Lipid Profile of Meat Parts of Cow Slaughtered at Obinze Abattoir, Imo State, Nigeria

Abstract

Meat, a vital component of human nutrition, offers essential nutrients for balanced diets and growth. However, it's cholesterol and fatty acid compositions impact cardiovascular health. This study aimed to describe the cholesterol content and fatty acid profile in various cow meat parts. Samples from torso, stomach, skin, intestine and lean meat were collected from an abattoir in Obinze, Imo State, Nigeria. Analytical methods involved gas chromatography fitted with flame ionisation detector (GC-FID) for fatty acid profile and Liebermann-Burchard method for cholesterol determination. Cholesterol concentrations varied across the meat parts, with torso meat exhibiting the highest (115±6.48 mg/kg) and stomach meat the lowest (67.76±5.69 mg/kg). Saturated fatty acids (SFAs) like stearic and palmitic acids were prominent. The monounsaturated fatty acid, oleic acid presented various concentrations: skin (26.19±2.00 mg/kg), torso (24.33±5.50 mg/kg), lean meat (13.10±1.30 mg/kg), stomach (12.511±2.91 mg/kg) and intestine (4.02±0.86 mg/kg). Meat parts contained fatty acids that are beneficial to human health not only in terms of essential fatty acids such as linoleic and alpha-linolenic acids, but also the polyunsaturated fatty acids, arachidonic, eicosapentaenoic and docosahexanoic acids. An understanding of these compositional variations provides valuable insights for shaping dietary choices and reducing cardiovascular risks associated with elevated cholesterol levels.

Keywords: Cholesterol, Cardiovascular health, Fatty acids, Meat composition**.**

Introduction

One of the healthiest and most nutrient-dense natural foods that humans eat to meet daily nutritional needs is meat. Meat easily helps in maintaining a balanced diet, adequate development and growth of humans. Meat is the edible parts from domestic, farmed and wild animals, such as goats, cows, sheep, and pigs etc (European Commission, 2004). Meat is source of quality proteins, different fats, minerals and vitamins (Pareira& Vicente, 2013)

providing needed nourishment (Vannice & Rasmussen, 2014). The specific fatty acids in meat determine its nutritional content and suitability for inclusion in a diet (Dinh, To & Schilling, 2021), and the ratio of these fatty acids is very important in nutrition and health (Cabrera &Saadoun, 2014).

Dietary cholesterol comes from animal-based foods (Ujowundu et al., 2014; Ojiako et al., 2018) and the cholesterol content in beef can vary depending on the cut and fat content. Dietary cholesterol and other lipids circulate in the bloodstream as lipoproteins. Lipoproteins have varying range of shapes and sizes, and each type is associated with different tasks. As dietary cholesterol is absorbed in the small intestine it is incorporated into chylomicrons, and transported in the bloodstream (Hussain, 2014).). The chylomicrons, deliver cholesterol to the liver and various tissues (Davidson, 1998). The liver is also involved in *de novo* biosynthesizes of cholesterol (Brown & Sharpe, 2016). In the presence of cholesterol, triglycerides and proteins and between the liver and the bloodstream, series of enzymatic reactions, low density lipoprotein (LDL) is synthesized (Gugliucci, 2023; Packard& Shepherd,1986; Brown&Goldstein, 1986). LDL-particles contain large proportion of cholesterol and are transported throughout the body. LDL-receptors on the surface of cells, particularly in the liver, bind LDL-particles and facilitate the uptake of cholesterol into the cells (Feingold, 2021; Goldstein & Brown, 1973). Circulating LDL levels can be increased in individuals who consume large amounts of saturated fat and/or cholesterol (Freeman & Walford, 2016). However, inefficient removal of LDL-particle from the bloodstream by LDL-receptors can facilitate the accumulation of cholesterol in the arterial walls, leading to atherosclerosis and cardiovascular disease (Goldstein, et al., 2001). Since the regulation of cholesterol metabolism is complicated and influenced by dietary (and others such as genetic, and lifestyle) factors, dysregulation of these processes can induce elevated LDL-cholesterol

levels. Elevated blood LDL-cholesterol level, is a significant risk factor for heart disease. Studies have shown that cow meat consumption is a common source of nutrient in Southern Nigeria (Adekunmi et al., 2017; Adesope et al., 2021; Petrikova et al., 2023). Therefore, knowledge of dietary sources of cholesterol and fatty acid elevating foods can be used to manage cholesterol levels and reduce cardiovascular risk.This research project seeks to investigate levels of fatty acids and cholesterol of different cow meat parts and thereby highlight the possible health risks associated with the consumption. It will also to identify potential health implications, raise awareness, and provide evidence-based recommendations for public health interventions. The outcomes will contribute to public health initiatives, informing policies and interventions aimed at promoting healthier dietary habits and reducing the risk of cardiovascular diseases and obesity in the region.

Materials and Methods

Study location

The study area, Obinze, is a town in Owerri West Local Government Area (LGA) in Imo State. It shares boundaries with Ngor-Okpola LGA in the south, Owerri Municipal Council in the east, Mbaitolu LGA in the south and Ohaki/Egbema LGA in the west. Its geographical coordinates are latitude 5°25′0” North and longitude 6°58′0″ East. Obinze is a university town with population of Owerri West Local Government estimated to be 99,265 (National Population Census, 2006). This abattoir is patronized daily by this population and people within the environs for purchase of meat and meat products.

Sample collection and Preparation

Samples used in the study were collected on different days from an abattoir in Obinze, Imo State, Nigeria. Total of 45 samples (15 samples each) were collected in three batches at weekly intervals for three weeks. Three samples of torso meat (cow hump), stomach meat, intestine meat, skin meat and lean meat of cow meat were obtained at early hours of the morning. The meat samples werepackaged in 250ml sample bottles that contained normal saline. The sample bottles were putin a cooler containing ice packs and transported to the laboratory for analysis. Each collected sample was carefully washed with distilled water, weighed and oven dried at 105 °C to constant weight. Afterwards, 10 g of each sample was homogenized using porcelain mortar and pestle into fine powder for further analysis.

Preparation of sample solutions and standard cholesterol solutions

Cholesterol content was determined by the method of Liebermann-Burchard (Attarde et al., 2010). Six standard volumetric flasks marked as s1, s2, s3, s4, s5 and s6 were used. Standard cholesterol solution of 0.4, 0.6, 0.8, 1.0 and 1.2 ml was added into five volumetric flasks whereas, flask six was kept blank. Thereafter, 2ml Liebermann-Burchard reagent was added to all six flasks and diluted with chloroform to a final volume of 10 ml. The flasks were kept in dark for 15 min after covering with a black carbon paper.Afterwards, the blank sample was used to zero the spectrophotometer at 640nm and the absorbance of all standards were determined using SP65 UV/Vis spectrophotometer and standard graph was plotted.

Determination of cholesterol content of Cow meat samples

The absorbance of 1ml of sample extract was determined using SP65 UV/Vis spectrophotometer after adding 1 ml oil sample, 2 ml Liebermann-Burchard reagent and 7 ml chloroform. Afterwards, cholesterol concentration of each sample was determined using a standard curve prepared by plotting the absorbance against mg/L cholesterol.

Determination of fatty acid profile

Fat extraction of meat samples

Fat extraction was carried out using Soxhlet extraction method as described by AOAC, (1990). A weighed portion (5g) of the homogenized sample was mixed with 60g of anhydrous sodium sulphate in mortar to absorb the moisture. The homogenate was placed in a 500ml beaker and extraction carried out with 300ml of n-hexane for 24 hours. Crude extract obtained was evaporated using a rotary vacuum evaporator at 40 ºC to dryness.

Fatty acid identification

Fatty acid analysis was done on gas chromatograph fitted with FID detector. SP™-2560 fused capillary column (100 m × 0.25 mm × 0.20 µm) was employed. Helium was used as a carrier gas at a flow rate of 0.8 ml/min. Both the injector and the detector temperature were set at 250 ºC. The oven temperature was programmed as follows: 60 °C held for 1 min, ramped at 15 °C/min to 165 ºC held for 1 min and finally ramped at 2 °C/min to 225 ºC held for 20 min.

Afterwards, the fatty acids were identified by retention time comparison to standard containing C4:0 – C24:0 saturated fatty acids (SFAs), C15:1 – C20:1 monounsaturated fatty acids (MUFAs), and C18 – C22 polyunsaturated fatty acids (PUFAs). This same standard was used for calculation of response factors, which were in turn used to calculate the levels of each fatty acid identified in the sample.

Statistical analysis

IBM SPSS Statistics version 20 was used to analyze the data collected. The data were subjected to one-way analysis of variance (ANOVA) at $p < 0.05$. Graphs were prepared using

GraphPad Prism 8.4.Results were expressed as mean ± standard deviation of quadruple determination.

RESULTS

Figure 1 present cholesterol concentration of torso meat (115.2±6.48 mg/kg), lean meat (94.7±2.27 mg/kg), skin meat (79.3 ± 6.30 mg/kg), intestine meat (74.9 ± 2.33 mg/kg) and stomach meat (67.76 ± 5.69 mg/kg), showing significantly elevated cholesterol in torso meat and lean meat samples and stomach meat showing the least concentration of cholesterol.

Figures 2 shows the saturated fatty acid (SFA) content of torso, skin, stomach, intestine and lean meats parts of cow meat. The saturated fatty acids (SFAs) detected are lauric acid C12, myristic acid C14, palmitic acid C16 and stearic acid C16. The study recorded highest concentrations of stearic acid (27.36±5.52 mg/kg in skin meat and 22.00±2.03 mg/kg in torso meat) and palmitic acid (18.76±4.36 mg/kg in lean meat and 12.60±3.20 mg/kg in stomach meat) compared to lauric and myristic acids. Lauric acid was significantly elevated in lean meat (5.65±1.38mg/kg) compared to torso, stomach, skin and intestine which showed no significant difference. Myristic acid content was significantly elevated in lean meat (10.98±2.96 mg/kg) compared to stomach, and intestine which also showed no significant difference, however myristic acid was not detected in torso and skin meats.

Figure 3 presents Oleic acid (C18:1) a monounsaturated fatty acid (MUFA) detected in all the meat parts. The oleic acid concentrations recorded for the meat parts include Skin (26.19±2.00 mg/kg), torso (24.33±5.50 mg/kg), lean meat (13.10±1.30 mg/kg), stomach 12.511±2.91 mg/kg) and intestine 4.02±0.86 mg/kg).

Figure 4a and 4b presents omega-6 fatty acids in each meat parts. Linoleic acid was prominent, with highest concentrations recorded in stomach meat (24.48±5.69 mg/kg) and

lean meat (16.70±1.32 mg/kg) and least in intestine meat (4.80±1.22 mg/kg). Arachidonic acid concentrations did not vary across the meat parts, with the highest concentrations recorded in skin meat (5.96±2.13 mg/kg) and lean meat (5.61±0.92 mg/kg). Stomach meat recorded the highest concentration of eisosadienoic acid (4.09±0.91 mg/kg) and torso meat the lowest (2.79±0.68 mg/kg), but was undetected in lean meat. Higher levels of dihomo-γ-linolenic acid was recorded in lean meat (8.60±1.03 mg/kg) compared to torso, stomach, skin and intestine which showed no significant difference. Tetracosapentaenoic acid concentration varied across meat parts, with intestine exhibiting the highest (7.76±0.46 mg/kg) and skin meat the lowest (2.02±0.24 mg/kg).

Figure 5 presents α-linolenic acid with significantly and high concentrations recorded in skin meat (16.00±2.52 mg/kg), lean meat (15.09±3.14 mg/kg) and Torso meat (12.69±2.07 mg/kg) and least amount in intestine meat (5.10±1.46 mg/kg).Eicosapentaenoic acid was undetected in stomach and lean meat. The concentrations of EPA recorded include; torso (4.98±1.37 mg/kg), skin (1.85±0.22 mg/kg) and intestine (3.96±0.81 mg/kg). A higher level of docosahexanoic acid was recorded in torso meat (14.44±4.30 mg/kg). The concentrations of DHA in other meat parts include; skin (7.78±1.28 mg/kg), stomach (2.55±0.34 mg/kg), lean meat (6.47±1.11 mg/kg) and intestine (4.66±0.83 mg/kg).

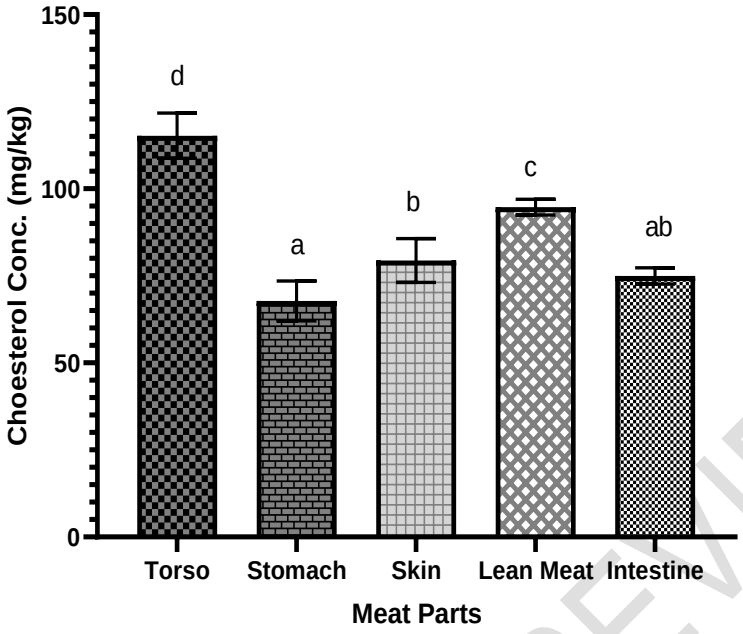

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Figure 1: Cholesterol distribution in Cow meat parts. Bars represent mean ± standard deviation of triplicate determinations. Bars with different alphabets are statistically significant ($p<0.05$).

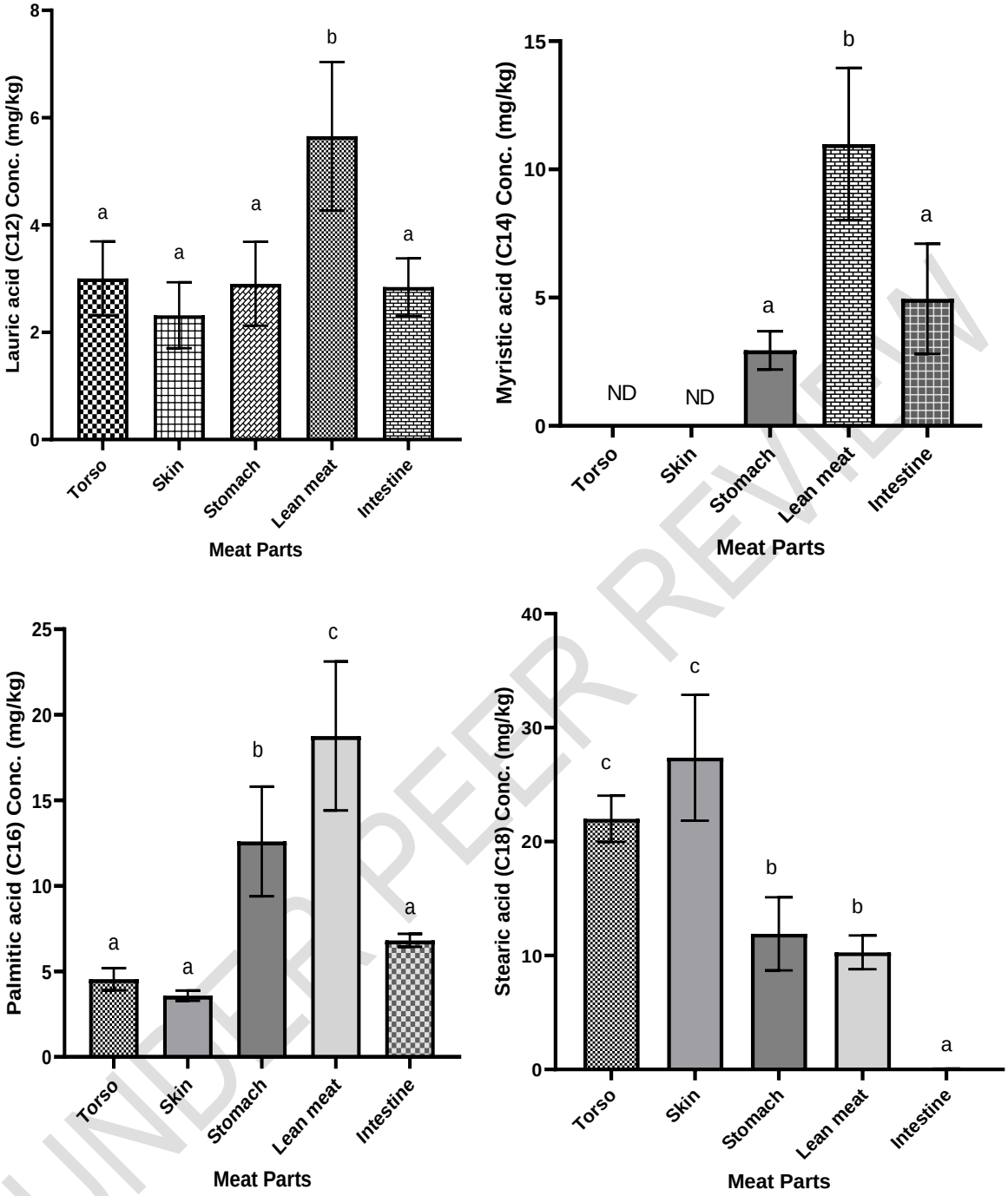

Figure 2: Saturated Fatty Acids (lauric,myristic, palmitic,and stearic acid) distributions in Cow meat parts. Bars represent mean ± standard deviation of triplicate determinations. Bars with different alphabets are statistically significant ($p<0.05$).ND = Not Detected

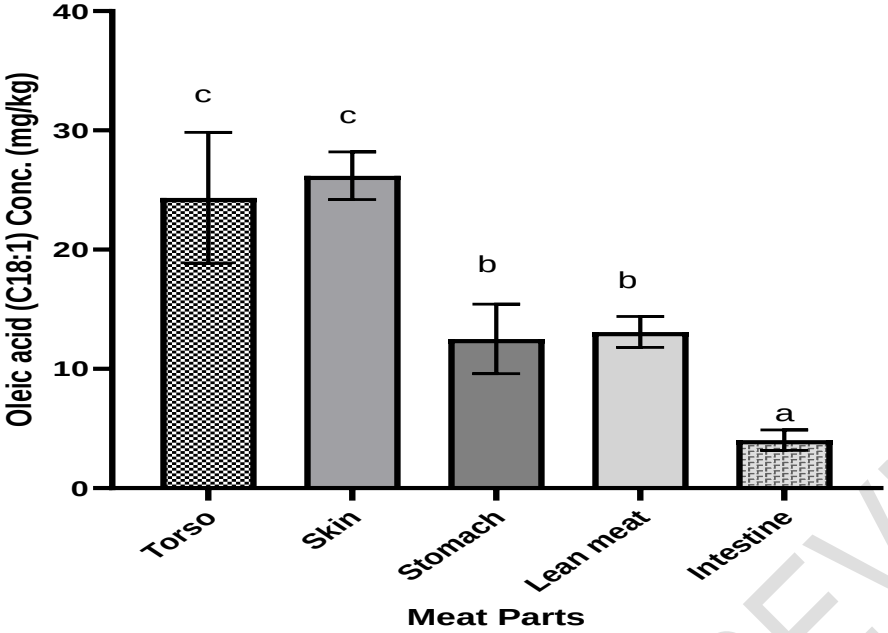

Figure 3 Monounsaturated fatty acid (MUFA) concentration distributions in meat parts. Bars represent mean ± standard deviation of triplicate determinations. Bars with identical alphabets are not statistically significant ($p>0.05$).

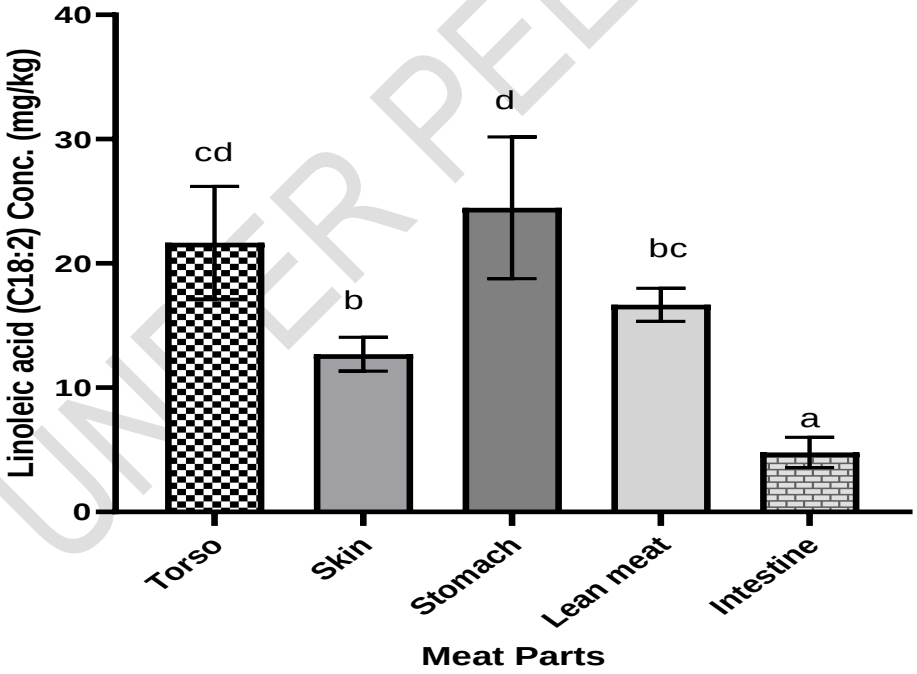

Figure 4a: Omega-6 fatty acids-linoleic acid concentration distribution in meat parts. Bars represent mean ± standard deviation of triplicate determinations. Bars with identical alphabets are not statistically significant ($p>0.05$).

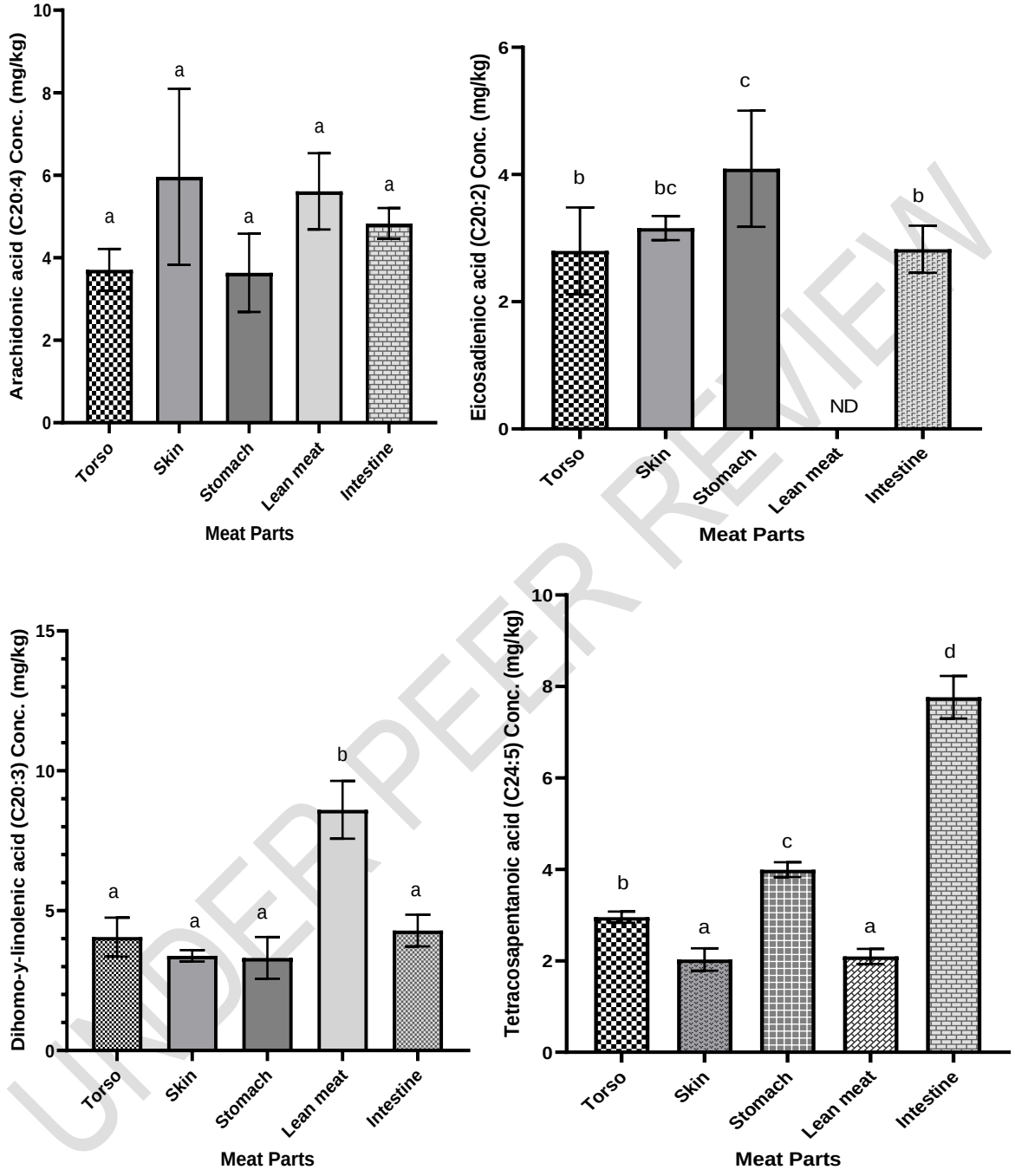

Figure 4b: Omega-6 fatty acids-Arachidonic,Eicosadienoic, Dihomo-γ-linolenic and Tetracosapentanoic acid concentration distribution in meat parts. Bars represent mean ± standard deviation of triplicate determinations. Bars with identical alphabets are not statistically significant ($p>0.05$).ND: Not Detected

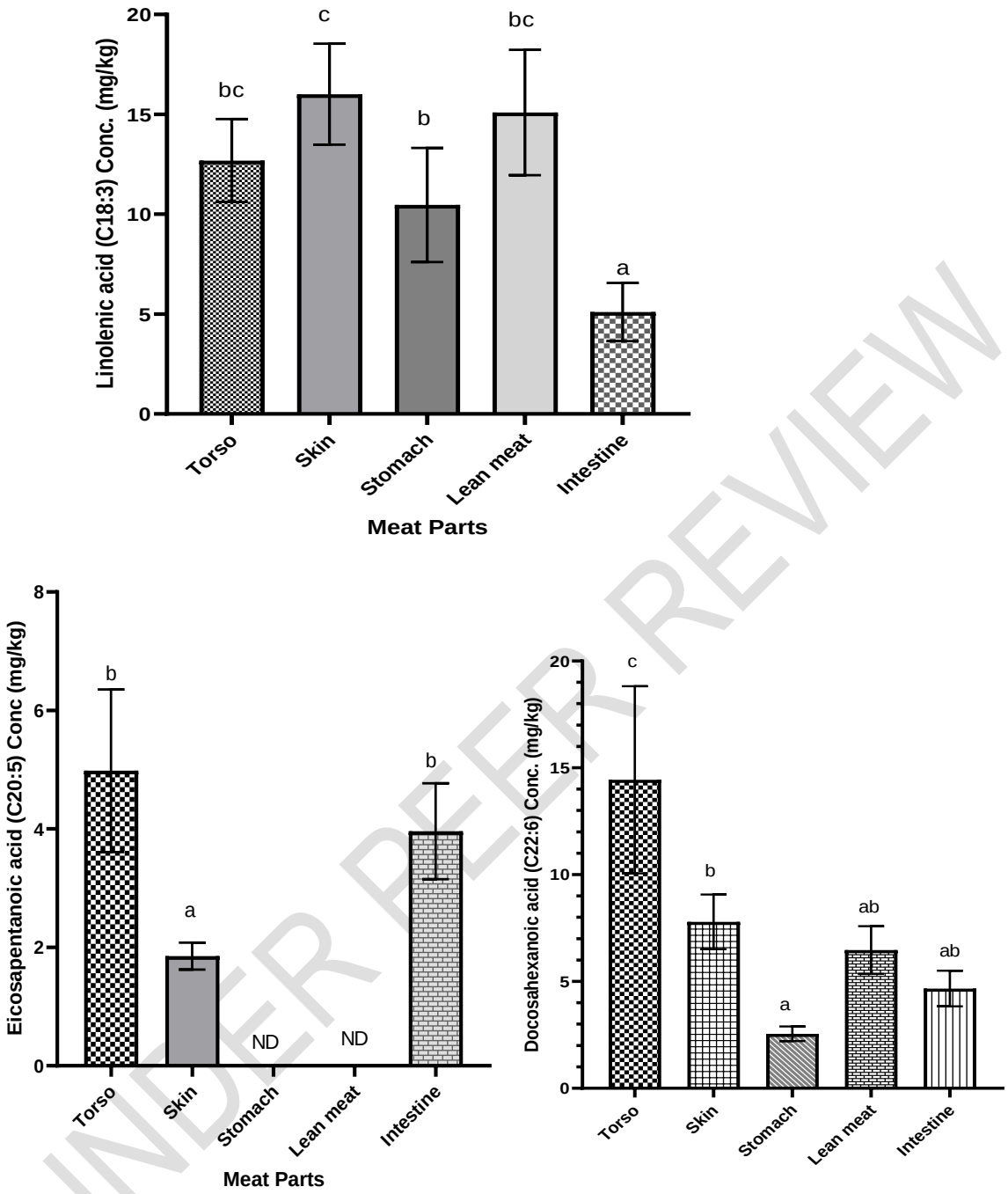

Figure 5: Omega-3 fatty acids-Linolenic, EPA, and DHA acid distributions in meat parts. Bars represent mean ± standard deviation of triplicate determinations. Bars with different alphabets are statistically significant ($p<0.05$).

DISCUSSION

Cow meat or Beef is a veritable source of protein and other essential nutrients, including cholesterol and saturated and unsaturated fats that can cause fatty deposits to build up in the blood. However, this common animal protein is also source of fats that can elevate the risk for high cholesterol, heart disease, and cardiovascular problems. In this study the nutritional value of the meat parts, particularly the cholesterol, fatty acid profile and lipid indices were assessed.

Cholesterol concentrations in the cow meat parts were recorded in the following order torso meat (115.2±6.48 mg/kg)> lean meat (94.7±2.27 mg/kg)> skin meat (79.3 ± 6.30 mg/kg) > intestine meat (74.9 ± 2.33 mg/kg) > stomach meat (67.76 ± 5.69 mg/kg). These results are above the values reported by Madu and Yakubu (2018) on total cholesterol in selected tropical cow meat parts in Ogun state, Nigeria. Also, the cholesterol content in this study are higher than those reported by Abonyi, Ogbu and Unigwe (2018) in muscle and edible offal of slaughtered pigs, goats and cattle at Nsukka Municipal abattoir.

Ruminant meat is characterized by high amount of saturated fatty acid (SFA) due to the ruminal bio-hydrogenation phenomenon (Ben-Abdelmalek et al., 2020) and it is possible to vary the FA composition by varying diet and the rearing system (Van-Harten et al., 2016; Margetin, Oravcová, Margetínová and Kubinec, 2018; Belhaj et al., 2020). In this study the method of rearing of the cow which meats were studied was by open grazing or free ranging. The recommended dietary intake of saturated fatty acids (SFAs) is noted to be below 10% of the total caloric intake. Excess saturated fat can cause cholesterol to build up within. The saturated fatty acids (SFAs) recorded in the cow meat parts studied in reducing order of magnitude include, lauric < myristic < stearic < palmitic in increasing order of magnitude. In the present study lean meat (5.65±1.38mg/kg) presented the highest amount of lauric acid

while the amount in torso, skin, stomach and intestine which ranged from 2.31±0.61 to 3.00±0.69 mg/kg showed no significant difference. High levels of SFAs (myristic, palmitic and stearic) have been reported by Dagne et al. (2021) in a study on the proximate composition and fatty acid profile of beef from three cattle breeds in Ethiopia. Lauric acid (LA; C12:0) a medium-chain saturated FA is implicated in having the largest cholesterol-raising potential among fatty acids. Lauric acid raises low-density lipoprotein-cholesterol (LDL-Cholesterol) and high-density lipoprotein-cholesterol (HDL-Cholesterol) (Mensink et al., 2003). However, the low levels of lauric acid in this study indicate no risk factor and support the methods grass feeding methods adopted by cattle breeders in Nigeria. Furthermore, studies have shown that excessive haemolysis of lauric acid induced Ca^{2+}-dependent premature RBC death can lead to anemia, at which any naked hemoglobin circulation may undergoes auto-oxidation or oxidation by other agents, precipitating inflammatory conditions (Dhaliwal et al., 2004; Alfhili&Aljuraiban, 2021).

Myristic acids was recorded in lean meat> intestine meat > stomach meat of the cows studied. The significantly elevated level of myristic acid in lean meat (10.98±2.96 mg/kg) than recorded in stomach and intestine in this study is a call for concern. Cow meatlLauric and myristic fatty acids are implicated in bad cholesterol elevations in blood and are strongly associated with early heart attack (Pećina&Ivanković, 2021). It is therefore suggested that limiting dietary myristic acid may be beneficial for those affected by elevated levels of atherogenic triglycerides in blood (Fernandez, 2020). The result of this study which show no recorded presence of myristic acid in torso and skin meat of cow and very low content in stomach meat and intestine meat of cow is a veritable information for individuals with elevated levels of serum atherogenic triglycerides to embrace, while limiting the consumption of lean meat that presented the highest concentration of myristic acid. Studies show that

moderate myristic acid consumption can improve long-chain omega-3 fatty acids concentrations in serum phospholipids, and also induce and improve cardiovascular health status of humans (Verruck et al., 2019)

Palmitic acid of levels lean meat (18.76 ±4.36 mg/kg) and stomach meat (12.60 ±3.20 mg/kg) were significantly higher compared to torso, skin and intestine meats. Palmitic acid makes up about 25% of the total fatty acids found in membrane phospholipids and triacylglycerols of adipose cells (Zhuang et al., 2019). The high level of palmitic acid recorded in lean meat and stomach meat is of serious health concern because these meat parts are very much consumed in Nigeria. Most Nigerians currently prefer the enteries of cow meat with the notion that they are of low fat content. However, the result of this study shows the contrary. The health risk of palmitic acid stems from its capacity to raise LDL-cholesterol due to its slow conversion to monounsaturated fatty acid (Brody, 1999). Stearic acid (18:0) levels in Skin meat (27.36±5.52 mg/kg) and Torso (22.00±2.03 mg/kg) were significantly higher compared to stomach and lean meats. It is reported that stearic acid (18:0) scarcely increases LDL-cholesterol levels, because after its absorption, it is rapidly converted to the monounsaturated oleic acid (18:1) (Brody, 1999). This implies that stearic acid express neutral effect on blood total and LDL-cholesterol levels as it is converted into oleic acid (18:1) in the organism without affecting the blood cholesterol levels (Ladeira et al., 2014). However, SFA (lauric, myristic and palmitic) with cholesterol-increasing properties are indicators of coronary heart disease (CHD) risks (Davis, Magistrali, Butler &Stergiadis, 2020).

The monounsaturated fatty acid (MUFA), Oleic acid (C18:1) presented the highest values of 26.19±2.00 and 24.33±5.50 mg/kg in Skin and Torso meat respectively and the intestine meat showing the least amount (4.02±0.86 mg/kg). Oleic acid reduces the level of LDL-cholesterol and increases the level of HDL-Cholesterol (Igenbayev et al., 2019). Oleic acid is reported to

regulate fatty acid and cholesterol biosynthesis by up-regulating AMP-activated protein kinase(AMPK), which readily phosphorylates and therefore inactivates acetyl-CoA carboxylase and 3-hydroxy-3-methyl-glutaryl CoA reductase two important enzymes of cholesterol biosynthesis. Activated AMPK stimulates the oxidation of fatty acids thereby reducing biosynthesis of cholesterol and triglycerides in hepatocytes and also prevent the development of fatty liver (Cheng et al., 2018; Zhang et al., 2021).The presence of Oleic acid is associated with slow progression of heart diseases and promotes antioxidant activity (Hur et al., 2005). However, individual responses to dietary fats can vary, and other dietary and lifestyle factors may as well determine overall cardiovascular health.

Linoleic and α-linolenic were the predominant PUFAs recorded in this study. The stomach meat (24.66±5.79 mg/kg) and Torso meat (21.66±4.54 mg/kg) and lean meat (16.70±1.32 mg/kg) presented the highest amount of linoleic acid. However, Skin meat (16.00±2.52 mg/kg), and lean meat (15.09±3.14 mg/kg) and Torso meat (12.69±2.07 mg/kg). These results indicate the varying distribution of concentrations of linoleic and α-linolenic in cow meat samples. Linoleic acid (LA) a primary omega-6 PUFA is vital in maintaining the fluidity and integrity of cell membranes, for proper cellular function and signal transduction. The result of the present study shows that the meat samples can adequately provide linoleic acid aprecursor PUFA needed for the synthesis of other omega-6 fatty acids, which include arachidonic acid (AA), and eicosanoids, which are important signaling molecules involved in inflammation, blood clotting, and immune response (Simopoulos, 2016).Appreciable amounts of arachidonic acid (AA) 3.63±0.95 - 5.96±2.13 in Stomach meat and Skin meat respectively, andeicosadienioc acid (C20:20) 4.09±0.91 – 2.80±0.68mg/kg in Torso to stomach meat respectively. Similarly,alpha-Linolenic Acid (ALA) a primary omega-3 PUFA essential for human health and can be converted systemically to eicosapentaenoic acid (EPA)

and docosahexaenoic acid (DHA). Appreciable amounts of omega-3 fatty acids—eicosapentaenoic acid (EPA); Torso (4.98±1.37mg/kg) and intestine (3.96±0.81mg/kg) (Figure 5) and docosahexaenoic acid (DHA); Torso (14.44±4.38mg/kg), Skin (7.78±1.28mg/kg) and lean meat (6.47±1.12mg/kg) (Figure 5), were also recorded in this study. The recording of these essential PUFA in the meat samples studied is encouraging because these fatty acids have anti-inflammatory properties and are capable of improving cardiovascular health and brain function of consumers. Omega-3 fatty acids and ALA can contribute in lowering blood pressure, reduce triglyceride levels, and improve blood vessel function. Docosahexaenoic acid (DHA) is essential for proper development of the nervous system in infants and may promote cognitive function in adults (Mozaffarian & Rimm, 2006).

Furthermore, a closer look of the PUFA results of this study show a total LA (omega-6 fatty acids) concentration at 80.28 mg/kg that was significantly higher than 59.34 mg/kg for ALA (omega-3 fatty acids). It is important to note that while omega-6 fatty acids are essential, excessive intake relative to omega-3s could result to pro-inflammatory effects that have the potential to cause chronic health conditions. At high concentration omega-6 fatty acids, especially linolenic can be converted into arachidonic acid, a building block for molecules known to promote inflammation, blood clotting, and the constriction of blood vessels.

Also, high omega-6 intake is associated to elevated risk of inflammatory diseases, which include cardiovascular disease, diabetes, and inflammatory disorders. Furthermore, Lower levels for eicosadienic, arachidonic, docosahexaenoic (DHA), dihomo-γ-linolenic, eicosapentaenoic and tetracosapentaenioc were observed in this study.

Conclusion

A diet high in saturated fat can lead to high LDL cholesterol levels and further lead to plaque buildup in the walls of arteries. This restricts blood flow and can lead to a heart attack or stroke. This study recorded the highest cholesterol concentration in torso meat and lean meat as well as saturated fatty acid such as palmitic, lauric and myristic acid lean meat of cow at significantly elevated level compared to other meat parts**.** Although, the meat parts contain beneficial unsaturated fatty acids which can contribute consistently to our diets, not only in terms of essential fatty acids such as linoleic acid and alpha-linolenic acid but also oleic acid, arachidonic acid, eicosapentaenoic acid and docosahexanoic acid. Understanding the variations in lipid contents of the meat parts provides valuable insights for managing dietary choices and reducing cardiovascular risks associated with elevated cholesterol levels.

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