Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 58 (2013) 14891-14901

ISSN: 2229-712X

Lipid composition of three organs of *Hippotragus equinus* (Roan Antelope)

Emmanuel Ilesanmi Adeyeye[1] and Pius Amoka Aye[2]

[1]Department of Chemistry, Ekiti State University, Ado Ekiti, PMB 5363, Ado Ekiti, Nigeria.

[2]Department of Animal Production and Health Sciences, Ekiti State University, Ado Ekiti, PMB 5363, Ado Ekiti, Nigeria.

ARTICLE INFO

Article history:

Received: 23 January 2013;

Received in revised form:

7 May 2013;

Accepted: 13 May 2013;

Keywords

Roan antelope,

Lipid composition,

Three organs.

ABSTRACT

The lipid composition of the heart, liver and brain of roan antelope was determined on a dry weight basis. The crude fat ranged between 4.16-8.65 g/100 g with corresponding contributing energy as 120-180 kJ/100 g and total fatty acid of 3.25-4.85 g/100 g. The fatty acids were (in % of total fatty acids): SFA: 46.3 (brain) > 39.5 (heart) > 37.7 (liver); MUFA (*cis*): 44.2 (brain) > 39.8 (heart) > 25.4 (liver); MUFA (*trans*): 0.131 (brain) > 0.121 (heart) > 0.053 (liver) and PUFA: 36.8 (liver) > 20.5 (heart) > 9.26 (brain). Best SFA level was C16:0 in brain (25.8 %) and in heart (25.2 %) but C18:0 in liver (17.3 %). C18:1 (*cis*-6) was highest MUFA in liver (12.7 %) but C18:1 (*cis*-9) was highest MUFA in heart (18.3 %) and brain (22.3 %). These *n*-6 PUFA were high in concentration: C18:2 (*cis*-9, 12) 2.05 -21.4 % and C20:4 (*cis*-5, 8, 11, 14) 3.91-13.3 %. SFA as food was 1.23-2.24 g/100 g and PUFA was 0.449- 1.20 g/100 g with corresponding energy contributions of 45.4-83.0 kJ/100 g and 16.6-44.2 kJ/100 g. AA/DGLA was 5.73-13.7; EPA/DHA was – to 0.027; LA/ALA was 7.48-60.6; *n*-6/*n*-3 was 2.72-51.9; PUFA/SFA was 0.200-0.976; MUFA/SFA was 0.676-1.01 and EPSI was 0.209-1.44. The only sterol of significance was cholesterol with a range of 88.7-1234 mg/100 g whereas total phospholipids range was 283-2791 mg/100 g with the brain being highest in concentration and the liver being lowest in both sterol and phospholipids respectively.

Introduction

Antelope is a term referring to many even-toed ungulate species indigenous to various regions in Africa and Eurasia. Antelopes comprise a miscellaneous group within the family Bovidae, encompassing those old-world species that are neither cattle, sheep, buffalo, bison, nor goats. A group of antelope is called a herd[1].

The English word “antelope” first appears in 1417 and is derived from the Old French *antelop*, itself derived from Medieval Latin *ant(h)alopus*, which in turn comes from the Byzantine Greek word anthólops, first attested in Eustathius of Antioch (*circa* 336), according to whom it was a fabulous animal “haunting the banks of the Euphrates, very savage, hard to catch and having long saw-like horns capable of cutting down threes[2]. It perharps derives from Greek *anthos* (flower) and *ops* (eye), perharps meaning “beautiful eye” or alluding to the animals long eyelashes; however this may be a later folk etymology. The word *talopus* and *calopus*, from Latin, came to be used in heraldry. In 1607 it was first used for living, cervine animals.

There are 91 species, most of which are native to Africa, in about 30 genera. The classification of tribes or sub families within Bovidae is still a matter of debate, with several alternative systems proposed.

Antelopes are not a cladistic or taxonomically defined group. The term is used loosely to describe all members of the family Bovidae which do not fall under the category of sheep, cattle, or goat. Usually all species of the Alcelaphinae, Antilopinae, Hippotraginae, Reduncinae, Cephalophinae, many Bovinae, the Grey Rhebok, and the impala are called antelopes.

The Hippotraginae or horse antelopes, include: Sable, *Hippotragus niger;* Roan, *H. equinus*; Gemsbok, beisa and fringe-eared oryx, *Oryx gazelle subs.*; Arabian oryx, *O. leucoryx;* Scimitar-horned oryx, *O. dammah*; Addax, *Addax nasomaculatus*.

Antelopes are ruminants, and thus have well-developed molar teeth, which grind cud (food balls stored in the stomach) into a pulp for further digestion. They have no upper incisors, but rather a hard upper gum pad, against which their lower incisors bite to tear grass stems and leaves. Their meat, milk and hides are all of excellent quality, and experimental eland husbandry has been going on for some years in both Ukraine and Zimbabwe. In both locations the animal has proved wholly amenable to domestication[3]. The antelope’s horn is prized for medicinal and magical powers in many places. The horn of the male Saiga in Eastern practice is ground as an aphrodisiac, for which it has been hunted nearly to extinction[4]. In the Congo, it is thought to confine spirits. Christian iconography sometimes uses the antelope’s two horns as a symbol of the two spiritual weapons that Christians possess: the Old Testament and the New Testament. Their ability to run swiftly has also led to their association with the wind, such as in the *Rig Veda*, as the steeds of the Maruts and the wind god Vayu.

The roan antelope (*Hippotragus equinus*) is a savanna antelope found in West, Central, East and Southern Africa.

Roan antelope are one of the largest species of antelope. They measure 190-240 cm (75-94 in) from the head to the base of tail and the tail measures 37-48 cm (15-19 in). The body mass of males is 242-300 kg (530-660 Ib) and of females is 223-280 kg (490-620 Ib). The shoulder of this species is typically around 130-140 cm (51-55 in) [5, 6, 7]. Named for their roan colour (a

Tele:

E-mail addresses: adeyeyeilesanmi2012@gmail.com

reddish brown), they have lighter underbellies, white eyebrows and cheeks and black faces, lighter in females. They have short, erect manes, very light beards and prominent red nostrils. The horns are ringed and can reach a metre long in males, slightly shorter in females. They arch backwards slightly.

They are similar in appearance to sable antelope and can be confused where their ranges overlap. Sable antelope males are darker, being black rather than dark brown.

Roan antelope are found in wood land and grassland savanna, mainly in the tropical and subtropical grasslands, savannas and shrublands biome, which range in tree density from forest with a grassy understorey (such as central Zambezian Miombo woodlannds) to grasslands dotted with few trees, where they eat midlength grasses. They form harem groups of five to 15 animals with a dominant male. Roan antelope commonly fight among themselves for dominance of their herd, brandishing their horns while both animals are on their knees.

In taxonomy antelopes are classified in the phylum Chordata, subphylum Vertebrata, class Mammalia, order Artiodactyla, family Bovidae, subfamily Hippotraginae, genus *Hippotragus*, species *H. equinus*, binomial name *Hippotragus equinus* Desmarest, 1804[8]. Species authority (É. Geoofroy Saint-Hilaire, 1803) and common names of: English-Roan Antelope, French-Antilope Chevaline, Antelope Rouane, Hippotrague. Six subspecies have been described, but the validity of most of these is still in doubt, and recent genetic studies have shown that only the western African subspecies (*koba*) constitutes a genetically separate group from those in the rest of Africa[9].

The roan antelope formerly occurred very widely in the savanna woodlands and grasslands of sub-saharan Africa, but has been eliminated from large parts of its former range. Remarkably, the species remains locally common in West and Central Africa, while in East and southern Africa, the traditional antelope strongholds, the species is now very rare. The species is now locally extinct in Burundi, Eritrea and possibly Gambia. It was also eliminated from Swaziland and later reintroduced to the privately owned Mkhaya Nature Reserve[10]. Native: Angola (Angola); Benin; Botswana; Burkina Faso; Cameroun; Central African Republic; Chad; Congo, The Democratic Republic of the; Cotê d' Ivoire; Ethiopia; Ghana; Guinea; Guinea-Bissau; Kenya; Malawi; Mali; Mauritania; Mozambigue; Namibia; Niger; Nigeria; Rwanda; Senegal; South Africa; Sudan; Tanzania, United Republic of; Togo; Uganda; Zambia; Zimbabwe.

Publications are hardly available on the nutritional qualities of roam antelope in particular works on lipid profiles. The study in this paper is therefore, an attempt to assess the lipid concentration (crude fat, fatty acids, phospholipids and zoosterols) from three organs (heart, liver, brain) of the roan antelope consumed in Nigeria as bush meat.

Materials and methods

Sample collection

Two matured roan antelope were collected from local hunters commissioned for the exercise from Iworoko Ekiti, Ekiti State, Nigeria.

Sample treatment

In the laboratory the roan antelope was dissected to remove the three organs, washed with distilled water and caught into bits for proper oven-drying until constant weight was reached. Drying was for 5 h at 70 ^{o}C. It was then ground, sieved and kept in freezer (-4 ^{o}C) pending analysis.

Extraction of lipid

0.25 g of each sample was weighed into the extraction thimble. Two hundred ml of petroleum ether (40-60 ^{o}C boiling range) was measured and then added to the dried 250 ml capacity flask. The covered porous thimble with the sample was placed in the condenser of the Soxhlet extractor arrangement that has been assembled[11]. The lipid was extracted for 5 h. The extraction flask with the oil was oven dried at 105 ^{o}C for 1 h. The flask containing the dried oil was cooled in the desiccator and the weight of the cooked flask with the dried oil was measured.

Preparation of methyl esters and analysis

Fifty mg of the extracted oil was saponified for 5 min at 95 ^{o}C with 3.4 ml of 0.5 M KOH in dry methanol. The mixture was neutralised by 0.7 MHCl. Three ml of 14 % boron triflouride in methanol was added[11]. The mixture was heated for 5 min at 90 ^{o}C to achieve complete methylation process. The fatty acid methyl esters were thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1 ml for analysis and lµl was injected into the injection pot of the GC. The fatty acid methyl esters were analysed using an HP 5890 powered with HP gas chromatograph (HP 5890 powered with HP ChemStation rev. A09.01 [1206] software [GMI, Inc, Minnnesota, USA]) fitted with a flame ionization detector. Nitrogen was the carrier gas with a flow rate of 20-60 ml/min. The oven programme was: initial temperature at 60^{o}C, first ramping at 10 ^{o}C/min for 20 min, maintained for 4 min, second ramping at 15 ^{o}C/min for 4 min and maintained for 10 min. The injection temperature was 250 ^{o}C whilst the detector temperature was 320 ^{o}C. A capillary column (30 m x 0.25 mm) packed with a polar compound (HP INNOWAX) with a diameter (0.25 µm) was used to separate the esters. Split injection type was used having a split ratio of 20:1. The peaks were identified by comparison with standard fatty acid methyl esters.

Sterol analysis

Sterol was analysed as described by AOAC[11]. The aliquots of the extracted fat were added to the screw-capped test tubes. The sample was saponified at 95 ^{o}C for 30 min, using 3 ml of 10 % KOH in ethanol, to which 0.20 ml of benzene had been added to ensure miscibility. Deionised water (3 ml) was added and 2 ml of hexane was added in extracting the non-saponifiable materials. Three extractions, each with 2 ml hexane, were carried out for 1 h, 30 min and 30 min respectively. The hexane was concentrated to 1 ml in the vial for gas chromatographic analysis and l µl was injected into injection pot of GC. The peaks were identified by comparison with standard sterols. The sterols were analysed using similar conditions as for fatty acid methyl ester analyses.

Phospholipids analysis

Modified method of Raheja, Kaur, Singh, & Bhatia[12] was employed in the analysis of phospholipids. About 0.01 g of the extracted fat was added to each test tube. To ensure complete dryness of the fat for phospholipids analysis, the solvent was completely removed by passing stream of nitrogen gas on the fat. Volume of 0.01 ml chloroform was added to the tube followed by the addition of 0.10 ml chromogenic solution. The tube was heated at 100 ^{o}C in water bath for l min 20 sec. The content was allowed to cool to the laboratory temperature and 5 ml hexane added and the tube shaken gently several times. The solvent and the aqueous layers were allowed to be separated. The hexane layer was recovered and concentrated to 1.0 ml for analysis. The phospholipids were analysed using an HP 5890

powered with HP gas chromatograph (HP 5890 powered [GMI, Inc, Minnesota, USA]) fitted with a pulse flame photometric detector. Nitrogen was used as the carrier gas with a flow rate of 20-60 ml/min. The oven programme was: initial temperature at 50 ^{o}C, whilst the detector temperature was 320 ^{o}C. A capillary column (30 m x 0.25 mm) packed with a polar compound (HP) with a diameter (0.25 µm) was used to separate the phospholipids. Split injection type was used having a split ratio of 20:1. The peaks were identified by comparison with standard phospholipids.

Quality assurance

Standard chromatograms were prepared for sterol, phospholipids and fatty acid methyl esters which were then compared with respective analytical results; calibration curves were prepared for all the standard mixtures and correlation coefficient determined for each fatty acid parameter, same for sterols and phospholipids. Correlation coefficient should be > 0.95 for the result to be acceptable. It was performed with Hewlett Packard Chemistry (HPCHEM) software (GMI, Inc 6511 Bunker Lake Blvd Ramsey, Minnesota, 55303, USA).

Calculation of fatty acid per 100 g in sample

At the data source and reference database levels, values for individual fatty acids are usually expressed as percentages of total fatty acids. At the user database levels, values per 100 g of food are required. A conversion factor derived from the proportion of the total lipid present as fatty acids is required for converting percentages of total fatty acids to fatty acids per 100 g of food. Total lipid level was multiplied by conversion factors of 0.561 (brain)[13], 0.789 (heart)[13] and 0.741 (liver)[13] to convert them to total fatty acids. For fatty acids, precision is best limited to 0.1 g/100 g of fatty acids[14].

Statistical analysis

Statistical analysis[15] was carried out to determine coefficient of variation in per cent (CV %), the mean and standard deviation. Also calculated were the chi-square (X^2) values. The X^2 was subjected to the table (critical) valve at $\alpha_{=0.05}$ to see if significant differences existed in the values of the results such as fatty acids, sterols and phospholipids.

Results and Discussion

Table 1 shows total lipids and calculated total fatty acid levels on dry weight basis. The values of total lipids between the three samples were not very much spread with the CV % of 44.1. The total fat of 4.16-8.65 g/100 g were much lower to the value in duck's meat and skin (43 %), chicken's meat and skin (18 %), beef fat (67 %), lamb fat (72 %) and pork fat (71 %). However the value of 8.65 g/100 g was slightly higher than in calf liver of 7.0 %[16]. Fornias[17] reported the proximate composition and energy value of cattle, pig and sheep by-products and lean beef, pork and lean meat of sheep. He reported the fat of cattle brain as 10.6 %, heart as 3.8 % and liver as 4.7 % wet weight with 77.6 %, 75.6 % and 72.8 % water content respectively which on dry matter basis gave a fat content of 47.3 % in cattle brain, 15.6 % (cattle heart) and 17.3 % (cattle liver); based on this , sheep has the following total fat: 38.1 % (brain), 22.4 % (heart) and 15.1 % (liver); for pig: 42.6 % (brain), 18.5 % (heart) and 8.73 % (liver); all these values were higher than the present report of 4.16-8.65 g/100 g. The total fatty acids (as calculated) was much close in values than in the total fat, this time with a value range of 3.25-4.85 g/100 g and lower CV % of 24.1. The total energy contribution due to total fatty acids was low at 120-180 kJ/100 g and low CV % of 24.1. The trend of total lipid concentration was brain > liver > heart but slight change in the total fatty acids and total energy having similar trend of brain > heart > liver.

Table II depicts the various levels and types of fatty acids in the samples. In the three samples the following fatty acids (FAs) were not detected: C2:0, C3:0, C4:0, C5:0 and C6:0 as well as C22:6 (*cis*-4, 7, 10, 13, 16, 19) in the heart. The following FAs also recorded 0.0 % value in all the samples: C8:0, C10:0 and C18:1 (*trans*-11) as well as C12:0 in the brain. In the brain of bull and hen, the only SFA detected were C22:0 (behenic acid) and C 24:0 (lignoceric acid)[18] unlike the brain of roan antelope where SFA of C14:0, C16:0, C18:0, C20:0, C22:0 and C24:0 were detected. While the values of C22:0 and C24:0 were low in the bull and hen brains (2.80-2.99 % and 3.31-3.54 % respectively)[18], their values were much lower in the brain of roan antelope with C22:0 (0.305 %) and C24:0 (0.038 %). The C22:0 and C24:0 have not been implicated in enhancing the level of low density lipoprotein (LDL) cholesterol unlike myristic (C14:0) and palmitic (C16:0) acids. The total SFA of the samples ranged as brain (46.3 %) > heart (39.5 %) > liver (37.7 %). The least concentrated SFA in all the samples were C24:0 (0.016-0.038 %), C22:0 (0.126-0.305 %), C20:0 (0.136-0.331 %), C12:0 (0.00-0.458 %). The major SFA levels came from C16:0 (16.7-25.8 %), C18:0 (12.6-17.3 %) and C14:0 (0.611-4.03 %) with the brain predominating in most of the results. The SFA CV % values ranged from 11.0-127. Some literature SFA values were (% total fat): beef fat (43 %); lamb fat (50 %); pork fat (37 %); chicken's meat and skin (33 %); duck's meat and skin (27 %) and calf liver (30 %)[16]; all these values were closely related to the results in roan antelope. The MUFA (*cis*) values were almost at par with the SFAs with a range of 25.4-44.2 %. Low levels of MUFA (*cis*) were observed in C14:1 (*cis*-9) (0.045-0.108 %), C20:1 (*cis*-11) (0.139-0.339 %) and C24:1 (*cis*-15) (0.016-0.038 %) whereas the major MUFA sources were C16:1 (*cis*-9) (2.05-5.45 %), C18:1 (*cis*-6) (12.7-18.5) and C18:1 (*cis*-9) (10.4-22.3 %). The MUFA (*cis*) CV % levels were 18:6-51.2. All the MUFA (*trans*) values were generally low with overall value range of 0.053-0.131 %; their CV % range being 0.00-44.8. Literature MUFA values were: beef fat (48 %), lamb fat (39 %), pork fat (41 %), chicken's meat and skin (42 %), duck's meat and skin (54 %) and calf liver (54 %)[16] which were not too far from the overall MUFA values of 25.5-44.3 % in the roan antelope. Grass-finished beef tends to produce more favourable SFA; in the bull brain SFA was 6.11 %[18] whereas it was 46.3 % in the roan antelope showing the roan antelope may depend on more varied vegetable sources than grass leaves and stems as food.

Table I still contains the polyunsaturated fatty acids (PUFA) composition of *n*-6 and *n*-3 in the samples. Among the *n*-6 family, C18:2 (*cis* -9, 12) (linoleic acid, LA) was the most concentrated in the samples with value range of 2.05-21.4 % with CV % of 80.7 and followed by C20:4 *n*-6, *cis* (arachidonic acid, AA) with value range of 3.91-13.3 %. Whilst total PUFA *n*-6 totalled 6.67-36.1 %, the *n*-3 PUFA ranged as 0.696-2.45 % with respective CV % of 71.3 and 54.5. C18:2 *n*-6, *trans* (or C18:2, *cis*-9, *trans*-11) (*trans*-linoleic acid or conjugated linoleic acid, CLA) had value range of 0.057-0.139 % whereas the value range in the brains of bull was 2.30 % and in hen was 0.113 %[18]. One of the factors that affect the total lipid found in a serving of meat is highly dependent upon the feeding regimen[19]. CLA is a constituent of ruminant animals and exist as a general mixture of conjugated isomers of linoleic acid (LA). The *cis*-9, *trans*-11 CLA isomer (rumenic acid or RA) accounts for up to 80-90 % of

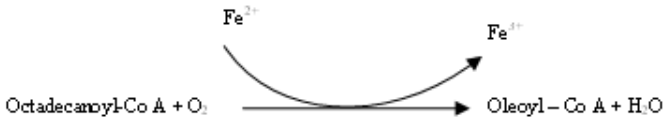
the total CLA in ruminant products[19]. Naturally occurring CLAs originate from two sources: bacterial isomerization and/or biohydrogenation of PUFA in the rumen and the desaturation of PUFA in the rumen and the desaturation of *trans*-fatty acids in the adipose tissue and mammary gland [20, 21]. Microbial biohydrogenation of LA and α-LA by anaerobic rumen bacterium *Butyrivibrio fibrisolvens* is highly dependent on rumen pH. Grain consumption decreases rumen pH, reducing *B. fibrisolvens* activity, conversely grass-based diets provide for a more favourable rumen environment for subsequent bacterial synthesis[19]. CLA has been shown in actions to reduce carcinogenesis, atherosclerosis and onset of diabetes. In the *n*-3 PUFA group, both C18:3 (alpha linolenic acid, α-ALA) and C22:6 *n*-3, *cis* (docosahexanoic acid, DHA) were of significance. C18:3 had values of 0.274-0.798 % while DHA had ND-1.94 % with their respective CV % of 59.5 and 110. Total PUFA (*n*-6 + *n*-3) totalled 9.26-36.8 % with a trend of liver > heart > brain. Total PUFA from literature were: beef fat (4 %); lamb fat (5 %); pork fat (15 %); chicken's meat and skin (19 %); duck's meat and skin (12 %) and calf liver (26 %)[16] which were virtually lower than the present results. The total PUFA of bull (20.2 %) and hen (21.2 %) brains were much higher than in the roan antelope brain of 9.26 %. The total unsaturated fatty acid (UFA) levels were: 60.4 % (heart) < 62.3 % (liver) > 53.6 % (brain) making all of them more favourable nutritionally. The MUFA + PUFA (total UFA) in three land snails consumed in Nigeria had values close to the present results with 57.1 % (*Archachatina marginata*), 62.5 % [*Archatina (archatina*) *archatina*] and 50.3 % (*Limicolaria* sp)[22].

Medium-chain fatty acids have 8-12 carbon atoms and are common in butterfat and the tropical oils. In the present samples C12:0 was present in minor quantities in heart and liver (0.109-0.458 %). Like the short-chain fatty acids, these fats have antimicrobial properties; are absorbed directly for quick energy; and contribute to the health of the immune system[23].

Long-chain fatty acids have from 14-18 carbon atoms and can either be saturated, monounsaturated or polyunsaturated. Myristic acid (14:0) is a ubiquitous component of lipids in most living organisms, but usually at levels of 1-2 % only. In the present samples C14:0 ranged from 0.611-4.03 %. However, it is more abundant in cow's milk fat, some fish oils and in those seed oils enriched in medium-chain fatty acids (e.g. coconut and palm kernel). In *Oreochromis niloticus* fish C14:0 formed 6.59 % FA in the skin and 4.19 % in the muscle[24] and 1.05 % (muscle) and 1.12 % (skin) of Tongue sole fish[25]. This FA is found very specifically in certain proteolipids, where it is linked via an amide bond to an N-terminal glycine residue, and is essential to the function of the protein components. Palmitic acid (16:0) is usually considered the most abundant SFA in nature, and it is found in appreciable amounts in the lipids of animals, plants and lower organisms. It comprises 20-30 % of the lipids in most animal tissues and it is present in amounts that vary from 10-40 % in seed oils. The FA formed the highest concentration (16.7-25.8 %) in the present results thereby confirming the above statement. Stearic acid (18:0) is the second most abundant SFA in nature, and again it is found in the lipids of most living organisms. In these samples (18:0) occupied the second highest position (12.6-17.3 %) in the SFA group. In lipids of some commercial importance, it occurs in the highest concentrations in ruminant fats (milk fat and tallow) or in vegetables oils such as cocoa butter and in industrially hydrogenated fats. It can comprise 80 % of the total fatty acids in gangliosides.

Oleic acid [9*c*-18:1 or 18:1(*n*-9)] is by far the most abundant monoenoic FA in plant and tissue, both in structural lipids and in depot fats. It comprised 10.4 -22.3 % in the samples forming the highest concentration of *cis* MUFA in heart (18.3 %) and brain (22.3 %) but second highest in liver (10.4 %). Olive oil contains up to 78 % of oleic acid and it is believed to have especially valuable nutritional properties as part of the Mediterranean diet. It has a number of important biological properties, both in the free and esterified form. Oleic acid is the biosynthetic precursor of a family of fatty acid with the (*n*-9) terminal structure and with chain-lengths of 20-24 or more. Petroselinic acid (6 *cis*-18:1) occurs up to a level of 50 % or more in seed oils of the Umbelliferae family, including carrot, parsely and coriander. In the present report, petroselinic acid occupied levels of 12.7-18.5 % in the samples being second highest *cis*-MUFA in heart (15.6 %), brain (18.5 %) but highest concentrated *cis*-MUFA in liver (12.7 %). These values were close at CV % of 18.6. Another monounsaturated fatty acid is the 16-carbon palmitoleic acid which has strong antimicrobial properties. It is found almost exclusively in animal fats. It occupied concentrated level of 2.05-5.45 % in the samples forming the third highest concentrated *cis*-MUFA. All of the *trans*-MUFA levels were all virtually of no significance values.

In nearly all higher organisms, including many bacteria, yeasts, algae, plants and animals, double bonds are introduced into fatty acids by an aerobic mechanism that utilizes preformed FAs as the substrate. Molecular oxygen and a reduced pyridine nucleotide (NADH or NADPH) are required cofactors. Thus in animals and yeasts, the co-enzyme A ester of octadecanoic (stearic) acid is converted directly to oleoyl-CoA by a concerted removal of hydrogen atoms from carbons 9 and 10 (D-stereochemistry in each instance). The stearoly-CoA desaturase system is in the endosplasmic reticulum membrane with the active centre exposed to the cytosol, and consists of three proteins: cytochrome b5 reductase, cytochrome b5 and the desaturase, which contains two atoms of iron at the active site.



The notoriously difficult to purify, but the evidence suggests that the yeast Δ^9-desaturase consists of two membrane spanning regions with the bulk of the protein protruding into the cytosol. The enzyme has much in common with hydroxylases and contains eight essential histidine residues that coordinate with the di-iron centre at the active site. The cytochrome b5 component is fused to the desaturase and is believed to facilitate electron transfer from NADH reductase to the catalytic di-iron core.

Palmitoleate is synthesised from palmitate by a similar mechanism. Subsequently, oleate can be chain elongated by two carbon atoms to give longer-chain fatty acids of the (*n-9*) family, while palmitoleate is the precursor of the (*n-7*) family of fatty acids. In mammalian systems the elongases are known to be distinct enzymes that differ from those involved in the production of longer-chain PUFAs. *Alpha*- and *beta*-oxidation can also occur to give shorter chain components of the two families.

Table 1. Crude fat levels of heart, liver and brain (g/100g dry weight)

Parameter	Heart	Liver	Brain	Mean	SD	CV%	X^2	Remark
Crude Fat	4.16	4.39	8.65	5.73	2.53	44.1	2.23	NS
Total fatty acid	3.28	3.25	4.85	3.79	0.915	24.1	2.23	NS
Energy kJ	121	120	180	140	33.9	24.1	2.23	NS

Table 2. Fatty acids compositions (%) of the heart, liver and brain (g/100g dry weight)

Fatty acid	Heart	Liver	Brain	Mean	SD	CV%
C2:0	-	-	-	-	-	-
C3:0	-	-	-	-	-	-
C4:0	-	-	-	-	-	-
C5:0	-	-	-	-	-	-
C6:0	-	-	-	-	-	-
C8:0	0.00	0.00	0.00	0.00	0.00	0.00
C10:0	0.00	0.00	0.00	0.00	0.00	0.00
C12:0	0.458	0.109	0.00	0.189	0.239	127
C14:0	0.611	3.34	4.03	2.66	1.81	67.8
C16:0	25.2	16.7	25.8	22.6	5.09	22.5
C18:0	12.6	17.3	15.8	15.2	2.40	15.8
C20:0	0.307	0.136	0.331	0.261	0.109	41.8
C22:0	0.284	0.126	0.305	0.238	0.098	41.1
C24:0	0.035	0.016	0.038	0.029	0.012	41.8
SFA total	39.5	37.7	46.3	41.2	4.54	11.0
C14:1 (*cis-9*)	0.101	0.045	0.108	0.085	0.035	40.6
C16:1 (*cis*- 9)	5.45	2.05	2.89	3.46	1.77	51.2
C18:1 (*cis-6*)	15.6	12.7	18.5	15.6	2.90	18.6
C18:1 (*cis*-9)	18.3	10.4	22.3	17.0	6.06	35.6
C20:1 (*cis*-11)	0.315	0.139	0.339	0.264	0.109	41.8
C24:1 (*cis*- 15)	0.035	0.016	0.038	0.029	0.012	41.8
MUFA (*cis*)	39.8	25.4	44.2	36.5	9.83	26.9
C18:1 (*trans-6*)	0.111	0.049	0.119	0.093	0.038	41.2
C18:1 (*trans-9*)	0.010	0.004	0.012	8.8e-3	3.94e-3	44.8
C18:1 (*trans-11*)	0.00	0.00	0.00	0.00	0.00	0.00
MUFA (trans)	0.121	0.053	0.131	0.102	0.042	41.6
C18:2 (cis-9,12)	12.6	21.4	2.05	12.0	9.69	80.7
C18:2 (*trans-9,11*)	0.130	0.057	0.139	0.109	0.045	41.3
C18:3 (*cis*-6, 9,12)	0.780	0.345	0.240	0.455	0.286	62.9
C18:3 (*cis*-9,12,15)	0.798	0.353	0.274	0.475	0.283	59.5
C20:2 (*cis-11,14*)	0.044	0.019	0.047	0.037	0.015	41.1
C20:3 (*cis*-8,11,14)	0.868	0.971	0.386	0.742	0.312	42.1
C20:3 (*cis*-11,14,17)	0.188	0.083	0.202	0.158	0.065	41.2
C20:4 (*cis*- 5,8,11,14)	4.97	13.3	3.91	7.39	5.14	69.6
C22:2 (*cis*-13,16)	0.035	0.016	0.038	0.029	0.012	41.8
C20:5 (*cis*-5,8,11,14,17)	0.035	0.016	0.038	0.029	0.012	41.8
C22:6 (*cis*- 4,7,10,13,16,19)	-	0.244	1.94	1.09	1.20	110
PUFA total	20.5	36.8	9.26	22.2	13.9	62.4

Table 3. Sample in g/100 g as food of the heart, liver and brain

Fatty acid	Heart	Liver	Brain	Mean	SD	CV%
C2:0	-	-	-	-	-	-
C3:0	-	-	-	-	-	-
C4:0	-	-	-	-	-	-
C5:0	-	-	-	-	-	-
C6:0	-	-	-	-	-	-
C8:0	0.00	0.00	0.00	0.00	0.00	0.00
C10:0	0.00	0.00	0.00	0.00	0.00	0.00
C12:0	0.015	3.54e-3	0.00	6.18e-3	7.84e-3	127
C14:0	0.020	0.109	0.195	0.108	0.088	81.0
C16:0	0.827	0.543	1.25	0.873	0.356	40.8
C18:0	0.413	0.562	0.766	0.580	0.177	30.6
C20:0	0.010	4.42e-3	0.016	0.010	5.84e-3	57.3
C22:0	9.32e-3	4.10e-3	0.015	9.41e-3	5.35e-3	56.9
C24:0	1.15e-3	5.04e-4	1.83e-3	1.16e-3	6.63e-4	57.2
SFA total	1.30	1.23	2.24	1.59	0.564	35.5
C14:1 (*cis-9*)	3.31e-3	1.45e-3	5.23e-3	3.33e-3	1.89e-3	56.8
C16:1 (*cis- 9*)	0.179	0.067	0.140	0.129	0.057	44.1
C18:1 (*cis-6*)	0.512	0.413	0.897	0.607	0.256	42.1
C18:1 (*cis*-9)	0.600	0.338	1.08	0.673	0.376	55.9
C20:1 (*cis*-11)	0.010	4.25e-3	0.016	0.011	5.94e-3	57.1
C24:1 (*cis*- 15)	1.15e-3	5.04e-4	1.83e-3	1.16e-3	6.63e-4	57.2
MUFA (*cis*)	1.31	0.824	2.14	1.42	0.666	46.9
C18:1 (*trans-6*)	3.64e-3	1.59e-3	5.77e-3	3.67e-3	2.09e-3	57.0
C18:1 (*trans-9*)	3.28e-4	1.43e-4	5.42e-4	3.32e-4	1.91e-4	57.4
C18:1 (*trans-11*)	0.00	0.00	0.00	0.00	0.00	0.00
MUFA (trans)	3.97e-3	1.73e-3	6.31e-3	4.00e-3	2.29e-3	57.2
C18:2 (cis-9,12)	0.413	0.696	0.099	0.403	0.299	74.1
C18:2 (*trans-9,11*)	4.25e-3	1.87e-3	6.74e-3	3.01e-3	3.31e-3	110
C18:3 (*cis*-6, 9,12)	0.026	0.011	0.012	0.016	8.20e-3	50.9
C18:3 (*cis*-9,12,15)	0.026	0.012	0.013	0.017	8.02e-3	47.2
C20:2 (*cis-11,14*)	1.43e-3	6.27e-4	2.27e-3	1.44e-3	8.22e-4	57.1
C20:3 (*cis*-8,11,14)	0.029	0.032	0.019	0.026	6.73e-3	25.7
C20:3 (*cis*-11,14,17)	6.17e-3	2.70e-3	9.80e-3	6.22e-3	3.55e-3	57.1
C20:4 (*cis*- 5,8,11,14)	0.163	0.432	0.190	0.262	0.148	56.5
C22:2 (*cis*-13,16)	1.15e-3	5.04e-4	1.83e-3	1.16e-3	6.63e-4	57.2
C20:5 (*cis*-5,8,11,14,17)	1.15e-3	5.04e-4	1.83e-3	1.16e-3	6.63e-4	57.2
C22:6 (*cis*- 4,7,10,13,16,19)	-	7.93e-3	0.094	0.051	0.061	119
PUFA total	0.671	1.20	0.449	0.773	0.384	49.7

Table 4. Energy contributions in kJ/100g of the heart, liver and brain

Fatty acid	Heart	Liver	Brain	Mean	SD	CV%
C2:0	-	-	-	-	-	-
C3:0	-	-	-	-	-	-
C4:0	-	-	-	-	-	-
C5:0	-	-	-	-	-	-
C6:0	-	-	-	-	-	-
C8:0	0.00	0.00	0.00	0.00	0.00	0.00
C10:0	0.00	0.00	0.00	0.00	0.00	0.00
C12:0	0.555	0.131	0.00	0.229	0.290	127
C14:0	0.740	4.03	7.22	3.99	3.23	81.0
C16:0	30.6	20.1	46.3	32.3	13.2	40.8
C18:0	15.3	20.8	28.3	21.5	6.53	30.4
C20:0	0.374	0.164	0.596	0.378	0.216	57.1
C22:0	0.345	0.152	0.548	0.348	0.198	57.0
C24:0	0.043	0.019	0.068	0.043	0.024	56.5
SFA total	48.1	45.5	83.0	58.9	20.9	35.6
C14:1 (*cis-9*)	0.122	0.054	0.194	0.123	0.070	56.9
C16:1 (*cis- 9*)	6.62	2.48	5.18	4.76	2.10	44.2
C18:1 (*cis-6*)	18.9	15.3	33.2	22.5	9.47	42.1
C18:1 (*cis*-9)	22.2	12.5	40.0	24.9	13.9	56.0
C20:1 (*cis*-11)	0.381	0.167	0.607	0.385	0.220	57.1
C24:1 (*cis*- 15)	0.043	0.019	0.068	0.043	0.024	56.5
MUFA (*cis*)	48.3	30.5	79.3	52.7	24.7	46.8
C18:1 (*trans-6*)	0.135	0.059	0.213	0.137	0.077	56.2
C18:1 (*trans-9*)	0.012	5.29e-3	0.019	0.012	7.06e-3	57.9
C18:1 (*trans-11*)	0.00	0.00	0.00	0.00	0.00	0.00
MUFA (trans)	0.147	0.064	0.232	0.148	0.084	56.7
C18:2 (cis-9,12)	15.3	25.8	3.66	14.9	11.1	74.3
C18:2 (*trans-9,11*)	0.157	0.069	0.249	0.158	0.090	57.0
C18:3 (*cis*-6, 9,12)	0.947	0.414	0.429	0.597	0.303	50.8
C18:3 (*cis*-9,12,15)	0.969	0.426	0.492	0.629	0.296	47.1
C20:2 (*cis-11,14*)	0.053	0.023	0.084	0.053	0.031	57.4
C20:3 (*cis*-8,11,14)	1.06	1.17	0.692	0.974	0.250	25.7
C20:3 (*cis*-11,14,17)	0.228	0.010	0.363	0.200	0.178	89.1
C20:4 (*cis*- 5,8,11,14)	6.03	16.0	7.03	9.69	5.49	56.7
C22:2 (*cis*-13,16)	0.043	0.019	0.068	0.043	0.024	56.5
C20:5 (*cis*-5,8,11,14,17)	0.043	0.019	0.068	0.043	0.024	56.5
C22:6 (*cis*- 4,7,10,13,16,19)	-	0.293	3.48	1.89	2.25	119
PUFA total	24.8	44.2	16.6	28.5	14.2	49.7

Table 5. Calculated parameters on fatty acids

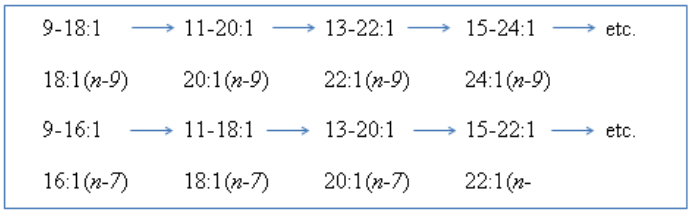
Parameter	Heart	Liver	Brain	Mean	SD	CV%	X^2	Remark
SFA	39.5	37.7	46.3	41.2	4.54	11.0	0.998	NS
MUFA $_{cis}$	39.8	25.4	44.2	36.5	9.83	26.9	5.70	NS
MUFA $_{trans}$	0.121	0.053	0.131	0.102	0.042	41.6	0.014	NS
MUFA $_{total}$	39.9	25.5	44.3	36.6	9.83	26.9	5.29	NS
PUFA	20.5	36.8	9.26	22.2	13.9	62.4	17.3	S
AA/DGLA	5.73	13.7	10.1	9.84	3.99	40.6	3.24	NS
EPA/DHA	-	0.020	0.027	0.023	4.96e-3	21.6	0.001	NS
LA/ALA	15.8	60.6	7.48	28.0	28.6	102	58.3	S
n-6	19.3	36.1	6.67	20.7	14.8	71.3	20.1	S
n-3	1.71	0.696	2.45	1.62	0.883	54.5	0.957	NS
n-6/n-3	11.3	51.9	2.72	22.0	26.3	119	62.7	S
PUFA/SFA	0.519	0.976	0.200	0.565	0.390	69.1	0.539	NS
MUFA/SFA	1.01	0.676	0.957	0.881	0.179	20.3	0.074	NS
EPSI	0.514	1.44	0.209	0.722	0.643	89.0	1.14	NS

Table 6. Sterols level (mg/100g) of the heart, liver and brain

Sterols	Heart	Liver	Brain	Mean	SD	CV%	X^2	Remark
Cholesterol	115	88.7	1234	479	653	137	1785	S
Cholestanol	3.40e-4	2.06e-4	3.68e-4	3.05e-4	8.66e-5	28.4	-	-
Ergosterol	1.79e-3	1.66e-3	1.84e-3	1.76e-3	9.29e-5	5.28	-	-
Campesterol	5.26e-4	5.15e-4	5.08e-4	5.16e-4	9.07e-6	1.76	-	-
Stigmasterol	1.65e-3	1.64e-3	1.66e-3	1.65e-3	1.00e-5	0.606	-	-
5- Avenasterol	8.85e-3	8.85e-3	8.85e-3	8.85e-3	0.00	0.00	-	-
Sitosterol	6.42e-3	6.41e-3	6.40e-3	6.41e-3	1.00e-5	0.156	-	-
Total	115	88.7	1234	479	654	137	-	-

Table 7. Phospholipids level (mg/100g) of the heart, liver and brain

Phospholipids	Intestine	Liver	Stomach	Mean	SD	CV%	X^2	Remark
Phosphatidylethanolamine	152	65.7	324	181	132	72.7	286	S
Phosphatidylcholine	292	214	1280	595	594	99.9	1187	S
Phosphatidylserine	1.92	5.96e-1	702	235	405	172	1393	S
Lysophosphatidylcholine	3.96	2.36	6.62e-1	2.33	1.65	70.8	2.34	NS
Phosphatidylinositol	2.24e-1	4.69e-1	485	162	280	173	967	S
Total	449	283	2791	1174	1403	120	3351	S



Petroselinic acid (6-18:1) in seed oils of the Umbelliferae is synthesised by an enzyme that removes hydrogen from position 4 of palmitate, before the resulting 4-16:1 is elongated by two carbon atoms. 16:0 desaturation 4-16:1 elongation 6-18:1 (petroselinic acid).

Current nutritional thinking appears to be that dietary *trans*-monoenoic FAs, both from ruminant fats and from industrial hydrogenation processes, should be considered as potentially harmful and in the same light as saturated fatty acids.ll in Table II, there were[11] important long- chain and very-long-chain fatty acids; long-chain fatty acids have from 14-18 carbon atoms and very-long-chain fatty acids have 20-24 carbon atoms. The two essential fatty acids (EFAs) are C18:2 *cis*-9, 12 and C18:3 *cis*-9, 12, 15 with respective values of 2.05-21.4 % and 0.274-0.798. Another important long-chain fatty acid is gamma-linolenic acid (GLA) (C18:3 *cis*-6, 9, 12). It formed a level of 0.240-0.780 % in the samples. It is found in evening primrose, borage and black currant oils. The body makes GLA out of omega-6 linoleic acid and uses it in the production of substances called prostaglandins, localized tissue hormones that regulate many processes at the cellular level. Eicosadienoic acid [C20:2 *cis* – 11, 14 or 20:2 (*n* - 6) all-*cis* -11,14- *eicosadienoic* acid] or homo-gamma-linoleic acid is an unknown naturally occurring PUFA. It is not enriched in any particular tissue, it is rare in all lipid classes. Dietary sources include herring and menhaden oils, cattle liver, swine brain lipids, shark oil[26]. Homo-γ-LA had levels of 0.019-0.047 % in total fatty acids of the samples or 0.05-0.51 % of the PUFA. The FA inhibits the binding of [^{3}H]-ITB$_4$ to pig neutrophil membrane with a Ki of 3 µm. In snails, homo-γ-LA had levels of 8.36-16.7 % in the total fatty acids, being the highest concentrated among the total PUFA FAs or 32.8-43.2 % of the PUFA[22]. The levels of C18:2 *cis*-9, *trans*-11 ranged from 0.057-0.139 % which were generally low. Both C20:3 *n*-6, *cis* (dihomo-γ-linolenic acid) (0.386-0.971 %) and C22: 2*n*-6, *cis* (docosadienoic acid, C22:2 *cis*-13, 16) (0.016-0.038 %) were all low in values. It has been suggested that arachidonic acid (C20:4 or C20:4 *cis*-5, 8, 11, 14) is detrimental to human health[27]. However, it promotes inflammation that is an important protective response when one is injured. It also forms the basis of anti-inflammatory prostaglanding that the body uses, to reduce inflammation[28]. The amount of arachidonic acid (AA) in beef is very low (less than 0.5 % of total fat); thus, great amount of beef have to be consumed to detect any contradictory effect. The present results had values of 3.91-13.3 % which were lower than in the brains of bull and hen (24.3-18.5 %)[22].

Some calculated parameters are shown in Table III. They included the SFA, MUFA *cis*, MUFA *trans*, MUFA total, PUFA and some other ratios. Metabolites of *n*-6 are significantly more inflammatory (especially AA) than those of *n*-3. This necessitates that *n*-3 and *n*-6 are consumed in balanced proportion; healthy ratios of *n*-6: *n*-3 range from 1:1 to 4:1[29]. In the samples (Table III) 2*n*-6/3*n*-3 (LA/ALA) ranged from 7.48-60.6. However on the total *n*-6/*n*-3, range was 2.72-51.9 which were both outside the literature value[29]. Typical Westhern diet provides ratios of between 10:1 and 30:1, that is, dramatically skewed towards *n*-6[30]. Here are the ratios of *n*-6 to *n*-3 fatty acids in some common oils: canola 2:1, soybean 7:1, olive 3-13:1, sunflower (no *n*-3), flax 1:3, cottonseed (almost no *n*-3), grape seed (almost no *n*-3) and corn oil 46 to 1 ratio of *n*-6 to *n*-3. The relative proportion of SFA/MUFA is an important aspect of phospholipid compositions and changes to this ratio have been claimed to have effects on such disease states as cardiovascular disease, obesity, diabetes, neuropathological conditions and cancer. For example, they have been shown to have cyto- protective actions in pancreatic β-cells. *cis*-Monoenoic acids have desirable physical properties for membrane lipids in that they are liquid at body temperature, yet are relatively resistant to oxidation. They are now recognised by nutritionists as being beneficial in the human diet. Values of

MUFA/SFA in samples ranged as 0.676-1.01 with low CV % of 20.3. The relative amounts of PUFA and SFA in oils is important in nutrition and health. The ratio of PUFA/SFA (P/S ratio) is therefore important in determining the detrimental effects of dietary fats. The higher the P/S ratio the more nutritionally useful is the oil. This is because the severity of atherosclerosis is closely associated with the proportion of the total energy supplied by saturated fats and polyunsaturated fats[31]. The present PUFA/SFA varied between 0.200-0.976 which were averagely normal for heart (0.519), liver (0.976) but low for brain (0.200). The AA/DGLA (di-homo-gamma-linolenic acid) values were 5.73-13.7. A high ratio between AA and DGLA, as an indicator of Δ-5 desaturase activity, in the skeletal muscle phospholipids has been related to good insulin sensitivity[32]. One suitable indicator of essential PUFA status index (EPSI), is the ratio between all essential PUFA (the sum of all *n*-3 and *n*-6 FAs) and all nonessential unsaturated FAs (the sum of all *n*-7 and *n*-9 FAs). The higher the essential PUFA status index the better the essential PUFA status[32]. The EPSI results were 0.514 (heart, just fair), 1.44 (liver, good ratio) and 0.209 (brain, poor value). The EPA/DHA results were poor at nd-0.027.

Table IV shows the fatty acids distribution per 100 g sample as food. The values produced from the SFA and MUFA were consistently highest in the brain as 2.24 g/100 g (SFA) and 2.14 g/100 g (MUFA) but in third position in PUFA (0.449 g/100 g). The National Institute of Health has published recommended daily intakes of FAs; specific recommendations included 650 mg of EPA and DHA, 2.22 g/day of α-LA and 4.44 g/day of LA. However, the Institute of Medicine has recommended DRI (dietary reference intake) for LA (*n*-6) at 12 to 17 g and α-LA *(n*-3) at 1.1 to 1.6 for adult women and men respectively. Although seafood is the major dietary source of *n*-3 FAs, a recent FA intake survey indicated that red meat also serves as a significant source of *n*-3 FAs for some populations[19], this could not be the case in the roan antelope.

The energy in food is held in form of fat, carbohydrate, protein and alcohol. Each gram of fat contains approximately 9 kilocalories (37 kJ). This value was used to calculate the energy levels of the various fat samples[33]. The energy density in the samples due to fat were 121 kJ/100 g (about 29.5 kCal/100 g) in heart, 120 kJ/100 g (about 29.3 kCal/100 g) in liver, 180 kJ/100 g (about 43.7 kCal/100 g) in brain (Table I). The 1990 Canadian RNI (Recommended Nutrient Intakes) included specific amounts for 3*n*-3 fatty acids and 2*n*-6 fatty acids. For *n*-3 fatty acids RNI is 0.5 % of total energy or 0.55 g/1000 kCal; for *n*-6 fatty acids, the RNI is 3 % of total energy or 3.3 g/1000 kCal[34]. For energy contribution in the samples, the following was observed in all the samples: SFA > MUFA > PUFA. The overall energy contribution by each fatty acid had been shown in Table V.

In the analysis of zoosterols, only cholesterol was detected in all the samples at appreciable levels (Table VI) with values of (mg/100 g): 115 (heart), 88.7 (liver) and 1234 (brain). Cholesterol is a fatty compound involved in the transport of fat in the blood stream and is also part of the structure of cell membranes of tissues of the body. It is not a dietary essential since adequate amounts are synthesised in the body from other dietary ingredients. Confusion has arisen between the terms blood cholesterol and dietary cholesterol. For most individuals dietary cholesterol has little or no effect on blood cholesterol levels because reduced synthesis in the body compensates for increased dietary intake[16]. However, there are individuals who are sensitive to dietary cholesterol[35] and most authorities advise a general reduction in cholesterol intake for everyone. These sterols recorded less than 0.001 mg/100 g in the samples: cholestanol, ergosterol, campesterol, stigmasterol, savenasterol and sitosterol.

Meat supplies about one third of the dietary cholesterol in many western diets with the remainder from eggs and dairy products. Since all these foods are valuable sources of nutrients there could be some nutritional risk in restricting their intake. Most authorities, but not all, recommend a reduction in dietary cholesterol to around 300 mg or less per day[16], this is more than the level in 100 g in the heart and liver samples under discussion. Some literature values of cholesterol are as shown (mg/100 g): fish (50-60), egg yolk (1260), meat and poultry (60-120), brain (2000-3000), liver (300-350)[16]. Sheep brain contains 2200 mg/100 g cholesterol level[35]. Garcia *et al*[36] reported (cholesterol/100 g) 40.3 and 45.8 or 40300 and 45800 mg/100 g of tissue in pastured and grain-fed steers (castrated bulls), respectively ($p < 0.001$). Cholesterol levels in bull brain were 874 mg/100 g and in hen brain it was 589 mg/100 g[18].

Table VII shows the levels of the various phospholipids. Phosphatidylcholine (PC) was the most abundant phospholipid in the three samples forming levels of (mg/100 g): 292 (or 65.0 %) in heart, 214 (or 75.6 %) in liver and 1280 (or 45.9 %) in brain. PC is the most abundant phospholipid in brain cell membranes comprising about 30 % of the total phospholipid content while phosphatidylserine (PS) makes up less than 10 %. In the present report PS made up 1.92 mg/100 g (0.428 %) in heart, 5.96e-1 mg/100g (0.211 %) in liver and 702 mg/100 g (25.2 %) in brain. The PC is the key building block of membrane bilayers, it is also the principal phospholipid circulating in plasma, where it is an integral component of the lipoproteins, especially the HDL[34]. PS has been shown to enhance mood in a cohort of young people during mental stress and to improve accuracy during tee-off by increasing the stress resistance of golfers. The US Food and Drug Administration (USFDA) had stated that consumption of PS may reduce the risk of dementia in the elderly[24]. Roan antelope would be good in this function. Phosphatidylethanolamine/cephalin (PE) was in the third position in concentration in two of the three roan antelope samples; values were 152 mg/100 g (33.9 %) in heart, 65.7 g/100 g (23.2 %) in liver and 324 mg/100 g (11.6 %) in brain. PE is found in all living cells, although in human physiology it is found particularly in nervous tissue such as the white matter of brain, nerves, neural tissue and in spinal cord[24]; this can easily be seen in the brain result. Phosphatidylinositol (PtIns, PI) is a negatively charged phospholipid. PI can be phosphorylated to form phosphatidylinositol phosphate (PIP), phosphatidylinositol bisphosphate (PIP_2) and phosphatidylinositol triphosphate (PIP_3). PIP, PIP_2 and PIP_3 are collectively called phosphoinositides. Phosphoinositides play important roles in lipid signalling, cell signalling and membrane trafficking[24]. PI was very insignificant in heart and liver with respective values of 2.24 e-1 mg/100 g (0.05 %) and 4.69 e-1 mg/100 g (0.17 %) but high in brain with a value of 485 mg/100 g (17.4 %). PI in the brains of hen and bull was lower than in the brain of roan antelope; they had values of (mg/100 g): 14.7 (bull brain) and 2.27 (hen brain). Lysophosphatidylcholine was low in value in the three samples with levels of (mg/100 g): 3.96(0.88 %) in heart, 2.36 (0.83 %) in liver and 6.62 e-1 (0.024 %).

Partial hydrolysis of PC with removal of only one fatty acid yield a lysophosphatidylcholine.

The correlation determined for all the standards: fatty acids, phospholipids and sterol, all had values ranging as follows: 0.99833-0.99997 (fatty acids), 0.99909-0.99999 (phospholipds) and 0.99920-0.99994 (sterols); all the correlation values were greater than 0.95 which is the critical correlation for acceptance of these types of analytical results, thus attesting to the quality assurance of the determinations.

In conclusion, the findings of this study showed that the samples possessed unequal distribution of all parameters (fatty acids, phospholipids and zoosterols) determined. In all the samples the unsaturated fatty acids values were correspondingly higher than in the saturated fatty acids. The fatty acids energy contribution by the samples were generally low. The unsaturated and low fats are good for healthy heart functioning. The only cholesterol level of major health concern came from the brain (1234 mg/100 g). The samples were good sources of PC, PE; PI and PS are good from brain. In Table 3 LA/ALA, *n*-6, *n*-3 and *n*-6/*n*-3 are all significantly different; in Table 6 cholesterol is significant and in Table 7 all values are all significant different except phosphatidylinositol; all under chi-square analysis.

References

1. http://www.hintsandthings.co.uk/kennel/collectives.htm
2. "Antelope". (http://dictionary.reference.com/browse/antelope) Dictionary.com.Online Etymology Dictionary. Douglas Harper, Historian. Accessed 1 September 2008.
3. Carr, A. The Land and Wildlife of Africa, part of the LIFE Nature Library series: 1964, renewed 1974 Time Life Inc.
4. http://www.guardian.co.uk/world/2003/mar/13/highereducation.science1
5. http://www.seaworld.org/animal-info/animal-bytes/animalia/eumetazoa/coelomates/deuterostomes/chordata/craniata/mammalia/artiodactyla/roan-antelope.htn
6. Burnie D, Wilson E (Eds). Animal: The definitive visual guide to the world's wildlife. DK Adult; 2005.
7. http://www.arkive.org/roan-antelope/hippotragus-equinus/#text=Facts
8. International Union for Conservation of Nature and Natural Resources Species Survival Commission (IUCN SSC) Antelope Specialist Group (2008). *Hippotragus equinus* (http://www.iucnredlist.org/apps/redlist/details/10167). In: IUCN 2008. IUCN Red List of Threatened Species. Downloaded on November 2008. Database entry includes a brief justification of why this species of least concern.
9. Alpers DL, Van Vuuren BJ, Arctander P, Robinson TJ. Population genetics of the roan antelope (*Hippotragus equinus*) with suggestions for conservation. Molecular Ecology. 2004; 13: 1771-1784.
10. East R. African antelope database 1999. Gland, Switzerland and Cambridge, UK: IUCN; 1999.
11. AOAC. Official methods of analysis 18th ed. Washington, DC, USA: Association of Official Analytical Chemists, 2005; 920.39 (A); 969.33 and 996.06; 970.51.
12. Raheja RK, Kaur C, Singh A, Bhatia IS. New colorimetric method for the quantitative estimation of phospholipids without acid digestion. Journal of Lipid Research. 1973; 14:695-697.
13. Anderson BA. Comprehensive evaluation of fatty acids in foods. VII: Pork products. Journal of American Dietetic Association. 1976; 69: 44-49.
14. Greenfield H, Southgate DAT. Food composition data, production, management and use. Rome, Italy: FAO; 2003.
15. Oloyo RA. Fundamentals of research methodology for social and applied sciences. Ilaro, Nigeria: ROA Educational Press; 2001.
16. Bender A. Meat and meat products in human nutrition in developing countries. FAO Food and Nutrition Paper 53. Rome, Italy, FAO; 1992.
17. Fornias CV. Edible by-products of slaughter animals. FAO Animal Production and Health Paper 123. Rome, Italy: FAO; 1996.
18. Adeyeye EI, Study of long-chain and other *n*-3 polyunsaturated fatty acids and other lipids in brains of bull and hen. Elixir Food Science. 2012; 47(2012): 8599-8606.
19. Daley CA, Abbott A, Dovie PS, Nader GA, Larson S. Grass fed versus grain fed beef: fatty acid profiles,antioxidant content and taste. Nutrition Journal. 2010; 9: 10-21.
20. Grinary JM, Corl BA, Lacy SH, Chouinard PY, Nurmela KV, Bauman DE. Conjugated linoleic acid is synthesized endogenously in lactating dairy cows by delta-9 desaturase. Journal of Nutrition. 2000; 130: 2285-2291.
21. Sehart N, Rickert RR, Mossoba MM, Dramer JKG, Yurawecz MP, Roach JAG, Adlof RO, Morehouse KM, Fritsche J, Eulitz KD, Steinhart H, Ku K. Improved separation of conjugated fatty acid methyl esters by silver ion-high-performance liquid chromatography. Lipids. 1999; 34: 407-413.
22. Adeyeye EI. Lipid composition of three different types of land snails consumed in Nigeria. Global Journal of Science Frontier Research Chemistry. 2012; 12(7) version 1.0:8-22.
23. Kabara JJ. The pharmaceutical effects of lipids. Champaign, IL: The American Oil Chemists Society; 1978.
24. Adeyeye EI. Levels of fatty acids, phospholipids and sterols in the skin and muscle of tilapia (*Oreochromis niloticus*) fish. Rivista Italiana Delle Sostanze Grasse. 2011; LXXXVIII (Gennaio/Marzo): 46-55.
25. Adeyeye EI, Owokoniran S, Popoola FE, Akinyeye RO. Fatty acids, phospholipids and sterols levels of skin and muscle of Tongue sole fish. Pakistan Journal of Science and Industrial Research, Series A; Phy. Science. 2011; 54(3): 140-148.
26. Yagaloff KA, Franco L, Suniko B. Essential fatty acids are antagonists of the leulotriene B4 receptor. Prostaglandins Leukotriene Essential Fatty acids. 1995; 52: 293-297.
27. Barham JB, Edens MB, Fonteh AN, Johnson MM, Easter L, Chilton FH. Addition of eicosaentanoic acid to γ-linolenic acid – supplemental diets prevents serum arachidonic acid accumulation in humans. Journal of Nutrition. 2000; 130: 1925-1931.
28. Fallon S, Enig MG. Tripping lightly down the prostaglandin pathways. Price-Pottenger Nutr. Foundation Health Journal. 1996; 20(3): 5-8 and on www. Weston APrice.org
29. Tribole E. The Ultimate Omega-3 Diet: Maximize the Power of Omega-3s to Supercharge Your Health, Battle Inflammation and Keep Your Mind Sharp. New York, USA: The McGraw-Hill; 2007.
30. Ruxton CHS, Calder PC, Reed SC, Simpson MJA. The impact of long-chain *n*-3 polyunsaturated fatty acids in human health. Nutrition Research Reviews. 2005; 18: 113-129.
31. Honatra G. Dietary fats and arterial thrombosis. Haemostasis. 1974; 2: 21-52.
32. Benatti P, Peluso G, Nicolai R, Calvani M. Polyunsaturated fatty acids: biochemical, nutritional and epigenetic properties. Journal of the American College of Nutrition. 2004; 23(4): 281-302.

33. Bingham S. Dictionary of Nutrition; A Consumer's Guide to the Facts of Food. London, UK: Barrie & Jenkins Ltd.; 1977.
34. Whitney EN, Cataldo CB, Rolfes SR. Understanding normal and clinical nutrition. New York, USA: West Publishing Company; 1994.
35. Paul AA, Southgate DAT. McCance and Wilddowson's The Composition of Foods 4th ed. London, UK: HMSO; 1978.
36. Garcia PT, Pensel NA, Sancho AM, Latimori NJ, Kloster AM, Amigone MA, Casal JJ. Beef lipids in relation to animal breed and nutrition in Argentina. Meat Science. 2008; 79:500-508.