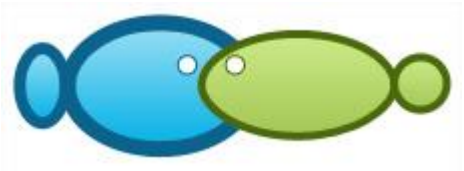

Fatty acid profile of some fresh and dried molluscs in Central Maluku, Indonesia

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Abstract. Maluku waters have various species of molluscs, like *Strombus luhuanus*, *Lambis lambis* or *Polymesoda erosa.* This research was conducted in Central Maluku in October 2018, aiming to determine some information regarding the fatty acid content of *S. luhuanus*, *L. lambis* and *P. erosa*. The fatty acid content of fresh and dried flesh of molluscs was analyzed by using gas chromatography coupled with mass spectrometry. The fatty acids detected in fresh and dried fresh of molluscs were Saturated Fatty Acids (SFA), Mono Unsaturated Fatty Acids (MUFA) and Poly Unsaturated Fatty Acids (PUFA). Of SFA, palmitic acid found in dried *L. lambis* presented the highest level (14.70%), while lauric acid, tridecanoic acid, heneicosanoic acid and tricosanoic acid presented the lowest levels in in fresh and dried *S. luhuanus* and *L. lambis*. Of MUFA, oleic acid in fresh *P. erosa* had the highest level (7.98%), while Cis-10 heptadecanoic acid had the lowest concentration in fresh *L. lambis* (0.02%). Arachidonic acid found in dried *S. luhuanus* presented the highest concentrations from PUFA (3.79%), while the lowest concentration was Cis-13,16-docosadinoic acid (0.02%) from dried *P. erosa*.
Keywords: *Lambis lambis*, nutritional content, *Polymesoda erosa, Strombus luhuanus*.

Introduction. Molluscs are the second-largest marine phylum, consisting of six classes, comprising about 23% of all the named marine organisms (Amsler et al 2001). Molluscs display good adaptation mechanisms, so they can be found in all habitats, ranging from the intertidal area to the deepest parts of oceans. Among the many molluscs, there are two classes, gastropod and bivalve, which are important to the coastal communities, especially in developing countries, such as Indonesia.

Some of the gastropods and bivalves, like *Strombus luhuanus*, *Lambis lambis*, *Anadara antiquata*, *Polymesoda erosa* and *Nerita chamaeleon* can be found in Maluku waters, especially in Central Maluku. They can be found abundantly in various substrates, such as sand, mud and gravel in the intertidal area and shallow subtidal zone up to a 20 m depth. Three ecosystems are preffered by the molluscs in the area, mangroves, seagrass and coral reefs (Haumahu 2011). The coastal community from Central Maluku, Indonesia, has been harvesting gastropods and bivalves traditionally to be consumed for a long time, especially when the sea is rough and fish are scarce (Leiwakabessy & Lewerissa 2017). Gastropods and bivalves in Central Maluku are usually harvested by women and children in intertidal area, during low tide.

Molluscs have a great potential to be utilized because they have a high nutritional value, with high levels of protein and fatty acids, which are essential for life. Different types of fatty acids, such as saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), omega 6 to omega 3, are all present in different classes of molluscs (Proksch et al 2002; Carballeira 2008), including gastropods and bivalves. According to King et al (1990), molluscs can be considered as a high protein food that can be included in a low fat diet. In addition, molluscs have high omega 3 fatty acid levels, like ecosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which can improve cardiovascular health (Mateos et al 2010).

Information about the nutritive value of molluscs from Indonesia waters is still lacking. To our knowledge, few studies have been conducted regarding the nutritional content of molluscs, mostly focusing on bivalves (Yenni et al 2012; Abdullah et al 2013). One of the first studies regarding the nutritive value of gastropods was carried out by

Leiwakabessy & Lewerissa (2017), focusing on the amino acid profile of two gastropods, the strawberry conch (*S. luhuanus*) and the spider conch (*L. lambis*) from Maluku waters, eastern Indonesia.

This research was conducted to study the fatty acids profile of two gastropods, *S. luhuanus* and *L. lambis*, as well as one bivalve, *P. erosa*, from Central Maluku District, Maluku Province, Indonesia.

Material and Method. Samples of gastropods and bivalves were collected in October 2018, from two islands in Central Maluku Regency. Gastropods *S. Luhuanus* and *L. lambis* were collected from the coastal waters of Suli village, Ambon Island, while *P. erosa* bivalves were collected from the intertidal area of Tuhaha village, Saparua Island, Maluku Province (Figure 1). The mollusc samples were preserved with ice in a cool box, transported to the laboratory, cleaned and removed from the shells. The flesh was separated from the innards. Only the flesh of molluscs was used in this study, fresh flesh and dried flesh.

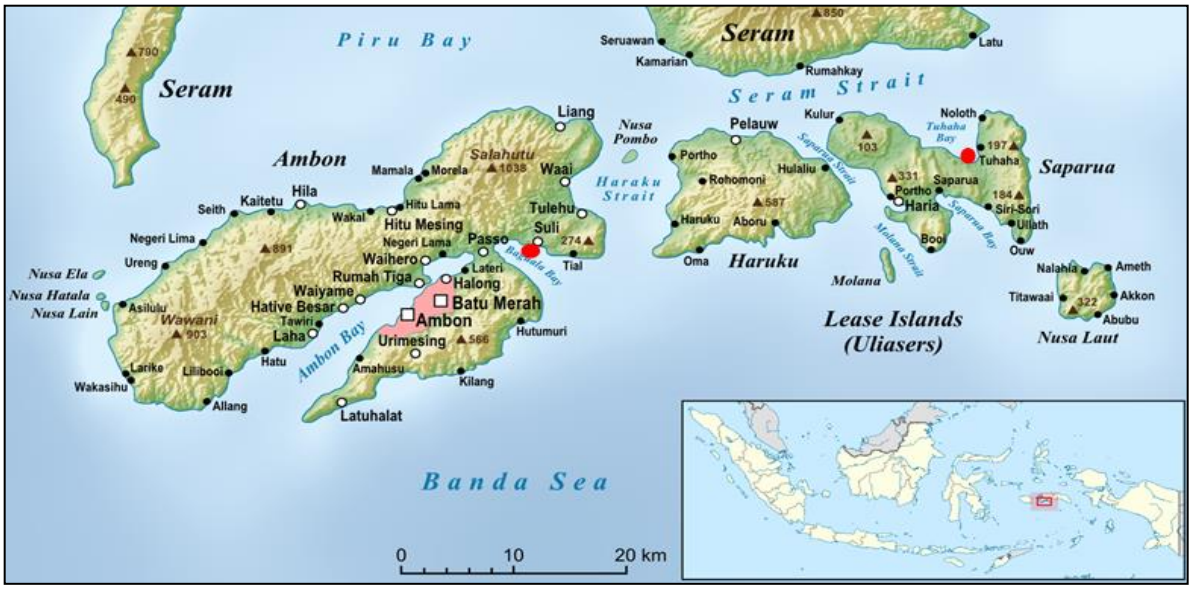

Figure 1. Sampling sites – Ambon and Saparua Islands.

The dried flesh was obtained by drying the fresh mollusc in an oven at 70°C, for 3 hours. Fatty acid contents of fresh and dried molluscs were analysed by using gas chromatography coupled with mass spectrometry (GC-MS).

Approximately 20 mg of lipid of the samples were extracted to produce fatty acid methyl esters (FAMEs), according to AOAC (2005) 969.33 procedure. One µL of the sample FAMEs was injected and separated by capillary gas chromatography (GC-Shimadzu 17A), equipped with a fused-silica capillary column (60 m length, 0.25 mm inner diameter) coated with 0.25 µm film thickness of cyanopropyl methyl silicone. The injector temperature was set at 220°C with a split ratio of 1:80, while the detector was set at 240°C. The column temperature was initially maintained at 125°C for 5 minutes, increased to 185°C gradually by 10°C increment for every 1-minute interval, with a 5 minute hold at each increment. The temperature was subsequently increased to 205°C by 5°C increment at every 1-minute interval with 10 minutes hold at each increment. The temperature was finally increased to 225°C at 3°C increment at every 1-minute interval and maintained for 7 min at 225°C. The flow rates of compressed air and hydrogen were 400 mL min^{-1} and 40 mL min^{-1}, respectively. The carrier gas was helium, at a flow rate of 40 mL min^{-1}. FAMEs standards were injected under the same conditions. The individual FAMEs of the samples were identified by comparison of the chromatographic properties with those of standards.

Results and Discussion

Fatty acid composition. The profile of fatty acids is presented in Table 1. There are three types of fatty acids found in the flesh of *S. Luhuanus*, *L. lambis* and *P. erosa*, namely SFA, MUFA and PUFA, with minor variations. The total number of identified fatty acids in fresh flesh ranges from 26 to 28, while in dried flesh from 26 to 27 (Table 1). SFA has a higher number of identified fatty acids compared with MUFA and PUFA, both in fresh and dried flesh of the three studied species. The total number of identified fatty acids found in this study is lower than those reported by Shanmugam et al (2007) for *Donax cuneatus* from India and by Bano et al (2014) for *Siphonaria* spp. from Pakistan. However, fatty acid levels from this study are higher than those reported by several researchers for molluscs (Mateos et al 2010; Babu et al 2011; Abdullah et al 2013; Srilatha et al 2013). Variation in fatty acid composition is affected by environmental factors such as temperature, salinity, pH and food source, as well as by biological factors such as sex type, reproduction and breeding cycles (Avila et al 2004; Mateos et al 2010).

Table 1

Fatty acid composition of molluscs

Species	*Fresh flesh*				*Dried Flesh*			
	SFA	MUFA	PUFA	Total	SFA	MUFA	PUFA	Total
S. luhuanus	12	6	9	27	11	7	9	27
L. lambis	12	7	9	28	12	6	9	27
P. erosa	11	6	9	26	11	5	10	26

Saturated Fatty Acids. The composition and content of SFA are presented in Table 2. The SFA values found in these three molluscs vary between species and between fresh and dried flesh of the molluscs and range from 0.02% to 14.7%. The GC-MS detected the lowest content of SFA for lauric acid, tridecanoic acid, heneicosanoic acid and tricosanoic acid, for fresh and dried flesh of gastropods *S. Luhuanus* and *L. lambis,* while tridecanoic acid had the lowest concentration out of the SFAs found in *P. erosa* bivalves. Tricosanoic acid in the dried flesh of gastropod *S. luhuanus* and tridecanoic acid could not be detected by GC-MS.

Table 2

Saturated fatty acid composition of fresh and dried flesh of molluscs

Saturated Fatty Acids	*Content (%)*					
	S. Luhuanus		*L. lambis*		*P. erosa*	
	Fresh	Dried	Fresh	Dried	Fresh	Dried
Lauric Acid, C12:0	0.02	0.03	0.04	0.04	0.10	0.03
Tridecanoic Acid, C13:0	0.02	0.02	0.02	0.03	-	-
Myristic Acid, C14:0	1.43	1.36	2.23	3.08	3.91	1.80
Pentadecanoic Acid, C15:0	0.18	0.23	0.28	0.34	0.33	0.25
Palmitic Acid, C16:0	7.55	7.22	11.26	14.70	14.44	6.46
Heptadecanoic Acid, C17:0	0.48	0.68	0.80	0.87	1.40	1.37
Stearic Acid, C18:0	2.11	2.13	2.91	2.72	3.58	2.39
Arachidic Acid, C20:0	0.06	0.06	0.12	0.10	0.35	0.24
Heneicosanoic Acid, C21:0	0.03	0.03	0.03	0.02	0.12	0.16
Behenic Acid, C22:0	0.15	0.12	0.11	0.11	0.13	0.11
Tricosanoic Acid, C23:0	0.02	-	0.04	0.02	0.05	0.06
Lignoceric Acid, C24:0	0.09	0.08	0.09	0.12	0.08	0.07
Σ SFA	12.14	11.96	17.93	22.15	24.49	12.94

Palmitic acid had the highest level out of the SFAs in both in fresh and dried flesh of molluscs, more than 50% of the total SFA content. The next fatty acids with high levels

are strearic acid and myristic acid. Saghk & Imre (1997), McLean & Bulling (2005), Mateos et al (2010), Yenni et al (2011), Abdullah et al (2013), Bano et al (2014) and Subasinghe et al (2019) also report the high content of palmitic acid in molluscs. On the contrary, Babu et al (2011) and Srilatha et al (2013) report that stearic acid has the highest content out of the SFA in molluscs. The highest palmitic acid level in dried flesh of *L. lambis* (14.70%) found in the present study is higher than the one reported by McLean & Bulling (2005) in *Perna canaliculus, Mytilus edulis aoteanus* and *Saccostrea cucullata*, higher than the one reported by Mateos et al (2010) in the offsprings of a *Haliotis* spp. hybrid (*H. laevigata* x *H. rubra*) and higher than in *Anadara antiquata* (Abdullah et al 2013). However, it is lower than palmitic acid reported by Saghk & Imre (1997) in *M. galloprovincialis* (19.1-26.2%) and by Bano et al (2014) in *Siphonaria* spp. (17.79-19.11%).

French et al (2002) stated that an unbalanced diet and the over consumption of palmitic acid by humans can increase the cholesterol level and thus increase the risk of arteriosclerosis, cardiovascular diseases and stroke.

Mono Unsaturated Fatty Acids. Oleic acid is the fatty acid with the highest percentage out of MUFA, followed by palmitoleic acid, in the three species of molluscs (Table 3). The lowest MUFA detected by GC-MS is cis-10-heptadecanoid acid (0.02%) in the fresh flesh of *S. Luhuanus* and *L. lambis*, while in *P. erosa* it was not detected. Nervonic acid was also not detected by GC-MS in the fresh flesh of *S. luhuanus* and dried flesh of *L. lambis* and *P. erosa*.

The highest content of oleic acid in molluscs has been reported by several authors (Saghk & Imre 1997; McLean & Bulling 2005; Yenni et al 2011; Srilatha et al 2013; Subasinghe et al 2019). Meanwhile, Shanmugam et al (2007) and Abdullah et al (2013) reported a higher content of palmitoleic acid in molluscs. Oleic acid found in the dried flesh of *P. erosa* (7.97%) is far higher than the content reported by Yenni et al (2011) in *Batissa violacea celebensis* and by Abdullah et al (2013) in *A. antiquata*, but lower than the one reported by Saghk & Imre (1997) in *M. galloprovincialis* and by Srilatha et al (2013) in *Meretrix casta*.

Table 3

Mono unsaturated fatty acid composition in fresh and dried flesh of molluscs

Mono Unsaturated Fatty Acids	*Content (%)*					
	S. Luhuanus		*L. lambis*		*P. erosa*	
	Fresh	Dried	Fresh	Dried	Fresh	Dried
Myristoleic Acid, C14:1	0.11	0.06	0.08	0.06	0.07	0.06
Palmitoleic Acid, C16:1	1.46	1.48	1.08	2.79	4.15	2.77
Cis-10-Heptadecanoid Acid, C17:1	0.02	0.05	0.02	0.07	-	-
Elaidic Acid, C18:1n9t	0.06	0.07	0.23	0.19	0.32	0.18
Oleic Acid, C18:1n9c	0.70	0.80	1.67	1.62	7.98	3.14
Cis-11-Eicosenoic Acid , C20:1	0.11	0.10	0.25	0.18	0.42	0.36
Nervonic Acid, C24:1	-	0.03	0.03	-	0.03	-
Σ MUFA	2.46	2.59	3.36	4.91	12.97	6.51

Oleic acid is more stable compared with other unsaturated fatty acids, thus it is more effective in reducing LDL cholesterol and increasing HDL cholesterol (Sartika 2008). In addition, the decrease of LDL/HDL cholesterol ratio can reduce the risk of atherosclerosis (Muller et al 2003).

Poly Unsaturated Fatty Acids. In the dried flesh of *P. erosa*, arachidonic acid has the highest content (in PUFA), followed by EPA (eicosapentaenoic acid), linoleic acid C18:2n6c and DHA (docosahexaenoic acid) (Table 4). Docosadienoic acid is the least abundant fatty acid out of PUFA (0.02%), found in the dried flesh of *P. erosa*. In the fresh flesh of the studied species it is not detected. The other fatty acid undetected by GC-MS is the linolelaidie acid, which is only detected in the fresh flesh of *P. erosa*.

The highest content of arachidonic acid found in the dried flesh of *S. luhuanus* (3.79%) is higher than the one reported by Yenni et al (2012) in *B. violacea celebensis,* Mateos et al (2010) in a hybrid of *Haliotis* spp. and Abdullah et al (2013) in *A. antiquata*. However, it is lower than the results reported by Shanmugam et al (2007) for *D. cuneatus* (6.75%).

Arachidonic acid is an omega 6 fatty acid, needed for growth and development of the brain (Almatsier 2002). EPA and DHA of PUFA are important in human health because they are the main component in the phospholipid membrane, regulating the fluidity of the membrane and the ion transportation. It also has structural roles in the brain cerebral cortex. Estiasih (2009) stated that the clinical effect of omega 3 is to reduce the cholesterol level in blood. EPA and DHA omega 3 are and essential fatty acids that must be derived from diet, because they cannot be efficiently synthesized from their precursor, α-linolenic acid (Burdge & Wootton 2002).

Table 4

Poly unsaturated fatty acid composition of fresh and dried flesh of molluscs

Poly Unsaturated Fatty Acid	*Content (%)*					
	S. Luhuanus		*L. lambis*		*P. erosa*	
	Fresh	Dried	Fresh	Dried	Fresh	Dried
Linoleic Acid, C18:2n6c	0.53	0.69	0.75	0.81	2.82	1.14
Linoleic Acid, C18:3n6	0.10	0.09	0.06	0.16	0.1	0.09
Linolenic Acid, C18:3n3	0.26	0.35	0.34	0.45	0.47	0.34
Cis-11,14-Eicosedienoic Acid, C20:2	0.33	0.39	0.11	0.43	0.49	0.58
Cis-8,11,14-Eicosentrienoic Acid, C20:3n6	0.20	0.20	0.20	0.26	0.13	0.20
Arachidonic Acid, C20:4n6	2.88	3.79	2.42	3.49	2.21	2.90
Cis-13,16-Docosadienoic Acid, C22:2	0.08	0.10	0.11	0.11	-	0.02
Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3	1.80	1.72	0.79	1.64	1.57	1.08
Cis-4,7,10,13,16,19-Docosahexaenoic Acid, C22:6n3	0.57	0.67	0.22	0.50	2.40	2.20
Linolelaidie Acid, C18:2n9t	-	-	-	-	0.10	-
Σ PUFA	6.75	8.00	5.00	7.85	10.29	8.55
Σ omega 6	3.71	4.77	3.43	4.72	5.26	4.33
Σ omega 3	2.63	2.74	1.35	2.59	4.44	3.62
ratio of omega 6/omega 3	1.41	1.74	2.54	1.82	1.18	1.20

The ratio between omega 6 and omega 3 fatty acids in Table 4 shows that the minimum value was found in the fresh flesh of *P. erosa*, while the maximum value was detected in the fresh flesh of *L. lambis*. Excessive amounts of omega-6 PUFA and a very high omega-6/omega-3 ratios in diets can promote the pathogenesis of many diseases, including cardiovascular disease, cancer and inflammatory and autoimmune diseases, whereas increased levels of omega-3 PUFA (a low omega-6/omega-3 ratio) exert suppressive effects (Simopoulos 2002). Even though the optimal ratio may vary with the disease under consideration, a 2-3/1 ratio of omega-6/omega-3 is recommended to reduce the risk of chronic disease (Simopoulos 2002). It can be seen in Table 4 that omega 6 to omega 3 ratios of the three species of molluscs studied are in the limits recommended by Simopoulos (2002).

Conclusions. The profile of fatty acids in fresh and dried flesh of *S. luhuanus*, *L. lambis* and *P. erosa* present little variation in total number of identified fatty acids, ranging from 26 to 28 fatty acids. A higher number of fatty acids fall in the SFA category than in PUFA or MUFA. The most dominant fatty acids found in SFA, MUFA and PUFA are palmitic acid (dried flesh of *L. lambis*), oleic acid (fresh flesh of *P. erosa*) and arachidonic acid (dried flesh of *S. luhuanus*), respectively. The minimum amount of fatty acids (0.02%) in fresh

and dried flesh of molluscs detected by GC-MS are lauric acid, tridecanoic acid, heneicosanoat acid, tricosanoic acid (SFA), cis-10-heptadecanoid acid (MUFA) and docosadienoic acid (PUFA). The ratio of omega 6 to omega 3 fatty acids for the three species of molluscs in Central Maluku is in the limits recommended by the scientific literature.

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