and kept in Fume block for digestion. The temperature was increased gradually, starting from 50 ^{o}C and increasing up to 250-300 ^{o}C. Digestion was completed in 70-85 minutes as indicated by the appearance of white fumes. The mixture was then left to cool. After cooling, the digested sample was filtered through Whatman 042 filter paper. The filtrate was transferred to 50 mL volumetric flasks and the content was made up to 50 mL with distilled water. The wet digested solution was transferred to a glass bottle. This was used for metal determination using Atomic Absorption Spectrometer (AAS) (Perkin Elmer model 460, made in USA). A blank solution was prepared; this consisted the binary acid mixture (HNO_3:$HClO_4$), H_2SO_4, and the distilled water used for sample digestion. The blank solution was set at zero. A suitable standard curve was generated in the AAS using standard solutions of metals of interest. Standard concentrations of 6, 12, 18, 24, 30 mg/L were used. Adequate standard curve was generated for each metal passing through the origin. After a good curve was achieved, the digested sample solutions were aspirated into the AAS for the analysis. A unique cathode lamp for each metal was utilized for the analysis, operating at its peculiar maximum operational wavelength. A digital concentration read-out (meter) gave the direct concentration of the metals as contained in the test sample (Dada et al., 2018b).

The data generated from the laboratory analyses of test samples were statistically analysed using multivariate analysis of variance (MANOVA). Mean differences were compared for significance using the Least Significant Difference (LSD) post hoc method. All statistical analyses were done using the SPSS (version 22).

3-Results and Discussion

The nutritional composition of fresh cow meat, white cowhide meat, and brown cowhide meat sampled in this study is presented in Table 1. Fresh cow meat from the three markets had the highest significant ($p < 0.01$) mean protein concentrations of between 21.16±0.08% and 22.53±0.14%. The mean protein concentrations of white cowhide meat (5.65±0.03% to 6.37±0.03%) and brown cowhide meat (5.46±0.04% to 6.20±0.19%) were significantly lower ($p < 0.01$), relative to fresh cow meat. The percentage concentrations of protein in brown cowhide and white cowhide meat were not significantly different ($p > 0.05$), except in Obalende market where brown cowhide meat protein content (5.46±0.04%) was significantly lower ($p > 0.05$) than that of white cowhide meat (5.65±0.03%). The highest percentage fat concentrations of

13.08±0.81 was recorded in brown cowhide meat from Mushin market, while the lowest percentage fat concentration of 0.38±0.49 was recorded in white cowhide meat from the same market.

Table 1. Nutritional status of cow meat, white cowhide meat, and brown cowhide meat samples

Nutrient components	Percentage composition in samples			
	Fresh cow meat	Brown cowhide meat	White cowhide meat	F
Obalende market				
Ash (%)	68.20±0.47	70.91±3.65	61.94±5.02	4.92ns
Moisture (%)	0.98±0.15b	0.15±0.06a	0.09±0.04a	79.91**
Fat (%)	9.06±0.61	9.80±7.84	2.52±0.09	1.47ns
Protein (%)	21.16±0.08c	5.46±0.04a	5.65±0.03b	83048.71**
Fibre (%)	ND	12.67±7.40	29.50±4.30	11.62*
Carbohydrate (%)	ND	0.80±0.04	0.95±0.04	21.13*
Oyingbo market				
Ash (%)	69.63±1.55b	67.09±6.13b	54.74±1.27a	13.74**
Moisture (%)	1.14±0.10b	0.11±0.08a	0.01±0.00a	228.85**
Fat (%)	6.37±1.72b	1.21±0.32a	1.36±1.49a	11.54*
Protein (%)	22.53±0.14b	5.98±0.10a	6.37±0.03a	28451.40**
Fibre (%)	ND	25.01±5.77	36.37±2.67	9.58*
Carbohydrate (%)	ND	0.84±0.05b	0.98±0.02b	19.50*
Mushin market				
Ash (%)	64.30±1.05	71.69±2.24	71.24±9.23	1.69ns
Moisture (%)	1.46±0.39b	0.28±0.17a	0.41±0.67a	5.89*
Fat (%)	12.20±1.69b	13.08±0.81b	0.38±0.49a	64.31**
Protein (%)	21.76±0.48b	6.20±0.19a	6.31±0.03a	2724.00**
Fibre (%)	ND	12.12±9.41	20.47±8.59	1.29ns
Carbohydrate (%)	ND	0.76±0.05b	1.18±0.13c	25.38*

**p<0.01; *p<0.05, ns: not significant, row values (mean ± standard deviation) followed by the same alphabet are not significantly different (LSD, p>0.05); ND = not detected.

The percentage protein content of fresh cow meat was within the conventional range of 22.3% (FAO, 2015). On the other hand, the percentage composition of protein in both brown and white cowhide meat was far below the normal range for beef. The low percentage protein content of cowhide meat (5-6%) in this study sharply contrasts the work of Sanusi et al. (2016) who reported a high percentage protein (58%) in cowhide meat sampled from markets in Sokoto, Northern Nigeria. Though, studies that empirically and directly corroborate our present findings were not readily available, it has been established that meat and meat products may only contain an average protein content of 22%; chicken breast may have a peak protein of 34% (FAO, 2015; Ahmad et al., 2018). The present study only preliminarily measured the crude protein in cow meat and cowhide meat, further studies that will quantify not only the crude proteins, but also the amino acids quality are desirable.

According to the results as presented in Table 2, one or more polychlorinated biphenyls (PCBs) occurred in all the fresh cow meat, brown cowhide meat and white cowhide meat sampled in this study (Table 2). Total PCBs was highest in cow meat sampled from Obalende (9.26 µg/kg) and Oyingbo (9.17 µg/kg) markets, but was highest in brown cowhide meat samples from Mushin market (12.11 µg/kg). The differences in PCBs concentrations in all the cow meat and cowhide meat samples from the three markets were not significantly different ($p > 0.05$), except for 2,3',4,4',5-Pentachloro-1,1'-biphenyl which occurred in significantly higher ($p < 0.01$) concentration of 3.07±0.00 µg/kg in cow meat obtained from Obalende market. Relative to cow meat and white cowhide meat, brown cowhide meat sampled from Obalende and Mushin markets had higher 2,2',5-Trichloro-1,1'-biphenyl concentrations of 0.69±0.29 µg/kg and 0.73±0.87 µg/kg, respectively. Moreover, 2,2',3,3',4,4',5,5'-Octachloro-1,1'-biphenyl was not detected, except in cow meat sampled from Obalende market. Brown cowhide meat sampled from Obalende, Oyingbo, and Mushin markets had the highest 2,3,3'-Trichloro-1,1'-biphenyl concentrations of 2.15±1.39, 1.04±0.99, and 5.21±7.02 µg/kg, respectively.

When compared with the maximum residue limit (MRL) of 40 µg/mg of fat specified by the European Commission (Kuzukiran and Filazi, 2015), the total PCBs concentrations found in meat and cowhide meat sampled in this study were within safe limits. Nevertheless, it should be noted that there are more PCBs in the environment than those assessed in this study, and that consumers are potentially exposed to dietary PCBs intake through other food sources, including fish, pork, milk and other dairy products.

The occurrence of PCBs in all the samples at concentrations that are generally not significantly different suggests that the PCBs detected in the brown cowhide meat likely originated from the same environmental sources, especially water and grazing food, and not from the singeing materials. In Nigeria, cattle rearing is mainly by nomadic open field grazing, where, right from birth, cattle spend their entire life feeding on green pasture. This potentially exposes these cattle to higher levels of PCBs ingestion, relative to cattle fed on formulated feed or concentrate. Green fodder tends to bear higher levels of PCBs, brought about by atmospheric deposition and soil-root uptake (Zennegg, 2018). Because the issue of nomadic open field grazing has generated much ethno-political tension in Nigeria, it would be a difficult task phasing it out for any modern or better alternatives, now or in the nearest future. Therefore, to reduce PCBs food chain contamination through grazing in the country, the Nigerian government will have to take holistic measures that will reduce PCBs in the environment, rather than looking in the direction of grazing control only.

Regrettably, official information on PCB situation in Nigeria's environment is scanty, and no formal regulatory PCBs limits or standards were readily found in literature. Though, a number of studies have assessed PCBs levels in foods, especially meat and fish (Adeyemi et al., 2009; Aina et al., 2016), these are limited in scope and do not give information on the general extent of PCB contamination in Nigerian foods and environment. To prevent excessive build-up of PCBs along the food chains, and forestall PCB toxicity in humans, it is expedient for the Nigerian government and relevant agencies to proactively develop food, water and environmental monitoring programmes for PCBs and related contaminants. This is necessary because persistent high levels of PCBs in human foods can lead to toxicity, resulting in serious health challenges including carcinogenicity, endocrine disruption, neurotoxicity, dermatological and pulmonary diseases, and developmental disorders in children (Kuzukiran and Filazi, 2015).

Table 2. PCB levels in cow meat, brown cowhide meat and white cow meat samples based on dry matter

PCB types	PCB concentrations in samples (µg/kg)			
	Cow meat	Brown cowhide meat	White cowhide meat	F
Obalende market				
2,2',5-Trichloro-1,1'-biphenyl	0.08±0.03	0.69±0.29	0.23±0.17	5.25ns
2,4,4' + 2,4',5-Trichloro-1,1'-biphenyl	0.31±0.06	0.42±0.07	0.42±0.24	0.54ns
2,3,3'-Trichloro-1,1'-biphenyl	1.10±1.24	2.15±1.39	0.66±0.49	1.42ns
2,2',5,5'-Tetrachloro-1,1'-biphenyl	0.54±0.43	0.48±0.32	0.25±0.27	0.59ns
2,2',3,5'-Tetrachloro-1,1'-biphenyl	0.58±0.43	0.47±0.16	0.74±0.53	0.34ns
2,3,3',4,4'- Pentachloro-1,1'-biphenyl	0.22±0.09	0.31±0.14	0.22±0.08	0.75ns
2,2',3,4',5',6-Hexachloro-1,1'-biphenyl	0.31±0.00	0.35±0.04	0.34±0.04	1.49ns
2,3',4,4',5-Pentachloro-1,1'-biphenyl	3.07±0.00	0.04±0.00	0.00±0.00	276.34**
2,2',4,4',5,5'-Hexachloro-1,1'-biphenyl	0.50±0.16	0.59±0.29	0.49±0.09	0.18ns
2,2',4,5,5'-Pentachloro-1,1'-biphenyl	0.49±0.11	0.99±0.55	0.69±0.52	0.99ns
2,2',3,4,4',5'-Hexachloro-1,1'-biphenyl	0.45±0.01	0.59±0.20	0.51±0.07	0.79ns
2,2',3,4,4',5,5'-Heptachloro-1,1'-biphenyl	0.66±0.01	0.04±0.00	0.37±0.40	1.68ns
2,2',3,3',4,4',5-Heptachloro-1,1'-biphenyl	0.92±1.31	0.31±0.26	1.53±0.65	1.52ns
2,2',3,3',4,4',5,5'-Octachloro-1,1'-biphenyl	0.03±0.00	ND	ND	-
∑PCBs	**9.26**	**7.43**	**6.45**	
Oyingbo market				
2,2',5-Trichloro-1,1'-biphenyl	1.72±0.98	1.42±1.30	0.06±0.06	2.64ns
2,4,4' + 2,4',5-Trichloro-1,1'-biphenyl	0.45±0.17	0.36±0.05	0.33±0.04	1.16ns
2,3,3'-Trichloro-1,1'-biphenyl	1.02±0.26	1.04±0.99	0.31±0.03	1.44ns
2,2',5,5'-Tetrachloro-1,1'-biphenyl	0.36±0.26	0.15±0.07	0.23±0.10	1.25ns
2,2',3,5'-Tetrachloro-1,1'-biphenyl	1.01±0.72	0.91±1.08	0.41±0.27	0.53ns
2,3,3',4,4'- Pentachloro-1,1'-biphenyl	0.35±0.15	0.23±0.07	0.24±0.06	1.24ns
2,2',3,4',5',6-Hexachloro-1,1'-biphenyl	0.40±0.13	0.34±0.04	0.32±0.01	0.83ns
2,3',4,4',5-Pentachloro-1,1'-biphenyl	0.24±0.43	ND	ND	-
2,2',4,4',5,5'-Hexachloro-1,1'-biphenyl	0.54±0.11	0.86±0.64	0.41±0.00	1.18ns
2,2',4,5,5'-Pentachloro-1,1'-biphenyl	1.91±1.38	0.53±0.14	1.39±1.42	1.12ns
2,2',3,4,4',5'-Hexachloro-1,1'-biphenyl	0.66±0.34	0.46±0.03	0.45±0.01	1.08ns
2,2',3,4,4',5,5'-Heptachloro-1,1'-biphenyl	0.23±0.40	ND	0.29±0.26	0.91ns
2,2',3,3',4,4',5-Heptachloro-1,1'-biphenyl	0.28±0.17	0.16±0.01	0.26±0.08	1.02ns
2,2',3,3',4,4',5,5'-Octachloro-1,1'-biphenyl	ND	ND	ND	-
∑PCBs	**9.17**	**6.46**	**4.70**	
Mushin market				
2,2',5-Trichloro-1,1'-biphenyl	0.31±0.28	0.73±0.87	0.23±0.00	0.41ns
2,4,4' + 2,4',5-Trichloro-1,1'-biphenyl	0.41±0.21	0.42±0.21	0.29±0.01	0.55ns
2,3,3'-Trichloro-1,1'-biphenyl	0.67±0.66	5.21±7.02	0.55±0.18	1.28ns
2,2',5,5'-Tetrachloro-1,1'-biphenyl	0.80±1.23	0.36±0.16	0.83±0.82	0.28ns
2,2',3,5'-Tetrachloro-1,1'-biphenyl	0.93±1.16	2.59±3.80	0.38±0.09	0.75ns
2,3,3',4,4'- Pentachloro-1,1'-biphenyl	0.3±0.31	0.28±0.14	0.17±0.01	0.63ns
2,2',3,4',5',6-Hexachloro-1,1'-biphenyl	0.46±0.03	0.32±0.01	0.10±0.18	1.29ns
2,3',4,4',5-Pentachloro-1,1'-biphenyl	0.80±0.00	ND	ND	-
2,2',4,4',5,5'-Hexachloro-1,1'-biphenyl	0.52±0.16	0.44±0.04	0.41±0.00	0.54ns
2,2',4,5,5'-Pentachloro-1,1'-biphenyl	1.05±0.99	0.43±0.02	0.48±0.14	1.07ns
2,2',3,4,4',5'-Hexachloro-1,1'-biphenyl	0.63±0.31	0.58±0.21	0.45±0.00	0.19ns
2,2',3,4,4',5,5'-Heptachloro-1,1'-biphenyl	0.08±0.00	0.36±0.41	0.01±0.00	0.30ns
2,2',3,3',4,4',5-Heptachloro-1,1'-biphenyl	0.76±0.71	0.39±0.06	0.58±0.76	0.29ns
2,2',3,3',4,4',5,5'-Octachloro-1,1'-biphenyl	ND	ND	ND	-
∑PCBs	**7.72**	**12.11**	**4.48**	

**Significant (p<0.01) difference among the row values; ns = No significant differences among the row values; ND = not detected.

As presented in Table 3, Cd, Pb, Ni, Mn, Cr, Hg, and As occurred in different concentrations in fresh cow meat, brown cowhide meat and white cowhide meat sampled from the three markets. Cadmium occurred in significantly higher ($p < 0.01$) concentrations of 0.25±0.01, 0.22±0.01, and 0.25±0.01 mg/kg in brown cowhide meat sampled from Obalende, Oyingbo, and Mushin markets, respectively. While Hg was not detected in fresh cow meat from Obalende and Oyingbo markets, it was consistently detected in brown cowhide meat and white cowhide meat sampled from all the markets. The highest significant ($p < 0.01$) Pb concentrations of 0.19±0.02, 0.11±0.16, and 0.11±0.15 mg/kg occurred in cow meat sampled from Obalende, Oyingbo and Mushin markets, respectively.

Table 3. Trace/toxic metal levels in cow meat, brown cowhide meat and white cow meat samples

Trace/toxic metal types	Concentrations of trace/toxic metals in samples (mg/kg)			
	Cow meat	Brown cowhide meat	White cowhide meat	F
Obalende market				
Cadmium	0.01±0.00a	0.25±0.01c	0.19±0.01b	1925.85**
Lead	0.19±0.02c	0.06±0.00b	0.03±0.00a	425.63**
Nickel	0.07±0.01c	0.02±0.00b	0.01±0.00a	289.12**
Manganese	0.22±0.02b	0.04±0.00a	0.03±0.00a	453.90**
Chromium	0.08±0.01b	0.03±0.00a	ND	153.56**
Mercury	ND	0.01±0.00	0.01±0.00	4.50ns
Arsenic	ND	0.01±0.00	0.01±0.00	0.00ns
Oyingbo market				
Cadmium	0.01±0.00a	0.22±0.01c	0.14±0.02b	184.67**
Lead	0.11±0.16	0.05±0.00	0.02±0.00	3.72ns
Nickel	0.06±0.00c	0.02±0.00b	0.01±0.00a	3443.17**
Manganese	0.27±0.02b	0.03±0.00a	0.02±0.00a	733.91**
Chromium	0.09±0.00c	0.03±0.00b	0.01±0.00a	9820.31**
Mercury	ND	0.02±0.00b	0.01±0.00a	64.00**
Arsenic	ND	0.01±0.00a	0.02±0.00b	10.13**
Mushin market				
Cadmium	0.01±0.00a	0.25±0.01c	0.19±0.01b	208.95**
Lead	0.11±0.15	0.06±0.01	0.03±0.00	3.61ns
Nickel	0.07±0.00c	0.02±0.00b	0.01±0.00a	334.32**
Manganese	0.23±0.00b	0.03±0.00a	0.02±0.00a	537.98**
Chromium	0.08±0.00c	0.04±0.00b	ND	2698.19**
Mercury	0.11±0.12	0.02±0.00	0.02±0.00	1.71ns
Arsenic	0.60±0.16	0.43±0.01	0.28±0.01	1.18ns

**$p<0.01$; ns: not significant, row values (mean ± standard deviation) followed by the same alphabet are not significantly different (LSD, $p>0.05$); ND = not detected.

Of these metals, three are essential trace elements (Ni, Mn, Cr), needed in small concentrations for important metabolic, biochemical or biological reactions; another three (Cd, Pb, Hg) are not known to mediate any biological reactions, and are referred to as non-essential toxic metals (Prashanth et al., 2015). In this study, the concentrations of these metals were generally in

concentrations below or within permissible levels, except for Cd, which concentrations in cowhide meat were both significantly higher, and above the permissible limits of 0.1 mg/kg (USDA, 2006; Codex Alimentarius Commission, 2011). Such isolated occurrence of Cd in the cowhide meat samples suggests local, post-slaughter contamination arising from the processing of hide to meat. Processing of cowhide to meat involves a number of steps including (1) dehairing and post-dehairing washing; (2) boiling in water; (3) soaking dehaired, boiled hide in cold water to soften and give it meat-like appearance. Each of these stages potentially exposes the resulting cowhide meat to contaminants. In this present study, Cd could have been deposited into the hide from the singeing and other dehairing materials (such as spent engine oil, scrapped tyres and plastics, detergents), contaminated water used in boiling and, or soaking the hide (Dada et al., 2018a). In addition, the typical physical environment in which cowhide is processed to meat is always visibly dirty and stench-emitting. These situations are capable of exposing consumers to excessively high levels of Cd and other contaminants. Cadmium is known to be carcinogenic and has a tendency to accumulate in the kidney, thereby causing renal dysfunction (Codex Alimentarius Commission, 2011; Dada et al., 2017). Hence, there is the need to put in place appropriate measures that will ensure meat consumers are not unnecessarily exposed to Cd and other contaminants.

Though, the issue of cowhide meat consumption always elicits divergent opinions among the populace, the relatively low percentage protein content in cowhide meat sampled in this study, and their higher loads of PCBs and Cd, make them least recommendable for consumption. However, if cowhide must be processed for consumption, the processing must be done within hygienic environment, and the final product (cowhide meat) must be wholesome. Therefore, government should enact minimum safety standards that operators of cowhide meat business must comply with.

Conclusions

Brown cowhide meat, white cowhide meat, and Fresh cow meat were assessed for nutritional and contaminant composition (PCBs and metals). The percentage protein in brown cowhide meat and white cowhide meat were low, relative to fresh cow meat. PCBs were present at low, permissible concentrations in all the samples. Cadmium occurred in significantly higher concentrations in brown cowhide meat and white cowhide meat, compared with fresh cow meat. Since meat's nutritional importance is partly derived from its high quality protein, the relatively low protein levels in brown and white cowhide meat, and their relative higher loads of some contaminants, make them least recommendable for consumption.

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