**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 (MUFAPUFA), C16:0 : C18:0 : 1cis – 9, %C18:0 in ΣSFA, %C18:0 in ΣSFA and ΣUFA (MUFAPUFA). 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 were 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, ESPI and ZUFA. In the sterols, only cholesterol was significant (although still very low) at 44.0 mg/100g (or 99.939%). 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 Lindberg, 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 parathyphletic 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 power ([https://en.wikipedia.org/wiki/Snail](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
- **Species:** *Lanistes libycus* Monfort, 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 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 Agó – 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, *Dockovida cookarum* by Gledhill (2002). Gledhill noted that *D. cookarum* was the first water mite species from the family Hyrobothidae 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. Fasuuyi (1990) in his own study area (Ajara fish ponds in Badagy, Nigeria), *L. libycus* also harboured...
**Lipid Profile of Snails**

Chaetogaster limnaei (von Baer), and an unidentified nematode species, each of which co-existed with D. cookaram 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 Ilbadan 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°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°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°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).

\[
\text{FACID} = \frac{\text{TL}}{\text{EP}} = \frac{\text{XFA}}{\text{XFA}}
\]

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:

    \[
    \text{XFA} = \frac{0.956 – 0.296}{\text{TL}}
    \]

    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).

    \[
    \text{XFA} = 0.417
    \]

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

**Data 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), Archachatina archatina (2.35 g/100g) and Limicolaria sp (2.22g/100g) (Adeye, 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 (Adeye, 2017).

In Table 2, shows the results for saturated fatty acid (SFA) and monounaturated 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-eminance 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.

In comparison with other published results, the sample SFA (25.7%) was lower than in A. marginita (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%) (Adeye, 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%) (Adeye, 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 EEp/100g which came from C16:0 (0.4431 EEp/100g), C18:0 (0.1913 EEp/100g) and C20:0 (0.0570 EEp/100g).
Table 1: Crude fat and other lipid related calculated values in *Lanistes libyces*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude fat</td>
<td>g/100g</td>
<td>3.30</td>
</tr>
<tr>
<td>Total fatty acidA</td>
<td>g/100g</td>
<td>2.86</td>
</tr>
<tr>
<td>Total energyB</td>
<td>kJ/100g</td>
<td>122</td>
</tr>
<tr>
<td>Total energyC</td>
<td>kcal/100g</td>
<td>29.7</td>
</tr>
<tr>
<td>Total fatty acid energyD</td>
<td>kcal/100g</td>
<td>106</td>
</tr>
<tr>
<td>Total fatty acid energyE</td>
<td>kcal/100g</td>
<td>25.7</td>
</tr>
<tr>
<td>Other lipid content</td>
<td>g/100g</td>
<td>0.44</td>
</tr>
<tr>
<td>Other lipid energyF</td>
<td>kcal/100g</td>
<td>16.3</td>
</tr>
<tr>
<td>Other lipid energyG</td>
<td>kcal/100g</td>
<td>3.96</td>
</tr>
</tbody>
</table>

*A Crude fat x XFA = 3.30 x 0.866; *Total energy = crude fat x 37.0; *Total energy = crude fat x 9.00; *Total fatty acid energy = total fatty acid x 37.0; *Total fatty acid energy = total fatty acid x 9.00; Other lipid energy = other lipid value x 37.0; Other lipid energy = other lipid value x 9.00.

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

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

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 libyces* 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 (Adeyeve, 2012). The *L libyces* 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 0.00011 (Adeyeve, 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 petroselinyl[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. libyces* with a value of 6.27% or 30.9% of total MUFA. EriCic 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 SFAs (such as C26:0) responsible for demyelination (Rasmussen et al., 1994; Sargentet 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 in 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 depostion 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.

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**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 0.0922% 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, which 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*.

<table>
<thead>
<tr>
<th>Fatty acid</th>
<th>% total fatty acids</th>
<th>EPg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>C18:2 (cis-9,12)</td>
<td>0.0949</td>
<td>0.2945</td>
</tr>
<tr>
<td>C18:3 (cis-6, 9, 12)</td>
<td>5.70</td>
<td>0.1629</td>
</tr>
<tr>
<td>C20:2 (cis-11, 14)</td>
<td>0.3409</td>
<td>0.0071</td>
</tr>
<tr>
<td>C20:3 (cis-8, 11, 14)</td>
<td>0.2498</td>
<td>0.0067</td>
</tr>
<tr>
<td>C22:2 (cis-13, 16)</td>
<td>0.2326</td>
<td>0.2945</td>
</tr>
<tr>
<td>n-6 PUFA (cis)</td>
<td>0.0923</td>
<td>0.0026</td>
</tr>
<tr>
<td>C18:2 (trans-9, 12)</td>
<td>10.4</td>
<td>0.2973</td>
</tr>
<tr>
<td>n-6 PUFA (total)</td>
<td>0.3194</td>
<td>0.0091</td>
</tr>
<tr>
<td>C18:3 (cis-9, 12, 15)</td>
<td>0.0949</td>
<td>0.2945</td>
</tr>
<tr>
<td>C20:3 (cis-11, 14, 17)</td>
<td>0.0012</td>
<td>0.0038</td>
</tr>
<tr>
<td>C20:5 (cis-5, 8, 11, 14, 17)</td>
<td>14.2</td>
<td>0.4055</td>
</tr>
<tr>
<td>C22:6 (cis-4, 7, 10, 13, 16, 19)</td>
<td>29.0</td>
<td>0.8294</td>
</tr>
<tr>
<td>n-3 PUFA (total)</td>
<td>43.5</td>
<td>1.24</td>
</tr>
<tr>
<td>n-6 + n-3 PUFA</td>
<td>53.9</td>
<td>1.54</td>
</tr>
</tbody>
</table>

PUFA = polyunsaturated fatty acid (Essential fatty acid)

The eicosanoids are hormone-like compounds and include prostaglandins, thromboxanes 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 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 *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*.

Linoleic acid (18:2n-6) (LA) → Arachidonic acid (20:4n-6) (AA) → Eicosanoids (Prostaglandins, Thromboxanes, Leucotrienes)

Linolenic acid (18 : 3n-3) (ALA) → Eicosapentaenoic acid (20 : 5n - 3) (EPA) → Docosahexaenoic acid (22 : 6n - 3) (DHA)

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

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**Fig. 2: Sequence of conversions of unsaturated fatty acids**

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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 ∆6 family, osbond acid (C22:5 n-6) started 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 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.

The following are used as status markers to reliably assess the functional PUFA status (Benetti et al., 2004). The best known marker is mead acid (total FA) with a value of 4.2889 which is this ratio: MUFA/PUFA; it had a value of 2.66 which was above average. The higher the MUFA/PUFA ratio, 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.

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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 PE 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). Phosphatidylcholine (PC) or PtdChls occupied the third position with a value of 30.6 mg/100g (7.55%). PE can be phosphorylated to form phosphorylcholinester phosphatide (PIP), phosphatidylcholinester biphosphate (PIP2) and phosphatidylcholinester trisphosphate (PIP3). PIP, PIP2 and PIP3 are collectively called phosphoinositides. Phosphoinositides play important roles in lipid signaling, cell signaling and membrane tracking. Phosphatidylethanolamine (PE) 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). Lyso phosphatidylcholine (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***

<table>
<thead>
<tr>
<th>Phospholipid</th>
<th>Value (mg/100g)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphatidylethanolamine (PE)</td>
<td>99.1</td>
<td>24.4</td>
</tr>
<tr>
<td>Phosphatidylcholine (PC)</td>
<td>245</td>
<td>60.4</td>
</tr>
<tr>
<td>Phosphatidylserine (PS,Ptd-L-Ser)</td>
<td>24.0</td>
<td>5.92</td>
</tr>
<tr>
<td>Lyso phosphatidylcholine (LPC)</td>
<td>7.00</td>
<td>1.73</td>
</tr>
<tr>
<td>Phosphatidylinositol (PI, PtdIns)</td>
<td>30.6</td>
<td>7.55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>406</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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 Farid 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, EPA1 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.

**References**


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