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NUTRITIONAL ASSESSMENT AND ANTIOXIDANT POTENTIAL OF SELECTED MEAT TYPES CONSUMED IN OWHELOGBO, DELTA STATE, NIGERIA

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Abstract

The present study aims at evaluating the nutritional value and antioxidant potential of various meat types (beef, pork, chicken, catfish and snails) consumed in Owhelogbo, community in Isoko Local Government, Delta State, Nigeria. The different meat samples were analyzed for nutritional composition and antioxidant properties. The results obtained show that the protein content varied from 20.09 to 61.74%, while the fat content varied from 2.00 to 12.08%. The calcium content ranged from 10.30 to 143.73 mg/100 g, while the phosphorous content ranged from 100.85 to 300.11 mg/100g. The linoleic acid content was in a range from 10.91 to 29.54%, while the linolenic acid content ranged from 0.84 to 5.53%. The content of vitamin A and vitamin D varied from 4.61 to 110.69 μg/100g and 2.15 to 18.05 μg/100g, respectively. The DPPH free radical scavenging ability and FRAP inhibitory activities of the different meat types ranged from 50.84 to 65.64% and 0.88 to 1.59%, respectively. The levels of high density lipoprotein and low density lipoprotein were in a range from 13.34 to 21.90 mg/dL and 2.30 to 5.59 mg/dL, respectively. The level of low density lipoprotein was the lowest in snail meat (SN), which suggests that it may be useful in managing obesity and preventing disorders linked to lipids. Consequently, the results conclude that snail meat may be a more valuable and innovative source of animal protein than beef, pork, chicken, and catfish.

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Introduction

Consuming enough protein is crucial for growth and well-being. Because of its amino acid composition and ease of digestion for humans, animal-derived protein is frequently of higher quality [1]. Although consuming too much protein has been connected to a higher risk of developing diabetes mellitus, milk and seafood are excellent sources of taurine and other amino acids that help with blood pressure and glucose metabolism. When consumed moderately, animal proteins are especially important for the health of those who are more vulnerable [2].

However, excessive consumption of animal foods high in protein is associated with poor health outcomes and a higher risk of metabolic and physiological abnormalities as well as diet-related non-communicable diseases (NCDs). These effects are partially attributed to several food ingredients such as potential carcinogens and saturated fats of processed meat, as well as the atherogenic methionin

metabolite homocysteine. Consuming foods high in saturated and trans fatty acids (TFA and SFA) is linked to the risk of cardiovascular diseases (CVDs) [2,3]. Around 70% of mortality and mobility worldwide are attributed to NCDs, and over 75% of annual deaths in Nigeria are caused by NCDs [4].

Polyunsaturated fatty acids (PUFA), such as omega-3 (n-3 PUFA) and omega-6 (n-6 PUFA), are crucial because of the diversity of fatty acids present in food. Two types of important fatty acids (EFA) are linoleic acid (LA) and alpha-linolenic acid (ALA) that are not synthesized by the human body and are included in the omega fatty acid group [5]. Furthermore, naturally occurring sterols (mostly phytosterols and cholesterol) that are important for human health make up the unsaponified fat fraction in food. To avoid chronic diseases linked to nutrition, the World Health Organization advised consuming no more than 300 mg of cholesterol per day to avoid chronic diseases linked to nutrition [6].

Blood plasma of all animals contains cholesterol, a lipid — waxy (fat-like) steroid that is present in cell membranes [7]. It is a crucial component of body cells and is involved in the synthesis of several hormones as well as fat digestion. When exposed to sunshine, a specific type of cholesterol found in the skin called 7-dehydrocholesterol can transform into vitamin D [8]. Two distinct types of cholesterol exist: serum cholesterol, or blood cholesterol, which is largely produced by the body and circulates in the blood and dietary cholesterol, derived from animal-based foods and beverages [9]. It is a necessary component of mammalian cell membranes to establish appropriate membrane permeability and fluidity [10]. Awareness of the link between dietary cholesterol and human disease has fueled research in food cholesterol content since the relationship between plasma cholesterol levels and atherosclerosis was shown in rabbits in 1913 [11]. Cholesterol has consequently gained significance in composition research on meat and poultry products. One essential lipid component that has been viewed as bad for human intake is cholesterol, which is thought to have harmful impacts on health. More precisely, meat products, especially red meat are a source of public concern [12].

Red meat, which is a popular product among most people globally, comprises edible animal muscle from sheep, pigs, cows, and several other animal species. Some groups, however, have been advocating for the consumption of plant-derived foods in place of animal-derived foods in recent years [13]. Red meat is regarded as a source of high-quality protein in addition to numerous other healthful nutrients like fatty acids, vitamins, minerals, and molecules regulating different biological responses [14]. On the other hand, excessive consumption of red meat may also lead to lipid metabolic abnormalities, inflammatory reactions, and maybe chronic disorders. Excessive ingestion of cholesterol and saturated fats alters serum total cholesterol levels. High serum cholesterol builds up in macrophages and triggers the NLRP3 inflammasome via the NF-κB signaling pathway [15]

Dyslipidemia is gaining global attention and has been shown to be a significant risk factor for cardiovascular and metabolic diseases, as well as the underlying cause of stroke and other life-threatening illnesses [16]. It has been demonstrated in recent years that aberrant lipid metabolism is caused by chronic inflammation [17]. Inflammation is caused by oxidative stress, and a study on red meat consumption found that eating red meat may alter oxidative stress, which in turn may cause inflammation and related disorders [18]. Furthermore, red meat — especially the cuts with a high myoglobin content — is the main source of serum iron. The overabundance of iron ions in the body can exacerbate an inflammatory response and cause oxidative stress [19]. Low-density lipoprotein cholesterol (LDL–C) and other lipoproteins in the blood can reach the artery intima through circulation, and an accumulation of lipoproteins in the arterial intima can cause pathological alterations and inflammation that endanger people's lives and health [20].

About 30% of pork flesh is fat, with a substantial proportion of saturated fats. Consuming excessive amounts of saturated fatty acids raises cholesterol levels and causes concerns about the possibility of hyperlipidemia, which can lead to cardiovascular disorders [21]. In other words, of all meats from farm animals, pork is the hardest to digest if not properly cooked. Moreover, the red-meat derived non-human sialic acid, N-glycolylneuraminic acid (Neu5Gc), is present in pig meat. Several studies demonstrated a relationship between consumption of red-meat derived Neu5Gc and inflammation, cancer, cardiovascular and autoimmune diseases [22].

Pork poses a health risk to humans due to its high cholesterol, high fat content, and high levels of bacteria, toxins, viruses, and parasites, all of which can cause a variety of illnesses and disorders [23]. For instance, approximately 40 different kinds of parasites and at least 30 diseases can be carried by feral pigs, which has an impact on both human and animal health. Pigs can spread numerous waterborne or foodborne illnesses to humans [24].

Among the most popular muscle foods consumed worldwide are turkey and broiler chickens in particular. They are a significant source of nutrients and dietary energy, including critical fatty acids, vitamins, high-quality proteins, and minerals that are highly bioavailable [25]. Due to their delicious flesh, ducks and geese also play a significant role in Eastern and Western Europe, as well as in Southeast and Eastern Asia.

According to Kim et al. [26], 40% of meat consumed globally in 2022 was poultry. Global poultry consumption increased by 287% during the period from 1990 to 2022. The main initiatives to enhance the quality of poultry carcasses and the nutritional content of meat are the rise in muscle percentage and the decrease in carcass fat content through rigorous restriction and selection [27].

The high fat content, especially saturated fatty acids, which significantly boost the possibility of cardiovascular illnesses and various types of cancer, has drawn criticism [28].

Catfish is nutrient-dense and extremely high in unsaturated fatty acids, vitamins, proteins, and minerals. Customers place a great priority on the nutritious content of fish meat. In addition, it contains a high concentration of fat-soluble vitamins and microelements, and omega-3 fatty acids, among other nutrients [29]. Consequently, there is a constant increase in the market for fish meat. Conversely, there is a declining global supply of fish and seafood. As a result, the interest in fish farming and aquaculture has increased [30].

The pulmonate, nocturnal, hermaphrodite African land snails (*Archachatina marginata*) belong to the *Achatinidae* family of gastropods. They are native to Africa and can be found throughout sub-Saharan Africa, from the eastern region of Lake Chad to the western Gambia. Their range reaches the Orange River in South Africa [31] in the south. Achatina (Lamarck) and Archachatina (Albers) are the two primary genera that comprise the enormous African land snails. The former is found across Africa, whilst the latter is only found in the sub-region of West Africa [32].

In most humid tropical locations, snails can be found in freshwater, marine, and terrestrial settings. Although a small number of land species and several marine species may be omnivores or carnivores, the majority of them are herbivores that graze on green vegetation, such as fruits and vegetables, on farms [33]. The habitat of land snails in Nigeria spans from the southern region's dense tropical high rainfall forest to the derived Guinea savannah's fringe riparian forests [31]. In Nigeria and certain other parts of Africa, land snails constitute a traditional source of protein for wildlife. The mollusks' protein content and chemical score are superior to those of the egg [34].

Snail flesh is considered a delicacy and is rich in nutrients. Due to its unique flavor, it is a top choice in lodging facilities and dining establishments. Many reports have said that it is a unique meat that can be used to cure kidney-related illnesses and hypertension [35]. According to [36], snails are a rich source of protein, omega-3 fatty acids and vitamins. In addition, the necessary amino acids lysine, leucine, isoleucine, and phenylalanine are all present in good balance in snail meat. Due to the widespread belief in its effectiveness in treating specific ailments, haemolymph, a bluish liquid obtained from snails, is frequently used in African traditional medicine. According snail is abundant in iron and copper, which are critical for oxidative phosphorylation and the synthesis of cellular energy [37].

The aim of this current investigation was to compare the nutritional and cholesterol level of selected meat/fish/ commonly consumed in Owhelogbo community, Delta State.

Materials and methods

Sources of material

The meat samples, namely beef, pork, chicken, catfish and snails, used in this study were bought from Owhelogbo market in Delta State, Nigeria. The reagents used for the analyses were of a high grade and quality, and were purchased from Pascal Scientific limited, Akure, Ondo State.

Study area and sites

Owhelogbo is an Isoko town located in Delta State's Isoko North Local Government Council between latitudes 50 351 N and 50 401 N and longitudes 60 181 E and 60 241 E. Its borders are as follows: Abbi to the south, Otor Owhe to the north, Ozoro to the east, and Orogun to the west.

Sample preparation

Processing of beef, pork, chicken meat and catfish meat

Samples of beef (BF), pork (PK), chicken meat (CHK) and catfish meat (CF) were rinsed with clean water to remove blood. Then, they were deboned, cut into small slices and weighed to about 4 g each. After that, the meat samples were boiled in clean water for 30 min. The boiled meat samples were dried in an oven at 62 °C for 60 min. and stored in an air tight zip lock polymer sack at a temperature of 0 °C in a refrigerator for further analysis.

Processing of snails

Snails (SN) were killed by breaking the shell and the content were removed carefully. Then, the snails were washed with alum and clean water to remove the slimy material. After that, the snails were cut into small slices and weighed to about 4 g each. The snails were boiled in clean water for 30 min. The boiled snails were dried in an oven at 62 °C for 60 min. and stored in an air tight zip lock polymer sack at a temperature of 0 °C in a refrigerator for further analysis.

Determination of proximate composition

The levels of moisture, ash, fat, and protein in the popcorn samples were estimated using methods from the Association of Official Analytical Chemists [38]. To calculate total amount of carbohydrates, the percentages of fat, protein, and ash were deducted from 100%. When determining the energy value, the percentages of crude protein, crude fat, and carbohydrate were multiplied by the required factors (2.44, 8.37, and 3.57, respectively), as shown by [39], to calculate the calorific value (in kcal/g) of the sample.

Determination of mineral composition

Using an Atomic Absorption Spectrophotometer AAS Model SP9, (Scitek, China), the values of calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), and zinc (Zn) were determined. NaCl and KCl were used as standards to calculate the amounts of sodium (Na) and potassium (K) in the meat samples using a flame emission photometer Sherwood Flame Photometer 410 (Sherwood Scientific

Ltd., Cambridge, UK) [40]. Using the Vanado-molybdate colorimetric method, phosphorus was determined. Additionally, the molar ratios of Na/K, Ca/Mg, and Ca/P were computed.

Determination of fatty acid composition

The different meat samples were extracted using a 2:1 v/v ratio of chloroform to methanol, and any solid material was eliminated using filtration. After the solvent was removed, the entire extracted lipid content was recovered in a nitrogen stream. After being redissolved in anhydrous chloroform/methanol (19:1 v/v), the samples were centrifuged at 10,000 x g for 10 minutes to remove any remaining particles (Centrifuge 5702 R, Eppendorf, United States). A methanol solution containing 14% (w/v) boron triflouride (BF3) was used to achieve tranmethylation. A 15 mL Teflon-lined screw-cap tube was filled with an aliquot of each sample and fifty nanograms of heptadecanoic acid (the internal standard). Following nitrogen gassing to remove the solvent, the samples were combined with 0.5 ml of 14% w/v BF3 reagent, warmed to 100 °C for 30 mins, and then cooled [40]. Hexane was used to extract the transmethylated fatty acids following the addition of saline solution. Parallel processing was done on a calibration mixture of fatty acid standards. Gas chromatography was used to evaluate aliquots from the hexane phase. A Hewlett-Packard gas chromatograph (5890 Series II, Gentech, United States) fitted with a flame-ionization detector was used to separate and quantify fatty acids. An Omegawax (30 m x 0.32 mm ID, Supleco, Bellefonte, PA) fused silica capillary column was injected with a two microliters split-mode aliquot of the hexane phase. Temperature settings for the injector were 200 °C, detector 230 °C, oven 120 °C at first, and 120–205 °C for eighteen minutes. Helium served as the carrier gas, and the flow rate was roughly 50 cm/sec. The constant flow mode of electronic pressure control was employed. The quantification of fatty acids in the lipid extracts was done using the internal standard (heptadecanoic acid, C17:0) and the calibration standards (NuCheck, Elysian, MN). The fatty acids listed are the mean of the three calculations. Total saturated fat (SFA), monounsaturated fat (MUFA), polyunsaturated fat (PUFA), PUFA/SFA, n-6/n-3, and MUFA/SFA were among the other fatty acid characteristics that were computed [41].

Determination of vitamin composition

Vitamins A, D, E and K were determined using UV-visible spectrophotometer (SP-UVG752, Scitek, China) [42].

Cholesterol estimation

Determination of cholesterol content

A 1-g homogenized sample was combined with 9 ml of ethanol and 1 mL of 33% KOH solution, and the mixture was well stirred for 20 secs. Afterwards, the sample was allowed to cool, 5 ml of deionized water was added, and it was agitated for a duration of two minutes in order to saponify the non-sterol lipids. The contents were shaken and centrifuged (Centrifuge 5702 R, Eppendorf, United States) for three minutes at 358xg after 10 mL of hexane was added. With caution, the top layer was detached and moved to a fresh flask. Following the addition of 10 mL hexane to the residual portion, each sample underwent a 3-minute centrifugation at 358xg. After being separated, the top layer was moved to the appropriate flasks. Each sample tube was then filled with 6 mL of Liebermann-Burchard reagent. After 30 minutes at room temperature, the absorbance of the tubes was evaluated in comparison to a blank that had been made in a similar manner but did not contain the sample [43].

Determination of antioxidant properties

Using a stirring plate (HPS-280, China), 10 g of the ground sample was hydrated in 100 ml of double-distilled water for 24 hrs to produce an aqueous extract of the various meat samples. After centrifuging the sample for 20 minutes at 9000 g, the supernatant was filtered and kept at 4 °C for additional analysis.

Determination of 2, 2-diphenyl-1-picryl hydrazyl radical (DPPH) radical scavenging activity

Using the procedure outlined by [44], the scavenging activity of the extract from the various meat samples against the DPPH radical was assessed. Samples were combined with 1% (w/v) Triton-X in 0.1 M sodium phosphate buffer (pH 7.0). Methanol was added to DPPH until it reached a final concentration of 100 µM. In a 96-well plate, microplate (DR-200B, Diatek, China), a 100 µl aliquot of each sample was combined with 100 µl of the DPPH radical solution, and the mixture was incubated for 30 mins at room temperature in the dark. The positive control in the experiment was reduced glutathione (GSH), and the blank was the buffer. Using a microplate reader (DR-200B, Diatek, China), absorbance was measured at 517 nm, and the following equation was used to calculate the percentage of DPPH radical scavenging activity.

$$DPPH\ radical\ scavenging\ activity\ (\%) = \\ = \frac{Absorbance(blank) - Absorbance(sample)}{Absorbance(blank) \times 100} \quad (1)$$

Determination of hydroxyl (OH) free radical scavenging activity

The ability of the extracts to scavenge hydroxyl radicals was assessed using the technique [45]. One milliliter of various extract concentrations (2–10 mg/ml), 1.0 ml of iron-EDTA solution (0.13% ferrous ammonium sulphate, 0.26% EDTA), 0.5 ml of 0.018% EDTA, 1.0 ml of DMSO (0.85% in 0.1 M phosphate buffer pH 7.4), and 0.5 milliliters of 0.22% ascorbic acid were included in the reaction mixture. After sealing the tubes securely and heating them in a water water bath WB-1R2H-7 (Infitek, China) bath at 80 to 90 °C for 15 min, 1.0 ml of ice-cold TCA (17.5%) was added to

stop the reaction. 3.0 ml of the Nash reagent (75.0 g of ammonium acetate, three milliliters of glacial acetic acid, and 2.0 ml of acetyl acetone) was added to the reaction mixture mentioned above. Distilled water was added to make a total volume of 1 L. The mixture was then incubated at room temperature for 15 mins to allow for the development of color. The intensity of the yellow color was evaluated at 412 nm using a UV-visible spectrophotometer SP-UVG752 (Scitek, China) in relation to a blank for the reagent. Gallic acid and ascorbic acid were utilized as benchmarks [46].

Determination of Ferric reducing antioxidant power (FRAP) assay

With some modifications, the ferric reducing antioxidant power (FRAP) test was carried out according to [47] instructions. After heating 30 ml of freshly prepared FRAP reagent to 37 °C and reading at 593 nanometers for the reagent blank, 100–150 microliters of each sample were added, and the volume was made up to a total volume of 1ml with distilled water. After 0 sec and 4 min, absorbance (A) values were obtained using a Jenway Vis Spectrophotometer 6305 (Fisher scientific, UK). After that, the absorbance (A593 nm) change for each sample between the final reading chosen and the blank reading was calculated calculated for each sample and correlated with the absorbance (A593 nm) of a Fe^{2} standard solution that was tested concurrently. The 4-minute data were chosen so that the FRAP values could be computed [46].

Determination of Fe^{2+} chelating ability

The chelating activity of the proteins and extracts on Fe^{2}+ was determined [48], methodology with minor adjustments. An amount of 200 µL sample aliquots was combined with 740 µL of deionized water and 20 µL of the 2 mM $FeCl_2$ solution, then allowed to stay at room temperature for 30 minutes. Following the incubation period, 200 µL of 5 mM ferrozine was added, and the mixture was left standing under the same conditions for a further 10 min. The absorbance was measured at 562 nm using a UV-visible spectrophotometer (SP-UVG752, Scitek, China). Instead of using the sample, distilled water without sample aliquots was used as a control. The capacity to chelate metals was computed [46].

Determination of 2, 2′-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid (ABTS)

With a few minor adjustments, the scavenging activity was calculated using the methodology outlined by [49]. The ABTS solution had 2.5 mM potassium persulfate and 7 mM ABTS and had been made 12 hours before it was used. After obtaining an absorbance of 0.7 ± 0.02 at 734 nm, the obtained solution was diluted with 200 mM phosphate buffer pH 7.4 and 4 mL of the diluted solution was combined with 40 mL of extract solution 0.1 mg/mL using a UV-visible spectrophotometer SP-UVG752 (Scitek, China). After ten minutes, the absorbance at 734 nm was measured using water as a control instead of the sample [46,49].

Determination of total phenols

Gallic acid was used as a reference when determining the total phenol content (TPC) using the Folin–Ciocalteu test [50]. A test tube was filled with 50 µl of an aqueous extract solution containing 0.5 milligrammes of aqueous extract. The test tube was well shaken after adding 500 µL of Folin-Ciocalteu reagent and 50 µL of distilled water. After three minutes, 400 µL of a 7.5% sodium carbonate solution was added, and the mixture was incubated for 40 min at 45 °C in a water bath (WB-1R2H-7, Infitek, China). At 765 nm, the absorbance was measured in relation to a blank. Using the normal 0.1 mg/mL gallic acid solution, the process was repeated. 400 µL of 7.5% sodium carbonate, 500 µL of Folin-Ciocalteu reagent, and 100 µL of distilled water are combined to create the blank. Using the gallic acid calibration curve, the total phenolic content was determined and represented as mg of gallic acid equivalent per gramme of sample (mg of GAE/g sample).

Ethical approval

30 Wister rat was used in the study. Before performing the experiment, it was approved ethically. The protocol for managing laboratory animals during the study was adhered to. Ethical approval was obtained from the Faculty Research Ethics Committee, Faculty of Science, Delta State University of Science and Technology, Ozoro (Ethical approval number: FOS/DSUST/24/0117). The research was carried out according to the guidelines of the ethics committee and the protocol was approved by FOS/DSUST/24/0117.

Statistical analysis

Three separate analyses were conducted, and one-way analysis of variance (ANOVA) was employed to examine the data using SPSS (21.0) software. The means were compared using the New Duncan's Multiple Range Tests (NDMRT), and significance was declared at the 5% level. Graphs were plotted using GraphPad Prism 6.

Results and discussion

Proximate composition and energy value of the different meat types

The proximate composition of the different meat types is shown in Table 1. The composition of moisture, ash, fat, fiber, protein, carbohydrates and energy content of the different meat types ranged from 5.88 to 9.04%, 0.54 to 2.99%, 2.00 to 12.08%, 0.38 to 1.34%, 15.61 to 61.74%, 23.73 to 70.31% and 362.94 to 417.20% respectively with significant (at $p < 0.05$) differences among them. These results are consistent with previous research. The result from moisture content showed that SN had the lowest moisture content, while the highest value was in BF. All of the meat samples had low moisture content, which indicates their strong potential stability [51]. With correct packaging, meat samples can be kept fresher for longer. In such

Table 1. Proximate composition (g/100 g) and energy value (kcal/ 100 g)

Parameters	BF	PK	CHK	CF	SN
Moisture	9.04 ± 0.02^{a}	8.78 ± 0.04^{b}	8.55 ± 0.03^{c}	7.04 ± 0.04^{d}	5.88 ± 0.05^{e}
Total ash	1.70 ± 0.03^{b}	0.79 ± 0.02^{d}	1.10 ± 0.10^{c}	0.54 ± 0.02^{e}	2.99 ± 0.05^{a}
Crude fat	2.02 ± 0.03^{d}	12.08 ± 0.05^{a}	2.00 ± 0.02^{d}	5.66 ± 0.04^{b}	4.32 ± 0.04^{c}
Crude fibre	1.05 ± 0.03^{c}	1.23 ± 0.03^{b}	0.38 ± 0.01^{e}	0.84 ± 0.05^{d}	1.34 ± 0.03^{a}
Crude protein	20.09 ± 0.20^{c}	20.11 ± 0.03^{c}	28.15 ± 0.50^{b}	15.61 ± 0.04^{d}	61.74 ± 0.06^{a}
Carbohydrates	66.10 ± 1.21^{b}	57.01 ± 1.10^{c}	59.82 ± 1.04^{c}	70.31 ± 1.02^{a}	23.73 ± 1.11^{d}
Energy	362.94 ± 3.21^{e}	417.20 ± 2.11^{a}	369.88 ± 2.11^{d}	394.62 ± 2.22^{b}	380.76 ± 2.03^{c}

Note: Means (± SEM) with different alphabetical superscripts in the same row are significantly different at P<0.05.
Key: BF: beef; PK: pork; CHK: chicken (broilers); CF: catfish; SN: snails.

circumstances, water-catalyzed or facilitated biological and chemical modification reactions are prevented [51].

The result from ash content analysis showed that CF had the lowest value, while SN had the highest value. The high ash content of SN may be due to the fact that snails are a rich source of minerals [52]. Since ash is the inorganic residue left over after water and organic matter are removed through heating in the presence of an oxidizing agent, the amount of ash in food materials can be utilized as an indicator of the mineral elements in those materials [53]. The result from crude fat determination showed that CHK had the lowest value, while PK had the highest value. The high fat content of PK may be attributed to the high fat content of pork meat. Pork is known to be very rich in fat [54]. The low fat content of the SN samples may be due to the low fat content in snails, which might be a reason for its recommendation as a safe animal fat and protein for those with kidney disease and blood-related illnesses [55].

Interestingly, the result from crude fiber determination showed that CHK had the lowest value while SN had the highest value. The fiber contents of all the different meat in this study were lower when compared to 2.75–3.56% previously reported by [56]. The consumption of food with adequate dietary fibre has been linked with the reduced risk of obesity, diabetes and coronary heart diseases [57].

The result from the determination of the crude protein content showed that SN had the highest value, while CF had the lowest value. The percentage of protein in all the meat samples, particularly the snail meat, shows that it is a good source of protein. According to [34], snails are high in omega-3 fatty acids, protein, and vitamins. Futhermore, the necessary amino acids lysine, leucine, isoleucine, and phenylalanine are all present in good balance in snail meat.

Meanwhile, the result from carbohydrates content showed that CF had the highest value while SN had the lowest value and this may be attributed to the high carbohydrate content of catfish [58]. The findings were consistent with those of [59]. The obtained carbohydrate contents in this study (23.73–70.31%) agreed with the previous finding of [60] that snail flesh is a delicate delicacy that is easy to eat and appetizing for the elderly without posing a health risk. The result from the energy content analysis showed that PK had the highest value, while BF had the lowest value. Pork meat is known to have the high energy content [61]. This result aligns with the result of other authors [62]. This opinion is also shared by [63], who said that eating snail meat lowers the chance of developing chronic illnesses, prevents clinical inadequacies in the elderly, and promotes overall health.

Mineral composition of the different meat types

The data in Table 2 show the mineral composition of the different meat types. The outcome demonstrated that the various meats had significantly different mineral compositions ($p < 0.05$). The portion of ingested nutrients that can be used for storage and regular bodily processes is known as nutrient bioavailability [64]. The mean values of the calcium, magnesium, phosphorous, potassium, sodium, iron, zinc, copper and manganese content of the different meat types ranged from 10.30 to 143.73 mg/100 g, 34.73 to 309.59 mg/100g, 100.85 to 300.11 mg/100g,

Table 2. Mineral composition (mg/100 g)

Parameters	BF	PK	CHK	CF	SN
Ca	15.10 ± 0.10^{d}	10.30 ± 0.08^{e}	127.51 ± 0.20^{b}	143.73 ± 0.11^{a}	103.62 ± 0.20^{c}
Mg	53.00 ± 0.11^{c}	34.73 ± 0.12^{e}	114.55 ± 0.31^{b}	41.87 ± 0.11^{d}	309.59 ± 0.19^{a}
P	117.37 ± 0.13^{d}	300.11 ± 0.51^{a}	221.90 ± 0.43^{c}	100.85 ± 0.21^{e}	271.41 ± 0.16^{b}
K	200.76 ± 0.83^{b}	302.53 ± 0.51^{a}	118.20 ± 0.01^{d}	190.21 ± 0.33^{c}	112.31 ± 0.51^{e}
Na	30.15 ± 0.13^{e}	76.41 ± 0.42^{a}	55.78 ± 0.19^{c}	41.89 ± 0.15^{d}	64.61 ± 0.30^{b}
Fe	30.24 ± 0.11^{c}	41.21 ± 0.71^{b}	57.15 ± 0.30^{a}	15.48 ± 0.22^{e}	17.23 ± 0.32^{d}
Zn	19.68 ± 0.09^{a}	7.44 ± 0.55^{c}	6.44 ± 0.41^{d}	9.22 ± 0.11^{b}	7.59 ± 0.62^{c}
Cu	0.12 ± 0.01^{d}	0.41 ± 0.04^{b}	0.15 ± 0.03^{d}	0.31 ± 0.02^{b}	0.87 ± 0.02^{a}
Mn	0.64 ± 0.02^{a}	0.30 ± 0.01^{b}	0.32 ± 0.01^{b}	0.20 ± 0.01^{c}	0.62 ± 0.01^{a}
Na/K	0.15^{e}	0.25^{c}	0.47^{b}	0.22^{d}	0.57^{a}
Ca/P	0.13^{d}	0.03^{e}	0.57^{b}	1.43^{a}	0.38^{c}

Note: Means (± SEM) with different alphabetical superscripts in the same row are significantly different at P < 0.05.
Key: BF: beef; PK: pork; CHK: chicken (broilers); CF: catfish; SN: snails.

112.31 to 302.53 mg/100g, 30.15–76.41 mg/100g, 15.48 to 57.15 mg/100g, 6.44 to 19.68 mg/100g, 0.12–0.87 mg/100g and 0.20 to 0.62 mg/100g respectively. The result showed that the magnesium, copper and manganese content was the highest in SN, while the phosphorus, potassium and sodium content was the highest in PK. This result aligns with the data of the other author who reported the high potassium and sodium content in snails [65]. The result also of this study showed that snail meat is rich in potassium and phosphorus.

The content of iron was highest in CHK and the lowest in CF. The result showed that all the meat types were rich sources of minerals but did not exceed the recommended value [66]. Calcium is responsible for formation of bone, clotting of blood, control of heartbeat and contraction of muscle. It has also been reported with potential to prevent type-2 diabetes [67]. Potassium and sodium are responsible for maintenance of body fluid, regulation of body pH, muscle and nerve signals [68]. Magnesium, zinc and phosphorus are responsible for metabolism of carbohydrate, bone and hemoglobin formation. Magnesium helps with the regulation of zinc level in the body. Hence, zinc and magnesium are reported as co-factors for management of diabetes through the initiation of insulin receptor [69].

The presence of copper and zinc in the various meat samples may be caused by the usage of pesticides, fertilizers, and herbicides in animal feed, as well as the dumping of waste and municipal sewage [70]. This is similar to the work reported by [71]. When copper levels rise above the maximum allowable limit, harmful consequences arise. Damage to the kidneys and liver might also result from high concentrations [72]. According to the study's findings, some heavy metal concentrations were higher than the permitted levels recommended by EC, WHO, and FAO committees [73].

The content of zinc was the highest in BF and the lowest in CHK. Drozd et al. [74] found that the meat of snails has a higher iron content (1.25 mg/100g) than that of broiler (1.25 mg/100g), goat (0.80 mg/100g), and tilapia fish (0.55 mg/100g). The content of copper and manganese was the highest in SN, while the copper content was the lowest in PK and the manganese content was the lowest in CF. Rygało-Galewska et al. [75] reported that snail meat is rich in copper and iron, which are important in oxidative phosphorylation and cellular energy production. According to scientific research, zinc, magnesium, and calcium are crucial for glucose metabolism because they act as components or cofactors for the enzymes involved in glucose metabolism, which improves the action of insulin by activating the insulin receptor [76]. Zinc is an important mineral element during pregnancy for normal development [77]. Zinc is an important co-factor for more than 70 enzymes and plays a central role in cell division, protein synthesis and growth [78].

Additionally, red meat contains iron. It is commonly recognized that iron is a redox-active metal that catalyzes the Fenton reaction, which produces hydroxyl free radicals. Excessive iron intake can cause oxidative stress, which is characterized by increased lipid peroxidation, altered proteins, and DNA damage. Long-term oxidative stress brought on by iron can result in the emergence of numerous illnesses, including cardiovascular diseases, type 2 diabetes, atherosclerosis, neurological disorders and chronic inflammation [79]. High iron intake (161 mg/wk vs. 100 mg/wk) was linked to an increased risk of ischemic stroke, per [80]. Foods with a calcium to phosphorus ratio of >1.0 are clearly rated good, whereas those with a ratio of less than 0.5 are clearly rated poorly. Reports state that children's growth, development, and tooth development are dependent on calcium and phosphorus [81].

The Ca/P molar ratios (0.03–1.43) of the samples were within the recommended value (>1). Hence, they may be adequate to prevent rickets and osteoporosis that were associated with calcium deficiency. Also, the result revealed that Na/K molar ratios (0.15–0.57) of the different meat samples were within the value (<1.0) recommended by the National Research Council (NRC, 1989) [82].

Fatty acid composition of the different meat types

The fatty acid content of the different meat is given in Table 3. The following ranges correspond to the composition of total saturated fatty acid (∑SFA), monounsaturated fatty acid (∑MUFA), and polyunsaturated fatty acid (∑PUFA); 26.92 to 54.29%, 14.47 to 42.02% and 18.22 to

Table 3. Fatty acid composition (%)

Samples	BF	PK	CHK	CF	SN
Saturated (SFA)					
Caprylic acid (C8:0)	0.30^{b}	0.39^{a}	0.10^{d}	0.20^{c}	0.11^{d}
Capric acid (C10:0)	0.72^{b}	0.88^{a}	0.66^{b}	0.51^{c}	0.42^{d}
Lauric acid (C12:0)	0.05^{d}	0.20^{c}	0.30^{b}	4.20^{a}	0.20^{c}
Myristic acid (C14:0)	1.21^{c}	2.41^{b}	1.09^{d}	3.26^{a}	0.02^{e}
Palmitic acid (C16:0)	18.20^{d}	26.39^{a}	23.30^{b}	19.03^{c}	8.91^{e}
Margaric acid (C17:0)	7.22^{b}	9.56^{a}	1.92^{d}	5.66^{c}	0.02^{e}
Stearic acid (C18:0)	17.07^{a}	8.19^{d}	9.50^{c}	4.99^{e}	10.15^{b}
Arachidic acid (C20:0)	0.25^{e}	2.66^{b}	0.30^{d}	1.71^{c}	2.71^{a}
Behenic acid (C22:0)	0.61^{d}	1.22^{b}	0.61^{d}	1.09^{c}	1.29^{a}
Lignoceric acid (C24:0)	1.78^{c}	2.39^{b}	0.90^{e}	1.50^{d}	3.51^{a}
∑SFA	47.41^{b}	54.29^{a}	38.68^{d}	42.15^{c}	26.92^{e}
Monounsaturated (MUFA)					
Palmitoleic acid (C16:1)	1.47^{d}	5.21^{b}	2.30^{c}	6.59^{a}	1.00^{e}
Oleic acid (C18:1)	10.55^{e}	31.92^{b}	37.30^{a}	25.42^{c}	15.87^{d}
Erucic acid (C22:1)	2.45^{b}	4.89^{a}	1.05^{d}	1.64^{c}	1.00^{e}
∑MUFA	14.47^{e}	42.02^{a}	40.65^{b}	33.65^{c}	17.87^{d}
Polyunsaturated (PUFA)					
Linoleic acid (C18:2)	12.74^{d}	29.54^{a}	18.09^{b}	10.91^{e}	17.89^{c}
Linolenic acid (C18:3)	5.41^{b}	2.61^{c}	0.87^{d}	0.84^{e}	5.53^{a}
Arachidonic acid (C20:4)	2.01^{e}	3.95^{c}	2.39^{d}	6.47^{b}	11.27^{a}
∑PUFA	20.16^{d}	36.10^{a}	21.35^{c}	18.22^{e}	34.69^{b}
MUFA/PUFA	0.72^{d}	1.16^{c}	1.90^{a}	1.85^{b}	0.52^{e}
PUFA/SFA	0.43^{d}	0.66^{b}	0.55^{c}	0.43^{d}	1.29^{a}
(PUFA+MUFA)/SFA	0.73^{e}	1.44^{c}	1.60^{b}	1.23^{d}	1.95^{a}

Note: Means (± SEM) with different alphabetical superscripts in the same row are significantly different at P < 0.05.
Key: BF: beef; PK: pork; CHK: chicken (broilers); CF: catfish; SN: snails.

36.10% respectively. The results showed that the saturated fatty acids namely caprylic acid (C8:0), capric acid (C10:0), lauric acid (C12:0), myristic acid (C14:0), palmitic acid (C16:0), margaric acid (C17:0), stearic acid (C18:0), arachidic acid (C20:0), behenic acid (C22:0) and lignoceric acid (C24:0) ranged from 0.11 to 0.39, 0.42 to 0.88%, 0.05 to 4.20%, 0.02 to 3.26%, 8.91 to 26.39%, 0.02 to 9.56%, 4.99 to 17.07%, 0.25 to 2.71%, 0.61 to 1.29%, 0.90 to 3.51% and 26.92 to 54.29% respectively. The monounsaturated fatty acids ranged from 1.00 to 6.59%, 10.55 to 37.30% and 1.00 to 4.89% for palmitoleic acid (C16:1), oleic acid (C18:1) and erucic acid (C22:1) respectively. The polyunsaturated fatty acids had the following ranges: 10.91 to 29.54%, 0.84 to 5.53%, 2.01 to 11.27% for linoleic acid (C18:2), linolenic acid (C18:3), arachidonic acid (C20:4) respectively. CF had the lowest content of PUFA and PK had the highest. Snails showed lower ($P < 0.001$) levels of unsaturated (UFA) to saturated (SFA) fatty acids ratio in comparison with the other meat types. The findings from this study on saturated fatty acids agrees with the findings of [83] which reported (66 32% in pork, 82.14% in beef, and 65.64% in rabbit). Futhermore, the leading causes of death in Western cultures are coronary heart disease and atherosclerosis, which are closely linked to diets high in cholesterol and saturated fat [84].

The research by Azemi et al. [85] indicates that linoleic acid, an unsaturated fatty acid, is likely to have its cholesterol-lowering impact through metabolism of a metabolite rather than linoleic acid itself. According to research by Astrup et al. [86], stearic acid, a long-chain saturated fatty acid, seems to have no effect on low density lipoprotein (LDL), or bad cholesterol, or total cholesterol. Scientific studies have also shown that in both normo-cholesterolemic men and women who ate a typical western diet and non-human primates, palmitic acid, lauric acid, and myristic acid raise LDL cholesterol, high density lipoprotein, total blood cholesterol, and the LDL/HDL ratio [87]. Studies have found that oleic acid has beneficial effect on total cholesterol, LDL and HDL compared with saturated fats [88]. The present study provides evidence that the oleic acid content was high in CHK and PK.

The findings of the present study demonstrated that the PUFA/SFA molar ratios in SN were higher than the FAO/WHO-recommended threshold of >1 [89]. This suggests that the meat of snails contains a higher proportion of polyunsaturated fatty acids than saturated fatty acids. Consuming a diet with this ratio has health benefits, including reducing the risk of cardiovascular diseases [34].

The PUFA+MUFA/SFA ratio was > 1.0 in all tested samples from different types of meat, namely, SN, CF, CHK and PK, which implies that the meat samples contain more good fats than the bad fats [90]. Since the meat samples were rich in monounsaturated fatty acids (MUFA) (14.47–42.02%) and polyunsaturated fatty acid (PUFA) (18.22–36.10%), they might have the ability to reduce LDL cholesterol while possibly increasing HDL cholesterol [91].

In general, the fatty acid profile can act as a vehicle for human health protection based on the ratio of their profile. The fatty acids ω-6 and ω-3, along with PUFA, MUFA, and SFA, are regarded as markers of primary significance for the nutritional assessment of fat [92]. For the prevention of atherosclerosis, a dietary ratio of ω-6/ω-3 less than 4:1 is advised [93]. Additionally, ω-3 fatty acids have anti-inflammatory qualities and are a crucial component of cell membranes [94].

They are therefore regarded as helpful compounds in the treatment of numerous chronic and inflammatory illnesses. In the current investigation, snails had the highest UFA/SFA ratio. This elevated lipid content of the diet is most likely what caused it. The higher ratio that was observed suggests a better profile of fatty acids, which is further supported by the high PUFA/MUFA ratio. The result from this study suggests that snail meat may be better for prevention of lipid-related diseases.

Vitamin composition of the different meat types

Data in Table 4 show the content of fat soluble vitamins in the different meat types. The content of vitamins A, D, E and K ranged from 4.61 to 110.69 µg/100 g, 1.79 to 18.05 µg/100 g, 0.30 to 0.39 µg/100 g and 10.70 to 70.07 µg/100 g, respectively. The present study showed that vitamin A and vitamin E were more abundant in CHK, while vitamin D was more abundant in SN. Vitamin K was more abundant in BF. These vitamins have a variety of distinct, essential roles in metabolism, and when they are either overly abundant or deficient, they can lead to health issues [94]. Hrubša et al. [95] reported that beef, pork, chicken and fish are rich source of vitamin B. The proper ratio of these vitamins is preserved by vitamin A, which is carried via fat and kept in the liver and fat tissue [96]. A vitamin D shortage can cause weak, fragile, or misshapen bones in addition to osteomalacia in adults and rickets in children [97]. Muscle lipid oxidation after slaughter may negatively impact the quality, flavour, and nutritional value of fresh, frozen, and cooked meat and meat products, making vitamin E a crucial part of the antioxidant defence

Table 4. Vitamin composition

Parameters	BF	PK	CHK	CF	SN
Vitamin A (µg/100 g)	4.61 ± 0.01^{e}	5.50 ± 0.02^{d}	110.69 ± 0.03^{a}	9.96 ± 0.02^{c}	54.99 ± 0.02^{b}
Vitamin D (µg/100 g)	4.14 ± 0.01^{c}	1.79 ± 0.05^{e}	2.15 ± 0.02^{d}	6.06 ± 0.01^{b}	18.05 ± 0.06^{a}
Vitamin E (mg/100 g)	0.03 ± 0.01^{c}	0.31 ± 0.07^{b}	0.39 ± 0.03^{a}	0.04 ± 0.01^{c}	0.30 ± 0.05^{b}
Vitamin K (µg/100 g)	70.07 ± 0.01^{a}	20.30 ± 0.00^{c}	11.00 ± 0.05^{d}	65.07 ± 0.01^{b}	10.70 ± 0.03^{e}

Note: Means (± SEM) with different alphabetical superscripts in the same row are significantly different at $P < 0.05$.
Key: BF: beef; PK: pork; CHK: chicken (broilers); CF: catfish; SN: snails.

system in live tissues [98]. Vitamin E content varies among meats, but it is generally low. It has been noted that chicken meat has more vitamin E than beef and pork. Except for chicken meat, meat is not a great source of vitamin E [99]. It has been noted that vitamin E helps to stabilise the colour of meat [100]. Meat quality metrics, particularly beef softness, can be enhanced by vitamin E concentration [101]. There are two forms of vitamin E: tocopherols and tocotrienols [102]. Tocotrienols in oil have also been shown in human studies to reverse platelet aggregation and carotid artery blockage, hence reducing the risk factors for arteriosclerosis, stroke, and ischemic heart disease [103].

Because tocopherols can scavenge free radicals, they can inhibit or postpone the initiation of the lipid peroxidation process in conjunction with other natural antioxidants such ascorbic acid and β-carotene. As an antioxidant, vitamin E shields fat in the membranes surrounding cells-including muscles, neurons, heart, and red blood cells — from oxygen-induced oxidative damage [104].

In addition to being vital for maintaining healthy bones and preventing heart disease, vitamin K is also necessary for other biological functions. Its biological function involves directing calcium into the right places in the body, such as the teeth and bones, and removing calcium from arteries and soft tissues [105].

Cholesterol content of the different meat

The cholesterol content of the different meat types is given in Table 5. Bile acids are produced from cholesterol, and fats cannot be metabolized without bile acids. The absorption of fat-soluble vitamins, including vitamins A, D, E, and K, depends on bile acids. The results of this study showed that the quantity of total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL–C), low density lipoprotein cholesterol (LDL–C) and very low density lipoprotein cholesterol (VLDL–C) ranged from 17.45 to 30.10 mg/dL, 89.03 to 130.67 mg/dL, 13.34 to 21.90 mg/dL, 2.30 to 5.59 mg/dL and 10.90 to 28.77 mg/dL, respectively. The highest level of TC was in PK, while the lowest was in SN. PK had the highest level of TG, while BF had the lowest. PK showed the highest level of HDL–C, while the lowest level was determined in SN. The level of LDL–C was the highest in PK and the lowest in SN. As for VLDL–C, PK had the highest level and BF had the lowest. It can be seen from the results obtained that the low density lipoprotein in the different meat samples was in the following order: SN > CF > CHK > BF > PK. In vertebrates, including humans, triglycerides make up the majority of body fat. They are also found in blood, where they facilitate the transport of blood glucose from the liver to adipose tissue in both directions [106].

It has been shown that dietary cholesterol causes an increase in blood levels of low-density lipoprotein (LDL) cholesterol in certain people. Dietary cholesterol may have less harmful effects than saturated and trans fatty acids [107], and the effect of decreased consumption of saturated fatty acids is lessened. According to some research, eating more cholesterol raises your chance of developing cardiovascular disease [107]. Extensive research, encompassing a substantial number of stroke cases, shows a significant positive correlation between the risk of both ischemic stroke and total stroke and the consumption of fresh red meat, processed meat, and red meat in general [108]. An 11%, 13%, and 11% higher risk of stroke overall was linked to increased consumption of one serving per day of fresh red meat, processed meat, and total red meat, respectively [109]. The risk of stroke can be elevated by consumption of red meat through a number of possible mechanisms [110]. Cholesterol and saturated fats can be found in red meat. High consumptions of saturated fats have been shown to increase plasma levels of total cholesterol, low-density lipoprotein cholesterol, and triglycerides, all of which may increase the risk of stroke [111].

A study has indicated that consuming a high-fat diet might result in raised cholesterol levels in the tissues, which may enhance the tissues' vulnerability to lipid peroxidation. However, this effect can be mitigated by the presence of sufficient antioxidants [112]. Increased triglycerides may be a factor in artery hardening or pancreatitis. Heart disease, stroke, and heart attacks are now more likely as a result [113]. Because an increase in high density lipoprotein cholesterol (HDL-c) is associated with improved cardiovascular health, it is referred to as "good cholesterol". Since the early to mid-1960s, cholesterol has been referred to as the "oily killer", particularly after a number of studies revealed that it is the primary cause of atherosclerotic lesions, which are the primary causes of coronary heart disease [114].

Due to growing awareness of the detrimental consequences of eating a diet high in cholesterol on one's health, most people today opt to consume foods that are cholesterol-free [115]. People consume a wide range of fatty meals, either as the main course or as ingredients in other dishes.

Table 5. Cholesterol content

Parameters	BF	PK	CHK	CF	SN
TC (mg/dL)	23.17 ± 0.06^{b}	30.10 ± 0.05^{a}	22.89 ± 0.04^{c}	19.23 ± 0.08^{d}	17.45 ± 0.09^{e}
TG (mg/dL)	89.03 ± 0.04^{e}	130.67 ± 0.04^{a}	121.50 ± 0.03^{b}	109.91 ± 0.09^{c}	90.30 ± 0.05^{d}
HDL–C (mg/dL)	16.89 ± 0.05^{b}	21.90 ± 0.05^{a}	16.85 ± 0.02^{c}	14.33 ± 0.06^{d}	13.34 ± 0.06^{e}
LDL–C (mg/dL)	4.50 ± 0.03^{b}	5.59 ± 0.04^{a}	3.61 ± 0.05^{c}	2.71 ± 0.06^{d}	2.30 ± 0.03^{e}
VLDL–C. (mg/dL)	10.90 ± 0.01^{e}	28.77 ± 0.03^{a}	17.69 ± 0.10^{d}	18.93 ± 0.09^{c}	19.42 ± 0.02^{b}

Note: Means (± SEM) with different alphabetical superscripts in the same row are significantly different at $P < 0.05$.
Key: BF: beef; PK: pork; CHK: chicken (broilers); CF: catfish; SN: snails; TC: total cholesterol; TG: triglyceride; HDL–C: high density lipoprotein; LDL–C: low density lipoprotein; very low density lipoprotein.

The current analysis showed that the cholesterol levels in the snail flesh were considerably lower. The result from this present study suggests that eating snail meat may be beneficial for controlling obesity and preventing lipid-related illnesses.

2, 2-diphenyl-1-picryl hydrazyl radical (DPP free radical scavenging ability of the different meat types

A stable free radical called 2, 2-diphenyl-1-picryl hydrazyl radical (DPPH) is frequently utilized to quickly assess the antioxidant activity of a material. As illustrated in Figure 1, the DPPH scavenging activity ranged from 50.84 to 65.64%. The most effective inhibitor of the DPPH was SN. Moreover, PK (48.44%), CHK (55.66%), and CF (56.39%) showed very high radical scavenging activities. Nonetheless, there were notable differences between the samples at $p > 0.05$. When the meat samples underwent the antioxidant reaction with hydrogen donors, they all showed notable antioxidant activity by scavenging the DPPH radical and reducing it to the equivalent hydrazine (Figure 1). The capacity of a component to donate hydrogen may be a source of its free radical-scavenging action. Each component demonstrated the significant antioxidant activity by scavenging free radicals such as DPPH. In line with the observation of Aouji et al. [55], SN have a higher inhibitory power against free radicals than CF, CHK, PK, and BF. The capacity of snail meat to reduce Fe^{3+} to Fe^{2+} provided evidence of its significant reducing characteristics. According to the antioxidant activities, the polyphenolics in the different meat types may function as reduction agents by giving free radicals an electron, thereby stopping chain reactions that are mediated by free radicals [116].

It is vital for human health to have antioxidants. The balance between oxidants and antioxidants is preserved throughout regular metabolism. It has been shown that the best defense against different oxidative stresses may involve combining natural antioxidant supplements with a balanced diet that includes adequate antioxidants [117].

Hydroxyl (OH) free radicals scavenging activity of the different meat

The results of the hydroxyl radical scavenging activity as illustrated in Figure 2 ranged from 43.39 to 63.44% with SN exhibiting significantly the highest and BF exhibiting the least ability to inhibit the hydroxyl radical. CF (52.93%), CHK (57.21%) and PK (56.50%) also exhibited high OH scavenging activity which implies that the different meats may serve as practical hydroxyl radical scavenger. Better antioxidant and free radical scavenging qualities were discovered when OH free radical scavenging and Fe^{2+}chelation were compared to other experimental materials, such as whole leaf, extract, and residue powder samples. This discovery could be explained by the separated protein's potent free bioactive peptides, which scavenge free radicals and function as antioxidants. In contrast, the wild lettuce leaf's capacity to scavenge free radicals and act as an antioxidant aligned with findings from earlier studies that examined the health benefits and antioxidant activity of various meat types [118]. It is well recognized that substances referred to as antioxidants, which inhibit the oxidation process by lowering the generation of free radicals, play a significant role in the prevention of long-term conditions like cancer, diabetes, obesity, and hypertension [119].

FRAP inhibitory activities of the different meat types

Figure 3 displays the ferric reducing antioxidant power (FRAP) of the various meat samples. Higher FRAP values were observed SN compared to the other meat samples, which showed a substantial diversity in their reducing activity. The FRAP value varied from 0.88 to 1.59% Fe^{2+}/mg. The reason for the increased ability of the different meat types to reduce Fe^{3+} to Fe^{2+} with increases from SN, CF, CHK, PK, and BF could be due to the inhibitory power of the meat samples to produce reductants that may react with the free radicals, stabilizing and finishing the radical chain [120]. The strong antioxidant qualities in snails may have contributed to their potential bioactive capabilities, as seen by the significantly ($p < 0.05$) higher antioxidant

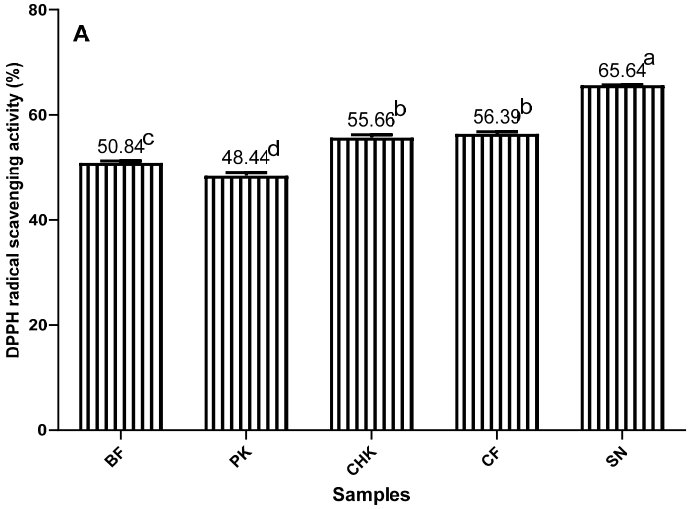

Figure 1. DPPH free radical scavenging ability

Note: Bars with different alphabetical superscripts are significantly different at $P < 0.05$.

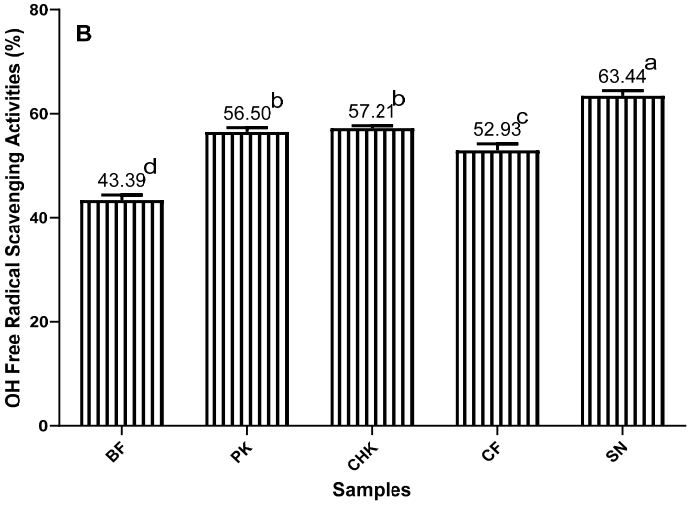

Figure 2. OH free radical scavenging ability

Note: Bars with different alphabetical superscripts are significantly different at $P < 0.05$.

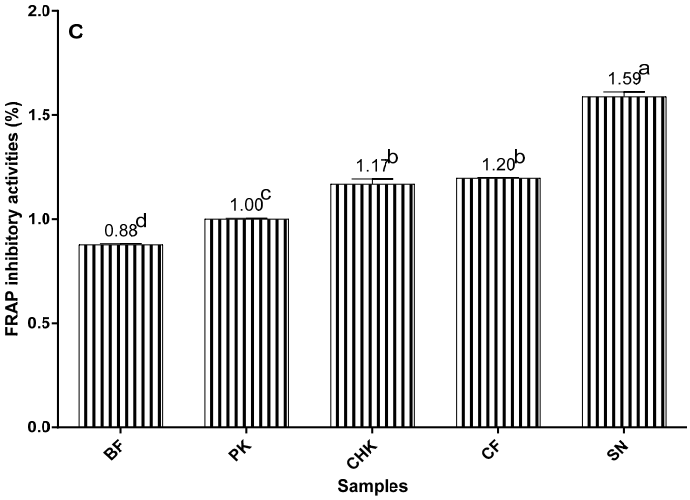

Figure 3. FRAP inhibitory activities

Note: Bars with different alphabetical superscripts are significantly different at $P < 0.05$.

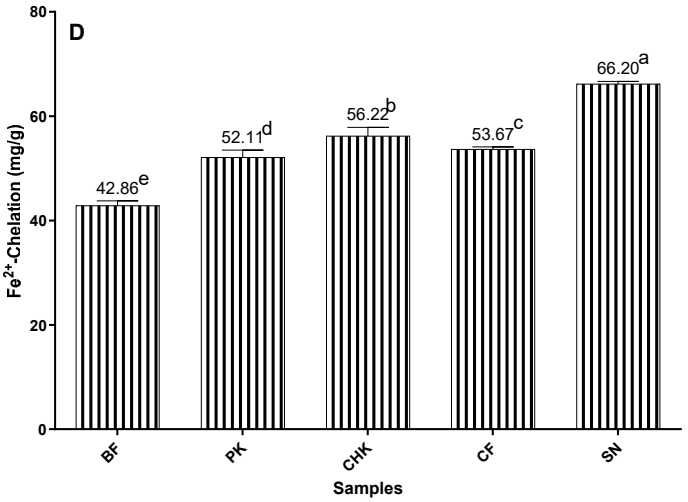

Figure 4. Fe^{2+} chelating ability

Note: Bars with different alphabetical superscripts are significantly different at $P < 0.05$.

properties observed in SN. Overall, the findings of SN antioxidant activities point to the possibility that snail meat can work as a useful scavenger of free radicals, preventing major degenerative diseases linked to them while also functioning as a useful snack during dietary interventions.

Fe^{2+} chelating ability of the different meat types

Figure 4 displays the antioxidant power of Fe^{2+}chelation for each of the meat samples. The maximum reduction ability of the various meat samples to reduce Fe^{3+} to Fe^{2+} was recorded in SN (66.20 mg/mL), and the lowest reduction ability was recorded in BF (42.86 mg/mL). The chelation power assay was used to evaluate the chelating ability of the various meat samples. The results showed that, in comparison to (CF, CHK, PK, and BF), the different meat samples had an impressive chelation power (42.86 mg/mL to 66.20 mg/mL in SN) [121].

ABTS scavenging ability of the different meat types

Antioxidant properties of the different meat types are presented in Figure 5. The ABTS values show that there were significant different meat samples ($p < 0.05$). The results demonstrated the scavenging capacity of the components against ABTS radicals in the range of 0.03 to 0.08 mMol/g (Figure 5). When it comes to scavenging free radicals, SN utperformed CF, CHK, PK, and BF. Compounds known as antioxidants shield cells from free radical damage. Despite being normal byproducts of cellular metabolism, free radicals have the ability to bind to healthy cells and cause illness within the body [122]. One of the spectrophotometric techniques used to assess the antioxidant activity of pure material solutions, aqueous solutions, and drinks Christodoulou et al. [123] is based on the production of the radical ABTS+.

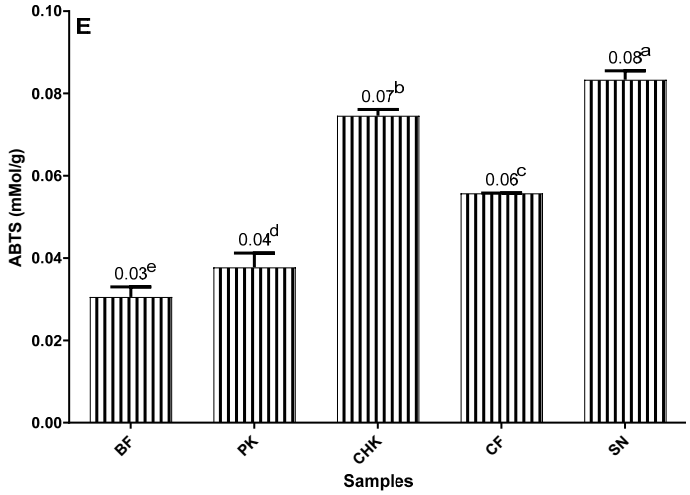

Figure 5. ABTS scavenging ability

Note: Bars with different alphabetical superscripts are significantly different at $P < 0.05$.

Total phenols of the different meat types

Figure 6 illustrates the total phenol content of the different meat samples. Total phenols were in a range from 46.53 to 73.57 mg GAE/g with SN having the highest and BF having the lowest levels. The result showed that all the meat possesses good antioxidant properties. The high polyphenol content may be the cause of the antioxidant action. Phenols have been shown to reduce the production of oxidized low-density lipoprotein (LDL), which is thought to be a causal factor of cardiovascular disease, by inhibiting the

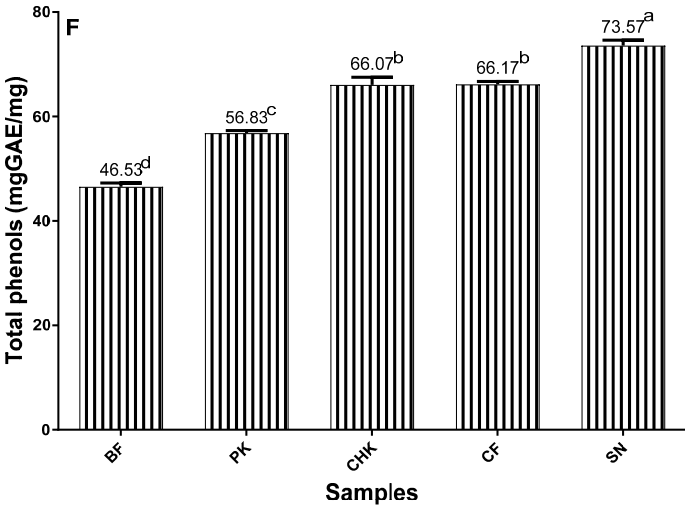

Figure 6. Total phenols

autoxidation of unsaturated lipids. Numerous prior investigations involving fruits or vegetables have also discovered a favorable relationship between total phenolic components and antioxidant activity, leading to the conclusion that high total phenol contents boost antioxidant activity [124].

Conclusion

The results of this study showed that the various meat samples had significant nutritional potential. However, SN exhibited better nutritional and antioxidant properties. From the foregoing, the results showed that SN had the highest protein content, magnesium content, PUFA+MUFA)/SFA ratio, vitamin D content, DPPH, OH free radical scavenging ability, FRAP inhibitory activities, Fe^{2+} chelating ability, ABTS scavenging ability, total phenols and had the lowest level of low density lipoprotein, which potentially aid in the control of obesity and the avoidance of illnesses linked to fat.

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