LIPID PROFILE OF *Lanistes libycus* EDIBLE PORTION (MORELET, 1848)

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E. I. Adeyeye[1]* and M. O. Aremu[2]

[1]Department of Chemistry (Analytical Unit), Ekiti State University, PMB 5363, Ado-Ekiti, Nigeria

[2]Department of Chemical Sciences, Federal University Wukari, PMB 1020, Taraba State, Nigeria

*Corresponding author: eiadeyeye@yahoo.com, adeyeyeilesanmi2012@gmail.com

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Abstract: This study determined the lipid profile of *Lanistes libycus* edible portion on dry weight basis. The parameters determined were total crude fat, total fatty acids, sterols and phospholipid levels. Calculated from the main results were total fatty acid; total energy (both in kJ and kcal) in various sources; fatty acid in edible portion (EP); fatty acid quality parameters such as MUFA/SFA, PUFA/SFA, EPA/DHA, n-6/n-3 (LA/α-LA),Σn-6/Σn-3, AA/DGLA, EPA + DHA, ESPI (MUFA/PUFA), C16:0 : C18: cis – 9, C18:0 : C18 : 1cis – 9, %C16:0 in ΣSFA, %C18:0 in ΣSFA and ΣUFA (MUFA + PUFA). The sample contained 3.30 g/100g crude fat and 2.86 g/100g total fatty acid. Whilst total energy of crude fat was 122 kJ/100g, the value for total fatty acid was 106 kJ/100g. The following fatty acids were high in concentration (% total fatty acid): C16:0 (15.5), C18:0 (6.69), C18:1 (cis – 9) (7.28), C22:1 (cis – 13) (6.27), C20:2 (cis – 11, 14) (5.70), C20:5 (cis – 5, 8, 11, 14, 17) (14.2) and C22:6 (cis – 4, 7, 10, 13, 16, 19) (29.0). The values for total saturated fatty acid, monounsaturated fatty acids and total polyunsaturated fatty acids are 25.7, 20.3, and 53.9%, respectively. The energy values (kJ/100g) for saturated fatty acid, monounsaturated fatty acids and total polyunsaturated fatty acids were 27.2 (25.7%), 21.5 (20.3%) and 57.0 (53.9%) respectively. These parameters were nutritionally good in the sample MUFA/SFA, PUFA/SFA, EPA/DHA, n-6/n-3 (LA/α-LA), AA/DGLA, EPA + DHA, EPSI and ΣUFA. In the sterols, only cholesterol was significant (although still very low) at 44.0 mg/100g (or 99.9938%). The total phospholipid value was 406 mg/100g and was dominated by phosphatidylcholine (PC) and followed slightly by phosphatidylethanolamine (PE) with a value of 245 mg/100g (or 60.4%) and 99.1 mg/100g (or 24.4%), respectively. *Lanistes libycus* could therefore be said to be low in fat content but very good in unsaturated fat at 74.3%, low in sterol with total value of 44.01 mg/100g and moderate in phospholipids with a total of 406 mg/100g.

Keywords: *Lanistes libycus*, lipid composition

Introduction

Snail is a common name that is applied most often to land snails, terrestrial pulmonate, gastropod mollusk class that have coiled shells large enough for the animal to retract completely in their adult stage. Gastropod is the largest and most diverse class of the phylum mollusk and has about 75,000 known living species (Ponder and Limdberg, 1997). Snails can be found in a very wide range of environments, including ditches, deserts, and the abyssal depths of the sea. Although, land snails may be more familiar to laymen, marine snails constitute the majority of snail species, have much greater diversity and a greater biomass. Snails can respire (land snail) through their lungs and they belong to the pulmonata group while those using gills (aquatic snail) are in the paraphyletic group. The land snail has a shell that is creamy to light brown often with indistinct brown colour bands. When retracted into their shell, some snails protect themselves with an anatomical structure called operculum (Kearney *et al*., 1998). Snails have true coelom, a body divided into three parts of head, visceral mass and muscular foot; organ system for circulation, respiration, digestion, excretion, nerve conduction and reproduction (Towel, 1989). Land snails range greatly in size and all are hermaphrodites (Benami and Heller, 2005). Most snails are herbivorous in nature, although a few land species and many marine species may be oviparous or carnivorous (Igwe, 2015). Land snails, freshwater snails and sea snails are all eaten in many countries of the world. For example, in Indonesia, they are fried as satay, a dish known as *sate kakul*. The eggs of certain species are eaten in a fashion similar to the way caviar is eaten. In Bulgaria, snails are traditionally cooked in an oven with rice or fried in a pan with vegetable oil and red paprika powder (https://en.wikipedia.org/wiki/Snail)

Lanistes libycus is a freshwater gastropod mollusk common in West Africa, and widely distributed in southwestern Nigeria (Ukoli, 1989; Brown, 1994). *Lanistes* is a genus of freshwater snails which have a gill and an operculum, aquatic gastropod molluscs in the family Ampullariidae, the apple snails (Bouchet and Neubauer, 2015).

The snail has the following scientific classification:

Kingdom: Animalia; Phylum: Mollusca; Class: Gastropoda; Superfamily: Ampullarioidea; Family: Ampullariidae; Subfamily: Ampullariinae; Tribe: Ampullariini; Genus: *Lanistes* Monfort, 1810 (Monfort, 1810); Species: *Lanistes libycus* Morelet, 1848 (Brown, 1994; "Lanistes". The apple snail website, accessed 16 May 2011).

Lanistes has a unique anatomy among the Ampullariidae: it has a "hyperstrophic" sinistral shell ("Shell". The apple snail website, accessed 16 May 2011). This means that the body of the snail is dextral (as in all other ampullariids), but the shell appears to be sinistral. However the sinistral appearance stems from the fact that the rotation of the shell as it grows is in an upward direction rather than the usual downward direction ("Shell". The apple snail website, accessed 16 May 2011). Geographic range of *Lanistes libycus* includes Africa and Madagascar but more specifically West African coastal species, ranging from Cote d'Ivoire to Gabon. *Lanistes libycus* is native to Benin, Cameroon, Cote d'Ivoire, Equatorial Guinea [Equatorial Guinea (mainland)], Gabon, Ghana, Nigeria and Togo. It is found in lakes, marshes and streams and for system classification, it is a freshwater snail.

Lanistes libycus is known to harbor water mite species in the mantle cavity. A study of freshwater bodies in Ago – Iwoye revealed the occurrence of a water mite species in the mantle cavity of *L. libycus* from Omi stream (Agbolade and Odaibo, 2004). The water mite was described as a new genus and species, *Dockovdia cookarum* by Gledhill (2002). Gledhill noted that *D. cookarum* was the first water mite species from the family Hybrobatidae to be reported as a parasite of freshwater mollusk. Agbolade and Odaibo (2004) presented an account of the prevalence and intensity of *D. cookarum* in relation to the abundance and size classes of *L. libycus* from Omi stream. Fasuyi (1990) in his own study area (Ajara fish ponds in Badagry, Nigeria), *L. libycus* also harboured

Chaetogaster limnaei (von Baer), and an unidentified nematode species, each of which co-existed with *D. cookarum* in some *L. libycus* specimens. *C. limnaei* had also been reported in *L. Ovum* (Fasuyi, 1990).

This report presents an account of the prevalence and intensity of the lipid profile of *L. libycus* edible part (although not usually used for human consumption). Suggestions are also made on the various likely methods for the extraction and refining of the extracted lipid.

Materials and Methods

Collection of samples

Samples of the snail were collected from the bank of Iyemoja River along Orita Challenge in Ibadan in the month of June, 2015. The snails were authenticated at the Ekiti State University, Ado Ekiti, in the Department of Zoology.

Sample treatment

Washed samples were wrapped in aluminum foil and frozen at -4^{o}C for 5 days before analysis was carried out. The shells were removed, edible portion and intestine were then separated. The edible portion was washed with distilled water, dried in the oven (98 – 100^{o}C) and pulverized in the blender into fine flour (3 microns), ready for analysis.

Crude fat determination

0.25 g of the aliquot was weighed into the extraction thimble and the fat extracted with petroleum ether (40 – 60^{o}C boiling range) using a Soxhlet apparatus (AOAC, 920.39, 2006). The extraction lasted 5 – 6 h.

Preparation of fatty acid methyl esters (FAMEs) and analysis

The crude fat extracted was converted to the methyl ester using the boron trifluoride method (AOAC, 969.33 and 996.06, 2006).

Analysis for sterols

The sterol analysis was as described by AOAC (970.51, 2006).

Analysis of phospholipids

Modified method of Raheja *et al*. (1973) was employed in the analysis of the extracted oil for phospholipids content determination.

When the content of total fatty acids in food or fat is not given, it is necessary to calculate it by using fatty acid conversion factor (XFA). The conversion factor reflects the ratio between the sum of fatty acids and total lipids (TL) in the food (Weihrauch *et al*., 1977).

FACID (g/100g EP) = TL (g/100g EP) x XFA

As fatty acid conversion factors (XN) are given only for lean (0.7) and fatty fish (0.9) (without indication of corresponding fat content) and not for crustaceans and molluscs, FAO/INFOODS (Nowak *et al.,* 2012) made further investigations on these factors.

Two ways estimate fatty acid conversion factors are proposed. For the purpose of this work first conversion factor was employed.

1. If fat is ≥ 0.55g/100g EP, the formulas of Weihrauch *et al*. (1977) should be used.
   For molluscs:
   Molluscs: XFA = 0.956 – 0.296/ TL
   Total lipids (TL) should be expressed as g/100g EP.
2. If fat is < 0.55 g/100g EP, the following fatty acid conversion factors should be applied to avoid negative values for the conversion factors (Nowak *et al*., 2012).
   Molluscs: XFA = 0.417

Further calculations were the conversions of the edible portion (EP) into two different units of energy: kJ/100g EP and kcal/100g EP.

Result and Discussion

Table 1 shows the crude fat content and other lipid related calculations of the sample. The value of 3.30 g/100g of the crude fat did not show the sample to be a major source of edible oil but a minor source. However, the total fatty acid had the larger share of 2.86 g/100g (86.7%) whereas other lipids had just 0.44 g/100g (13.3%). The total energy due to 3.30 g/100g crude fat was 122 kJ/100g (29.7 kcal/100g) in which the total fatty acid had a value of 106 kJ/100g (25.7 kcal/100g). Other lipid content would just contribute 16.3 kJ/100g (3.96 kcal/100g) of energy. The lipid composition of three edible snails consumed in Nigeria have the following crude fat values: *Archachatina marginata* (2.38 g/100g), *Archatina archatina* (2.35 g/100g) and *Limicolaria* sp (2.22g/100g) (Adeyeye, 2012) this results shows that the levels of lipid in *Lanistes libycus* is higher when compared to other edible land snails. Their corresponding energy concentrations were (kJ/100g): 88.1, 87.0 and 82.1. The crude fat in *L. libycus* was also found to be higher than the crude fat in the various parts of *Pandalus borealis* (a marine organism): whole shrimp (1.30 g/100g and 48.1 kJ/100g), flesh (1.31 g/100g and 48.5 kJ/100g) and shell (0.80 g/100g and 29.6 kJ/100g), all on dry weight basis (Adeyeye, 2017).

In Table 2, shows the results for saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) of the edible portion (EP) of *L. libycus* sample. The total SFA was 25.7% of total fatty acids. This 25.7% SFA was contributed mainly from four saturated fatty acids: C14:0 (1.14%), C16:0 (15.5%), C18:0 (6.69%) and C20:0 (1.99%). Minor SFA contributors were C8:0, C10:0, C12:0, C22:0 and C24:0. C6:0 recorded 0.00%. SFA with C12:0, C14:0 and C16:0 are known to be primary contributors to elevated blood cholesterol, and so contribute to cardiovascular diseases; C14:0 being the major culprit. SFA with 12, 14 or 16 carbons generally constitute about 25% of the total fat in animal foods. All the 12, 14 and 16 carbons SFA constituted a value of 16.9% being lower than 25% (the usual minimum value in animals). However, C18:0 may not be as hypercholesterolemic as the other SFA (apparently because it is converted to oleic acid (Bonanome and Grundy, 1988).

The C16:0 is most prevalent (usually) SFA in our diet and is present to some degree in essentially all fats. The value of C16:0 in the total SFA was 60.3% showing its pre-eminence in the total SFA. Considering the influence on the lipoprotein profile, 16:0 is intermediate, that is, it can be neutral when placed on a triglyceride molecule with PUFA, MUFA or 18:0, or cholesterol-raising when attached along with 12:0 + 14:0. In high amounts, 16:0 can even raise TC and LDL when substituted for 18:0, MUFA or PUFA in people who already have elevated TC or who eat large amounts of cholesterol. Hence, general advice has been to remove as much SFA from diet as possible (Hayes, 2002). However, Enig and Fallon (2000) had enumerated many important roles in the body chemistry.

In comparison with other published results, the sample SFA (25.7%) was lower than in *A. marginata* (43.0%), *A. archatina* (37.5%) and *Limicolaria* sp (49.8%) being contributed by C16:0 (13.6 – 19.4%) and C18:0 (23.4 – 28.7%) (Adeyeye, 2012). However, the present value of SFA in in *L. libycus*(25.7%) was higher than in *P. borealis* shrimp whole organism (18.3%), flesh (18.8%) and shell (19.6%) being contributed mainly by C16:0 (10.2 – 11.2%) and C18:0 (7.01 – 9.19%) (Adeyeye, 2017).

The edible portion of the fatty acid was generally as dictated by the various SFA components. The total edible fatty acid contributed by the sample was 0.7361 EPg/100g which came from C16:0 (0.4431 EPg/100g), C18:0 (0.1913 EPg/100g) and C20:0 (0.0570 EPg/100g).

Table 1: Crude fat and other lipid related calculated values in *Lanistes libycus*

Parameter	Unit	Value
Crude fat	g/100g	3.30
Total fatty acid[a]	g/100g	2.86
Total energy[b]	kJ/100g	122
Total energy[c]	kcal/100g	29.7
Total fatty acid energy[d]	kJ/100g	106
Total fatty acid energy[e]	kcal/100g	25.7
Other lipid content	g/100g	0.44
Other lipid energy[f]	kJ/100g	16.3
Other lipid energy[g]	kcal/100g	3.96

[a]Crude fat x XFA = 3.30 x 0.866; [b]Total energy = crude fat x 37.0; [c]Total energy = crude fat x 9.00; [d]Total fatty acid energy = total fatty acid x 37.0; [e]Total fatty acid energy = total fatty acid x 9.00; [f]Other lipid energy = other lipid value x 37.0; [g]Other lipid energy = other lipid value x 9.00

Table 2: Saturated and monounsaturated fatty acid profile and corresponding edible portion (EP) of *Lanistes libycus*

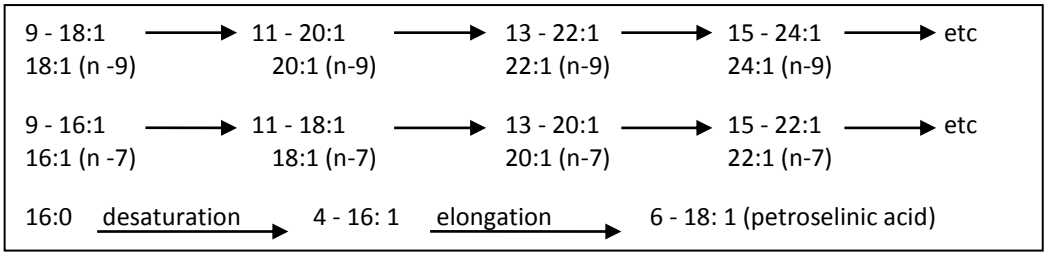
Fatty acid	% total fatty acids	EPg/100g
C6:0	0.0000	-
C8:0	0.1176	0.0034
C10:0	0.0075	0.0002
C12:0	0.2740	0.0078
C14:0	1.14	0.0326
C16:0	15.5	0.4431
C18:0	6.69	0.1913
C20:0	1.99	0.0570
C22:0	0.0199	0.0006
C24:0	0.0025	0.0071
SFA	25.7	0.7361
C14:1 (cis-9)	0.0027	0.0001
C16:1 (cis-9)	0.9325	0.0267
C18:1 (cis-6)	4.13	0.1180
C18:1 (cis-9)	7.28	0.2080
C20:1 (cis-11)	1.69	0.0483
C22:1 (cis-13)	6.27	0.1792
C24:1 (cis-15)	0.0025	0.0001
MUFA (cis)	20.3	0.5803
C18:1 (trans-6)	0.0077	0.0002
C18:1 (trans-9)	0.0007	0.0000
C18:1 (trans-11)	0.0000	-
MUFA (trans)	0.0084	0.0002
MUFA (total)	20.3	0.5806

EP = edible portion of the fatty acid

In the same Table 2, we have the values for MUFA concentration. Total MUFA was 20.3% of the total fatty acid (FA). Major contributors for MUFA were C16:1 (cis-9) (0.9325%), C18:1 (cis-6) (4.13%), C18:1 (cis – 9) (7.28%), C20:1 (cis – 11) (1.69%) and C22:1 (cis – 13) (6.27%). Very minor contributors were C14:1 (cis – 9), C24:1 (cis – 15) and trans-MUFA (C18:1 trans – 6, trans – 9 and trans – 11) with a total concentration of 0.084% of total FA. Again total MUFA in the land snails had higher values than in *L. libycus* as follows: *A. marginata*[total MUFA = 24.0% (6.61 cis + 17.4 trans)], *A. archatina* [total MUFA = 23.8% (6.11 cis + 17.7 trans)] and *Limicolaria* sp [total MUFA = 24.8% (9.15 cis + 15.6 trans)] showing trans-MUFA to be far predominating in the land snails (Adeyeye, 2012). The *L. libycus* MUFA was also lower than in the MUFA of the various parts of the *P. borealis* body parts: whole organism (40.0%), flesh (39.2%) and shell (40.6%) with virtual none contribution of trans-MUFA with corresponding values (%) of 0.00015, 0.00009 and 0.0001 (Adeyeye, 2017). Oleic acid, C18:1 (cis-9) is by far the most abundant monoenoic fatty acid in plant and animal tissues, both in structural lipids and in depot fats. Oleic acid has a number of important biological properties, both in the free and esterified form. It is the biosynthetic precursor of a family of FA with the (n-9) terminal structure and with chain-lengths of 20 – 24 or more. *In vitro* studies by Weber *et al*. (1995) revealed that triacylglycerols containing petroselinoyl [18:1 (n – 12)] moieties are hydrolysed by pancreatic lipase at much lower rates than other triacylglycerols. The Weber *et al.* (1995) data show that petroselinic acid (6c – 18 : 1) from dietary triglycerols is absorbed by rats as readily as oleic acid, but the former reduces the concentration of arachidonic acid in tissue lipids which suggests [in view of earlier studies (Mohrhauer *et al.*, 1967)] petroselinic acid mediated inhibition of arachidonic acid synthesis. Ericic acid (C22:1 cis – 13) occupied the second position in the MUFA concentration *L. libycus* with a value of 6.27% or 30.9% of total MUFA. Erucic acid is a fatty acid that is apparently responsible for a favourable response of persons with nervous system disorders (Christensen *et al*., 1988). The administration of erucic acid in the diet reduces the serum levels and brain accumulation of very-long-chain of SFAs (such as C26:0) responsible for demyelination (Rasmussen *et al*., 1994; Sargent*et al*., 1994). Gadoleic acid – trivial name for cis-cos-9-enoic acid (20:1 n-11) is a common but minor constituent of animal tissues and fish oils, often accompanied by the 13 – isomer. It is also found is rapeseed oil and seed oils of related species. C16:1 is beneficial in reducing bad cholesterol (LDL) and it behaves like a saturated and not as unsaturated FA in its effect on HDL-cholesterol (Nestle *et al*., 1994). It also reduces the fat deposition in blood vessels and blood clot formation (Grundy, 1994). In the Table 2, the edible portions of the fatty acids were all low due to the corresponding levels of the fatty acids.

Total EPg/100g was 0.5806.

The production of longer chain fatty acids of the n-9 family and n-7 family as well as production of petroselinic acid are shown in scheme 1.



Scheme 1: Production of longer chain n-9 and n-7 families and petroselinic acid

Table 3 contains the PUFA n-6 and n-3 FA profile and corresponding edible portion (EP) of *L. libycus*. In the n-6 PUFA group, the following FA predominated: C18:2 (cis-9,12) (3.71%), C20:2 (cis-11, 14) (5.70%), C20:3 (cis-8, 11, 14) (0.3409%), C20:4 (cis-5, 8, 11, 14) (0.2498%) and C22:2 (cis-13, 16) (0.2326%) with total n-6 PUFA being 10.3% of total FA. The C18:2 (trans-9, 12) was 0.0923% giving a total n-6 PUFA as 10.4%. The bulk of PUFA FA in *L. libycus* could be seen in the n-3 PUFA with a total value of 43.5%. The n-3 PUFA values were contributed majorly by C18:3 (cis-9, 12, 15) (0.3194%), C20:5 (cis-5, 8, 11, 14, 17) (14.2%) and C22:6 (cis-4, 7, 10, 13, 16, 19) (29.0%). Hence, n-6 + n-3 PUFA was 53.9% with n-3 PUFA being 80.3% of total PUFA. The essential FAs affect the fluidity, flexibility and permeability of the membranes; they are the precursor of the eicosanoids, are necessary for maintaining the impermeability barrier of the skin and are involved in cholesterol transport and metabolism. Knowledge of the significance of the long-chain PUFA of the n-3 type, particularly EPA and DHA, for human health has increased considerably since the 1970s (Stansby, 1990a, b). The n-6 series are derived from LA and the n-3 series from ALA. Physiologically more important than these parent FAs are their elongated and denaturated derivatives of metabolites.

Table 3: PUFA n-6 and n-3 fatty acid profile and corresponding edible portion (EP) of *Lanistes libycus*

Fatty acid	% total fatty acids	EPg/100g
C18:2 (cis-9,12)	3.71	0.1060
C18:3 (cis-6, 9, 12)	0.0949	0.0027
C20:2 (cis-11, 14)	5.70	0.1629
C20:3 (cis-8, 11, 14)	0.3409	0.0097
C20:4 (cis-5, 8, 11, 14)	0.2498	0.0071
C22:2 (cis-13, 16)	0.2326	0.0067
n-6 PUFA (cis)	10.3	0.2945
C18:2 (trans-9, 12)	0.0923	0.0026
n-6 PUFA (total)	10.4	0.2973
C18:3 (cis-9, 12, 15)	0.3194	0.0091
C20:3 (cis-11, 14, 17)	0.0132	0.0038
C20:5 (cis-5, 8, 11, 14, 17)	14.2	0.4055
C22:6 (cis-4, 7, 10, 13, 16, 19)	29.0	0.8294
n-3 PUFA (total)	43.5	1.24
n-6 + n-3 PUFA	53.9	1.54

PUFA = polyunsaturated fatty acid (Essential fatty acid)

The eicosanoids are hormone-like compounds and include prostaglandins, thrombaxanes and leukotrienes. Several eicosanoids originate from arachidonic acid (AA) which can be synthesized from LA. By virtue of their competitive inhibition in the enzyme systems, FAs of n-3 type especially EPA and DHA, can slow down the eicosanoid overproduction and thus prevent or cure health disorders (Fig. 1) (Lands, 1986). This is further explained as shown in Fig. 2 from FAO/WHO (1994).

The PUFA n-3 FAs have antiatherosclerotic efficacy (Singer, 1994).

There is evidence suggesting that long-chain n-3 polyunsaturated fatty acids also have beneficial effects on disease other than those of the heart and of the blood vessels. They include (Brenner, 1990): inflammatory diseases; nephritis; strokes; arthritis; lupus erythematosus; multiple sclerosis; cancer; skin diseases; asthma. It is observed that EPA and DHA were the predominant n-3 fatty acids in the sample as observed in several marine fish lipids (Yamada and Hayashi, 1975).

In Table 3, FAs with significant concentration with corresponding good edible portion concentrations came from C18:2 (cis-9, 12), C20:2 (cis-11, 14), C20:5 (cis-5, 8, 11, 14, 17) and C22:6 (cis-4, 7, 10, 13, 16, 19). The EPg/100g was 0.2945 in n-6 PUFA (cis), 0.2973 in n-6 PUFA (total), 1.24 in n-3 PUFA (total) and 1.54 in n-6 + n-3 PUFA. The total n-6 PUFA values in the land snails were higher than in *L. libycus*: it was 31.4% in *A. marginata*, 37.2% in *A. archatina* and 24.1% in *Limicolaria* sp whereas only C18:3 cis-9, 12, 15 (ALA), an n-3 PUFA had values of 1.37 – 1.65 in the land snails while other n-3 PUFA had values of 0.00 – 0.00%; this gave values of n-6 + n-3 (PUFA) of 25.5 – 38.7% in the land snails which were all lower than the 53.9% in the *L. libycus*. In *P. borealis*, range of n-6 PUFA (total) was 23.1 – 24.0%, n-3 PUFA (total) was 16.7 – 18.5% and n-6 + n-3 (PUFA) was 39.8 – 42.0% still lower than in *L. libycus.*

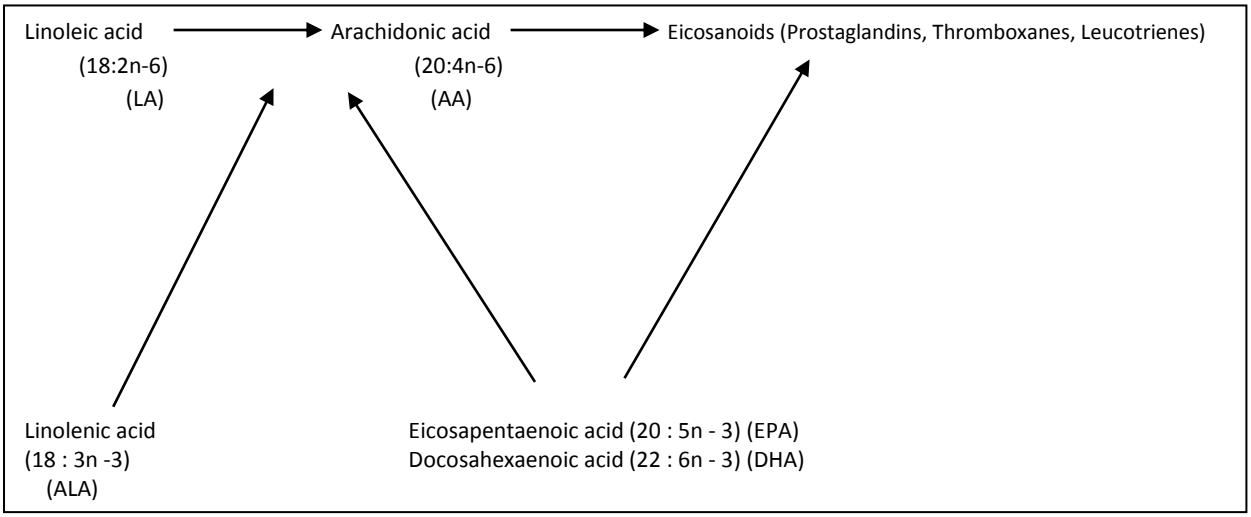
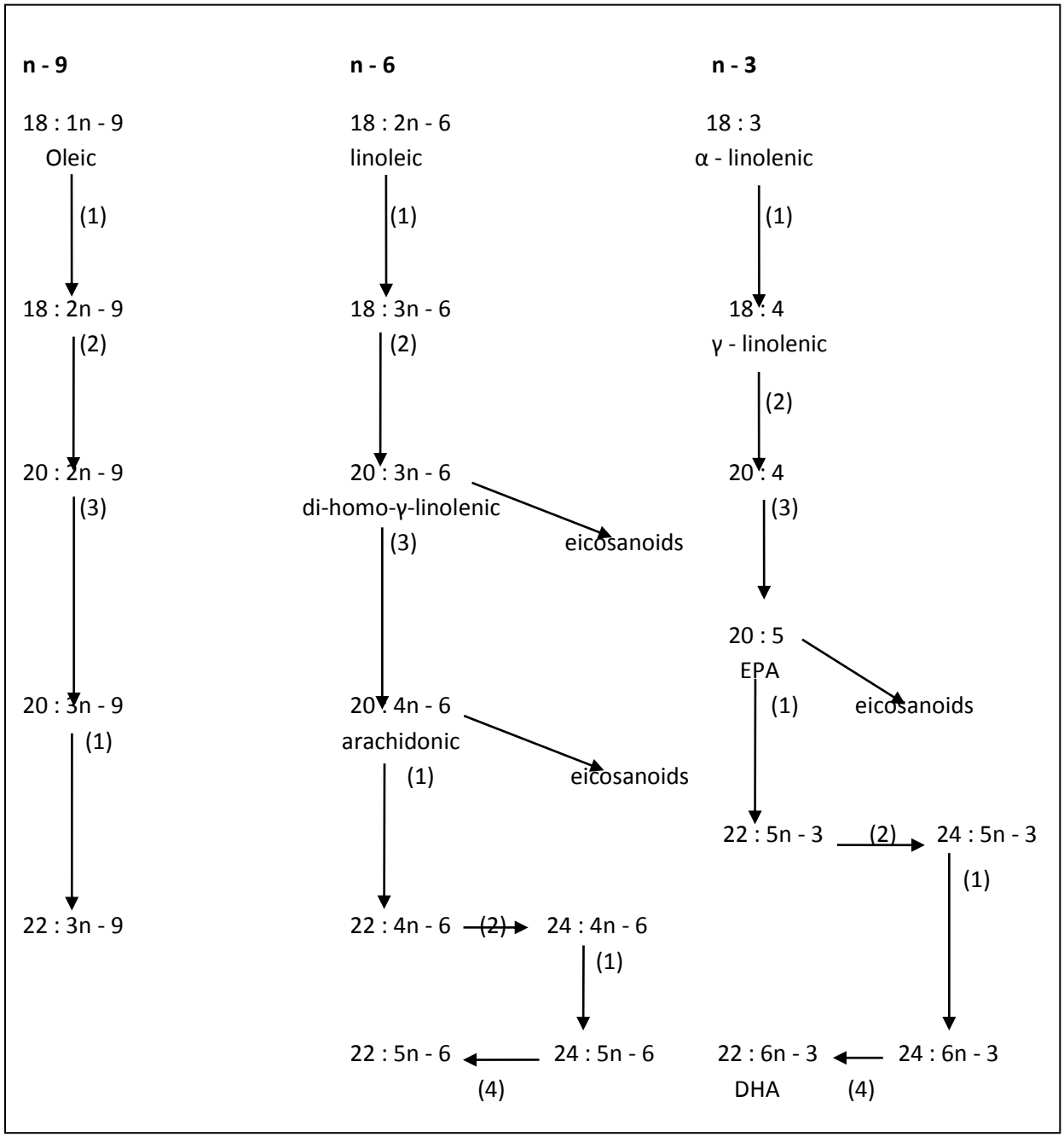


Fig. 1: Competition between n-3 and n-6 polyunsaturated fatty acids can slow down the eicosanoid formation (Lands, 1986)



(1) = Δ 6 desaturases; (2) = elongases; (3) = Δ 5 desaturases; (4) = β - oxidation (peroxisomes) (FAO/WHO, 1994; Food and Nutrition Board, 2002/2005)

Fig. 2: Sequence of conversions of unsaturated fatty acids

In Table 4 we have the energy values and their percentage levels of the FAs in kJ/100g and kcal/100g edible portion for the SFA and MUFA. What is important to note is that the percentages of the energy values were correspondingly equivalent to the FA values. What were significant in the fatty acid levels were also significant in the energy levels. All energy contributions were low. All the observations made in Table 4 applied to the observations in Table 5 with only one exception; the exception being that energy contributions from the PUFA were higher than in the SFA and MUFA.

Some quality parameters of the fatty acids of *L. libycus* as extracted from Tables 2 and 3 can be observed in Table 6. The relative proportion of MUFA/SFA had a value of 0.7887. The ratio is an important aspect of phospholipid compositions and changes to the ratio also have effects on such disease states as cardiovascular disease, obesity, diabetes, neuropathological conditions and cancer. The PUFA/SFA (P/S) is 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 SFA and PUFA fats (Honatra, 1974). The value of P/S in this report is good (2.10). The n-6 and n-3 complete for the same enzymes and have different biological roles; the balance between n-6 to n-3 FAs in the diet is of considerable importance (WHO/FAO, 1994). The ratio of n-6 to n-3 or specifically LA to ALA in the diet should be between 5:1 and 10:1 (WHO/FAO, 1994) or 4 – 10 g of n-6 FAs to 1.0 g of n-3 FAs (Canadian Government Publishing Center, 1990). As LA is almost always present in foods, it tends to be relatively more abundant in animal tissues. Our LA/ALA in this result was close to the ratio of 10:1 with a value of 11.6 but Σn-6/Σn-3

much lower than the value of 4-10 g (n-6) FAs to 1.0 g of n-3 FAs with 0.2973 to 1.24 g/100g. The desaturation and elongation leading to the production of EPA and DHA as well as AA might not be impaired by the LA/ALA (11.6:1), whereas the AA was low (0.2498%) but the EPA (14.2%) and DHA (29.0%) were high making it virtually unnecessary to synthesize both EPA and DHA. The AA/DGLA had a value of 0.7327 which could be said to be averagely good. 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 activity (Benatti *et al*., 2004).

Table 4: Energy values (and percentage values) of the fatty acid profile of *Lanistes libycus* in kJ/100g and kcal/100g (EP saturated and monounsaturated)

Fatty acid	Energy in kJ/100g (% value)	Energy in kcal/100g (% value)
C6:0	- (-)	- (-)
C8:0	0.1244 (0.118)	0.0303 (0.118)
C10:0	0.0079 (0.007)	0.0019 (0.007)
C12:0	0.2898 (0.274)	0.0705 (0.274)
C14:0	1.21 (1.14)	0.2934 (1.14)
C16:0	16.4 (15.5)	3.99 (15.5)
C18:0	7.08 (6.69)	1.72 (6.69)
C20:0	2.11 (1.99)	0.5127 (1.99)
C22:0	0.0210 (0.020)	0.0051 (0.020)
C24:0	0.0026 (0.002)	0.0006 (0.002)
SFA	27.2 (25.7)	6.62 (25.7)
C14:1 (cis-9)	0.0029 (0.003)	0.0007 (0.003)
C16:1 (cis-9)	0.9863 (0.932)	0.2399 (0.932)
C18:1 (cis-6)	4.37 (4.13)	1.06 (4.13)
C18:1 (cis-9)	7.70 (7.28)	1.87 (7.28)
C20:1 (cis-11)	1.79 (1.69)	0.4345 (1.69)
C22:1 (cis-13)	6.63 (6.27)	1.61 (6.27)
C24:1 (cis-15)	0.0026 (0.002)	0.0063 (0.002)
MUFA (cis)	21.5 (20.3)	5.22 (20.3)
C18:1 (trans-6)	0.0082 (0.008)	0.0020 (0.008)
C18:1 (trans-9)	0.0007 (0.001)	0.0002 (0.001)
C18:1 (trans-11)	-	-
MUFA (trans)	0.0089 (0.008)	0.0022 (0.009)
MUFA (total)	21.5 (20.3)	5.22 (20.3)

Table 5: Energy values (and percentage values) of the fatty acid profile of *Lanistes libycus* in kJ/100g and kcal/100g (EP n-6 PUFA and n-3 PUFA)

Fatty acid	Energy in kJ/100g (% value)	Energy in kcal/100g (% value)
C18:2 (cis-9, 12)	3.92 (3.71)	0.9540 (3.71)
C18:3 (cis-6, 9, 12)	0.1004 (0.095)	0.0244 (0.095)
C20:2 (cis-11, 14)	6.03 (5.70)	1.47 (5.71)
C20:3 (cis-8, 11, 14)	0.3606 (0.341)	0.0877 (0.341)
C20:4 (cis-5, 8, 11, 14)	0.2642 (0.250)	0.0643 (0.250)
C22:2 (cis-13, 16)	0.2461 (0.233)	0.0599 (0.233)
n-6 PUFA (cis)	10.9 (10.3)	2.66 (10.3)
C18:2 (trans-9, 12)	0.0976 (0.092)	0.0237 (0.092)
n-6 PUFA (total)	11.0 (10.4)	2.68 (10.4)
C18:3 (cis-9, 12, 15)	0.3379 (0.319)	0.0822 (0.319)
C20:3 (cis-11, 14, 17)	0.0139 (0.013)	0.0034 (0.013)
C20:5 (cis-5, 8, 11, 14, 17)	15.0 (14.2)	3.65 (14.2)
C22:6 (cis-4, 7, 10, 13, 16, 19)	30.7 (29.0)	7.46 (29.0)
n-3 PUFA (total)	46.0 (43.5)	11.2 (43.5)
n-6 + n-3 PUFA	57.0 (53.9)	13.9 (53.9)

The following are used as status markers to reliably assess the functional PUFA status (Benatti *et al*., 2004). The best known marker is mead acid [trivial name for all-cis-icosa-5, 8, 11-trienoic acid (20:3n-9)]. The synthesis of this FA is promoted if there are insufficient concentrations of LA and ALA to meet the need for the synthesis of long-chain PUFA. EPA and DHA inhibit mead acid synthesis; the presence of mead acid indicates a general shortage of all essential PUFA. Mead acid was not detected in the sample, EPA/DHA ratio being 0.4889. Another suitable indicator of essential PUFA status is the PUFA status index (EPSI) which is this ratio: MUFA/PUFA; it had a value of 2.66 which was above average. The higher the EPSI status index the better the essential PUFA status. Finally, if there is a functional shortage of DHA, the body starts to synthesize the most comparable long-chain PUFA of the n-6 family, osbond acid (C22:5 n-6). Therefore, under steady state conditions, the ratio between DHA and osbond acid is a reliable indicator of the functional DHA status (Neuringer *et al*., 1986). Therefore, the PUFA in *L. libycus* could not cause functional distress; it contained no osbond acid.

The sterol levels in the sample can be seen in Table 7. Cholesterol was the steroid of significance as it formed 44.0 out of a total sterol level of 44.01 mg/100g. The 44.0 mg/100g amounted to 99.9938% of the total cholesterol. Cholesterol is a high molecular weight alcohol that is manufactured in liver and most human cells. In conjunction with SFA, cholesterol in the membrane gives cells necessary stiffness and stability. When the diet contains excess of PUFA, this replaces SFA in the cell membrane, so that the cell wall actually becomes flabby. The bile salts are made from cholesterol. Bile is vital for digestion and assimilation of fats in the diet. Cholesterol does act as antioxidant thereby protects us against free radical damage that leads to heart disease and cancer; this is the likely reason for the fact that cholesterol levels go up with age. Babies and children need cholesterol-rich foods throughout their growing years to ensure proper development of their brain and nervous system. Dietary cholesterol plays an important role in maintaining the health of the intestinal wall (Alfin-Slater and Aftergood, 1980). This is why low-cholesterol vegetarian diets can lead to leaky gut syndrome and other intestinal disorders.

Table 6: Some quality parameters of the fatty acids of *Lanistes libycus* extracted from Tables 2 and 3

Parameter	Value
MUFA/SFA	0.7887
PUFA/SFA	2.10
EPA/DHA	0.4889
n-6/n-3 (LA/α-LA)	11.6
Σn-6/Σn-3	0.2393
AA/DGLA	0.7327
EPA +DHA	43.2
ESPI (MUFA/PUFA)	2.66
C16:0:C18:1cis-9	2.13
C18:0:C18:1 cis-9	0.9195
% C16:0 in ΣSFA	60.2
% C18:0 in ΣSFA	26.0
ΣUFA=(MUFA+PUFA)	74.3
ΣFA	100

ΣUFA = total unsaturated fatty acid; EPSI = essential PUFA status index; ΣFA = total fatty acid

Table 7: Sterol levels (mg/100g) of edible portion of *Lanistes libycus*

Sterol	Value	Percentage level
Cholesterol	44.0	99.9938
Cholestanol	5.60e-4	0.0013
Ergosterol	6.72e-4	0.0015
Campesterol	9.37e-4	0.0021
Stig-masterol	4.80e-5	0.0001
5-Avenasterol	4.41e-4	0.0010
Sitosterol	8.23e-5	0.0002
Total	44.01	100

The phospholipid levels of the EP of *L. libycus* are shown in Table 8. The highest concentrated phospholipid was phosphatidylcholine (PC) with a value of 245 mg/100g (60.4%) out of 406 mg/100g. The closest level to this 245 mg/100g was phosphatidylethanolamine (PE) with a value of 99.1 mg/100g (24.4%). The PC is the 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 (Whitney *et al*., 1994). The 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 (Adeyeye, 2011). Phosphatidylinositol (PI or PtdIns) occupied the third position with a value of 30.6 mg/100g (7.55%). PI can be phosphorylated to form phosphatidylinositol phosphate (PIP), phosphatidylinositol biphosphate (PIP2) and phosphatidylinositol trisphosphate (PIP3). PIP, PIP2 and PIP3 are collectively called phosphoinositides. Phosphoinositides play important roles in lipid signaling, cell signaling and membrane tracking. Phosphatidylserine (PS) was in the fourth position in the concentration profiles with a value of 24.0 mg/100g (5.92%). 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 (Adeyeye, 2011). Lysophophatidylcholine (LPC) was the least concentrated in the sample (7.00 mg/100g; 1.73%). Partial hydrolysis of PC with removal of only one FA yields a lysophosphatidylcholine molecule.

Table 8: Phospholipid levels (mg/100g) of edible portion of *Lanistes libycus*

Phospholipid	Value	% level
Phosphatidylethanolamine (PE)	99.1	24.4
Phosphatidylcholine (PC)	245	60.4
Phosphatidylserine (PS,Ptd-L-Ser)	24.0	5.92
Lysophosphatidyl-choline (LPC)	7.00	1.73
Phosphatidylinositol (PI, PtdIns)	30.6	7.55
Total	**406**	**100**

PE is also called cephalin and PC is also called lecithin

The biological effects of EPA and DHA have been widely investigated, as well as their impact on lipoproteins, blood pressure, cardiac function, endothelial function, vascular reactivity, asthma and anti-inflammatory effects (Lopez-Huertas, 2010; Liang and Hwang, 2000; Calder, 2015 and Fariadian *et al*., 2016). With expanding public awareness of the health benefits of EPA/DHA, there is an urgent need to locate and appropriate source. *Lanistes libycus* has been shown to be a viable source of the PUFA oil as shown in this report. For quantitative extraction of the lipid from *L. libycus* the following extraction methods are proposed: agitated extraction (AE), ultrasonic extraction (UE), Soxhlet extraction (SE) and homogenizer extraction (HE). The lipid can then be refined through degumming, neutralization and bleaching to produce high-quality *Lanistes libycus* oil (Kuo *et al*., 2017).

Conclusion

Lanistes libycus had low crude fat, moderate SFA and MUFA but high in PUFA. Very low trans-FAs were observed. Good ratios were observed in MUFA/SFA, PUFA/SFA, EPA/DHA, LA/ALA, AA/DGLA, EPSI and ΣUFA (MUFA + PUFA). However, because of it as a good source of edible oil: SFA (25.7%), MUFA (20.3%), PUFA (53.9%); moderate phospholipid (406 mg/100g) and low total cholesterol (40.0 mg/100g), methods to extract and purify the oil of *L. libycus* had been proposed to increase the availability of EPA and DHA in particular.

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