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Comparison of Fatty Acid and Proximate Composition between *Holothuria edulis* and *Holothuria scabra* Collected from Coastal Water of Sabah, Malaysia

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Abstract

The nutritional values of different species of sea cucumber are greatly concerned because of their dietary and curative properties. In this study, two species of sea cucumber, *Holothuria edulis*, a low-valued noncommercial species, and *Holothuria scabra*, a high-valued commercial species were selected to compare its proximate composition and fatty acids. *H. edulis* a prevalent species in coastal water of Sabah is not commercially importance like *H. scabra*. Sea cucumbers were captured live from the Sabah marine habitat. All samples were immediately eviscerated, freeze-dried and stored at 4˚C in until analyzed. Silylating agent N, O-Bis(trimethylsilyl) trifluoroacetamide (BSTFA) was used to derivitization of fatty acid prior to gas chromatography-mass spectrometry (GC-MS) analysis. Proximate compositions (%), such as moisture, crude protein, crude lipids and ash were carried using standard methods. Major fatty acids in *H. edulis* and *H. scabra* were saturated fatty acid (SFA) accounted for 83.95% and 98.60%, respectively and dominated with Palmitic acids. Polyunsaturated fatty acid (PUFA), arachidonic acid of 16.05% was found only in *H. edulis*, but absent *H. scabra*. Proximate compositions (dry weight) were varied greatly within these two species. Moisture, crude protein, crude lipids and ash of 85.5%, 70.5%, 1.37% and 1.27% respectively were obtained in *H. edulis*. On the other hand 84.5% of moisture, 51.2% of crude protein, 0.27% of crude lipids and 4.44% of ashes were determined in *H. scabra*. Significantly higher protein ($p < 0.05$) content and detection of PUFA in *H. edulis* compare to *H. scabra* could be the choice of option for the utilization of this non commercial species as nutraceutical industry and also alternatives to reduce the pressure on heavily exploited species of *H. scabra*.

Keywords

Fatty Acids, Proximate Composition, *H. scabra* and *H. edulis*

1. Introduction

Malaysia coastal water are preferable habitat for diversity of marine fauna and flora due to its tropical climate. Sea cucumbers are predominant and widely harvested in Sabah, Malaysia. In 2013, total of 284 tonnes sea cucumbers were harvested both commercial and natural sectors in Malaysia, out of which 292 tonnes were from Sabah [1]. Among 62 species of sea cucumbers 20 of them were commercially important species and have been recorded in coral reef area of Peninsular Malaysia and Sabah [2]. On the other hand, more than 30 species of sea cucumbers including *Holothuria scabra*, *Thelenota ananas*, *Stichopus chloronotus* were harvested in Philippines [3], while in Canada and other countries in higher latitudes of the northern hemisphere mainly focused on four *Cucumaria frondosa*, *C. japonica*, *Parastichopus californicus* and *P. parvimensis* [4]. Indonesia and Philippines accounted for 47% of world's Holothuroidea harvest [3] and most of these were from artisanal fishing. Sea cucumbers have been well recognized as a tonic and traditional medicine in Chinese and Malaysian societies for their effectiveness against hypertension, asthma, rheumatism, cuts and burns, impotence and constipation [5]. Especially for wound healing, the fatty acids of sea cucumber are crucial component for regenerative trait of this marine organism invertebrate [6]. Sea cucumber fed on sediment and detritus particles which are habited specific. The species of *Holothuria atra*, feeds on sediments with less micro algal biomass compared to *Stichopus chloronotus*, which forage on sediment patches with finer particles while *Holothuria tubulosa* are particularly ingesting sediment with high organic content. The proximate composition of sea cucumber varies from one species to another species due to their disparity in their seasonal variation and feeding behavior [6].

Poly Unsaturated Fatty Acids (PUFA) were the primary fatty acid in sea cucumber of which Eicosapentaenoic acid (EPA) [7] arachidonic acid (ARA) [8], docosaheaxanoic acid (DHA) [9] are the dominant fatty acids being reported across various studies. Mono Unsaturated Fatty Acids (MUFA) were detected in the body wall of sea cucumber [6] of which Palmitoleic acid detected as anti-inflammatory effect, anorexic and mitigation on type 2 diabetes [10] and also has potentiality for curing obesity [11]. The proximate composition and fatty acids composition vary within the species and also inhabitance of diverse marine ecosystem. Total lipids content in Malaysian sea cucumbers species viz. *Holothuria scabra*, *H. leucospilota*, *H. atra* and *Stichopus horrens* on dry matter basis was 0.72%, 1.42%, 0.99% and 1.55% respectively [12].

Benthic feeder sea cucumbers with microbial-enriched detritus are generally contained branched chain fatty acids such as saturated fatty acid [5]. In addition the fatty acid compositions were also varies due to regional climate and diets [6].

H. scabra from Persian-Gulf in subtropical region [13] and from Sulu Sea in tropical region [14] have differences in fatty acid compositions. On the other hand, Fatty acid composition varies widely across species and subject to alteration in food processing practices [14]. Fatty acid composition of Malaysian *Stichopus chloronotus* for the screening of wound healing properties was also conducted [5]. Sea cucumbers are marketed according to their species, as *H. whitmaei* (Black teatfish) and *H. scaba* (Sandfish) are more expensive species (high value species) compare to *H. edulis* (Pink fish) and *H. fuscopunctata* (Elephant trunk fish), which are low valued species [15]. There is a lack of study regarding the nutritional value and fatty acid composition of local sea cucumber of low valued species like *H. edulis*. Therefore, this particular study was conducted to investigate nutritional value and fatty acid composition on the commercially harvested high valued sea cucumber and wild, noncommercial low valued sea cucumber species.

2. Materials and Methods

2.1. Sample Collection

Holothuria edulis was collected from, Sepanggar Bay, Sabah, Malaysia using scuba diving whereas *Holothuria scabra* was collected from the bay adjoining Kampung Baru-Baru, Tuaran, Sabah with the aid of local artisanal fisherman. Twenty five samples for each species were collected during dry season. Collected sea cucumbers were kept in ice box and taken back to Borneo Marine Research Institute, University Malaysia Sabah laboratory for freezing at −20˚C prior to homogenization. Samples were identified to assure the desired species according to identification guidelines as described [15]. After identification the sea cucumbers were cleaned and removed their entrails. Only the body wall and muscle band were taken for analyses due to the fact that majority of nutritional values were found in body wall and muscle [6].

2.2. Sample Preparation

All samples were eviscerated before by hand. Post-lacerated body weight of sea cucumber were taken and directly dried in oven until constant weight for the determination of moisture content. Samples were freeze-dried and blended to fine powder form for the determination of total crude protein, total crude lipids, ashes and profiling fatty acids. Samples of sea cucumber were diced into small pieces (1 cm) and dipped into distilled water for 45 minutes to de-saline samples. Desalination process repeated for five times. Prior to freeze-drying, samples were kept in −80˚C for two days. Freeze dried samples were blended with a lab scale blender into fine powder form to increase total surface area for better extracting process. Finally blended samples were kept in 4˚C to avert dried samples from rehydration and oxidization.

2.3. Determination of Proximate Composition

Total crude protein (%) of sea cucumber was determined by a KjeltechTM2300 auto analyzer (Foss Tector, Sewdeen). Total crude lipid (%) was analyzed using the petroleum ether extraction method (Soxtec TM System 2043 Extraction Unit of Foss Tecator, Sweden). Ash (%) and moisture (%) were determined according to standard methods [16].

2.4. Total Lipid Extraction

Lipids from body wall of sea cucumber were extracted using a modified method of Folch [17]. A total of 2 g of the powder sea cucumber sample was dissolved into 19 ml of solvent mixtures of chloroform, methanol and water in the ratio of 1:2:0.8 0 volume basis [18]. The extractions steps were repeated for three times to ensure complete extraction of total lipid content. The organic layers were combined and partitioned with 10 ml chloroform and 10 ml of 5% NaCl to remove any non-lipid impurities such as salt and urea. The lower layer which was the chloroform layer was siphoned when a clear separation was seen. Collected chloroformlayer was dried using sodium sulphate, during collected layer appeared to be cloudy which indicate contamination of water. Silylating agent N,O-Bis(trimethylsilyl) trifluoroacetamide (BSTFA) was used to derivitization of fatty acid prior to gas chromatography-mass spectrometry (GC-MS) analysis.

2.5. GC-MS Analysis

The trimethylsilyl (TMS) derivatives samples were injected into a GC-MS system consisting of an Agilent 7890A gas chromatograph system coupled with an Agilent 5975C mass spectrometry detector. Modified setting of GC-MS with reference was used [19]. A capillary column HP-5MS (30 m × 0.25 mm) of 0.25 μm film thickness of coated material was used. Fatty acids were identified by the retention time with reference to known standards. Analysis was carried out in triplicate, together with a blank solvent and each replicate was tested for three times. The obtained results were reported in relative abundance of the fatty acid compositions.

2.6. Statistical Analysis

Independent T-test at 5% confidence was used to test the proximate analyses and fatty acid composition between *H. edulis* and *H. scabra* using SPSS v22.

3. Results

3.1. Fatty Acids Profiles

A total of seven types fatty acids were detected from the two species of sea cucumber as shown in Table 1.

Comparison of Fatty Acids Profiles between *H. edulis* and *H. scabra*

Total three types of fatty acids, palmitic, stearic acid (SFA) and arachidonic acid (PUFA) were detected in *H. edulis*. On the other hand six types of fatty acids detected in *H. scabra*. Four of them myristic, pentadecyclic, palmitic, and stearic acid were belongs to saturated fatty acids while palmitoleic acid and nonahex-

Table 1. List of fatty acids with their common name found in *Holothuria edulis* and *H. scabra* and their respective relative percentage of fatty acid (mean ± standard deviation).

Fatty acids	*H. edulis*	*H. scabra*	Significance
Saturated fatty acids (SFA)			
Myristic acid C14:0	n.d	5.08 ± 0.55	
Pentadecylic acid C15:0	n.d	2.08 ± 2.48	
Palmitic acid C16:0	43.67 ± 1.70^a	49.57 ± 3.59^b	<0.0001
Stearic acid C18:0	40.32 ± 4.01^a	41.87 ± 5.84^a	>0.05
Σ SFA	83.95 ± 4.76^a	98.60 ± 2.42^b	<0.001
Monounsaturated fatty acid (MUFA)			
Palmitoleic acid C16:1	n.d	0.48 ± 6.23	
Σ MUFA	n.d	0.49 ± 4.25	
Polyunsaturated fatty acid (PUFA)			
Arachidonic acid C20:4(n-6)	16.05 ± 4.59	n.d	
Σ PUFA	16.05 ± 4.59		
Long chain fatty acid (LCFA)			
Nonahexacontanoic acid C69:0	n.d	0.93 ± 1.87	
Σ LCFA	n.d	0.93 ± 1.87	

Values in the same row with different letters are significantly different at P < 0.05; n.d.: not detected; SFA: saturated fatty acid, PUFA: polyunsaturated fatty acid, MUFA: monounsaturated fatty acid and LCFA: Long chain fatty acid.

acontanoic acid were belongs to unsaturated and long chain saturated fatty acid respectively (Table 1).

SFA was the major fatty acids in both species, accounted for 83.9% and 98.6% of total fatty acids in *H. edulis* and *H. scabra* respectively. Palmitic acid was the major SFA in both *H. edulis* and *H. scabra*, accounted of 43.63% and 49.57%, respectively. On the other hand percentage of stearic acid was observed significantly higher (P < 0.05) in *H. scabra* than the percentage of stearic acid obtained in *H. edulis*. MUFA and HUFA were not found in *H. edulis*, while PUFA was not detected in *H. scabra*.

3.2. Proximate Analyses

Generally, both species of sea cucumber have high percentage of protein and moisture, while low lipid content in their body wall. Moisture content in whole body except internal organ of *H. edulis* and *H. scabra* were of 85.56% and 84.49% respectively (Table 2). The total crude protein of 70.35% in *H. edulis* was significantly higher (P < 0.05) than the crude protein of 51.21% obtained in *H. scabra*. Low amount of crude lipids of 1.37% and 0.27% were determined in *H. edulis* and *H. scabra* respectively (Table 2).

So, percentage or protein and lipids in *H. edulis* were significantly higher (P < 0.05) than values of those obtained in *H. scabra*. On the other hand, ash content of *H. scabra* was remarkably higher than ash content obtained in *H. edulis*.

Table 2. Proximate compositions of both *H. edulis* and *H. scabra* (dry weight basis express as mean ± standard deviation)).

Parameters (%)	*H. edulis*	*H. scabra*
Moisture	85.56 ± 1.23[a]	84.49 ± 1.10[a]
Crude protein	70.35 ± 0.29[a]	51.21 ± 0.95[b]
Crude lipids	1.37 ± 0.04[a]	0.27 ± 0.03[b]
Ash	1.27 ± 0.03[a]	4.44 ± 0.31[b]
Nitrogen Free Extract	27.01 ± 0.25[a]	44.08 ± 1.25[b]

4. Discussion

4.1. Fatty Acids

Sea cucumbers are benthic feeder which its food source is microbial-enriched detritus that generally contain branched chain fatty acid such as polysaturated fatty acids (PUFAs), mono saturated fatty acids (MUFAs), and saturated fatty acid (SFAs) [5].

The percentage of SFA, MUFA and PUFA in *H. scabra* was 37.71, 25.43 and 36.84 respectively [13], and 71.26, 7.69 and 21.06 respectively [12] [20]. In this study majority of fatty acid obtained in *H. scabra* were belongs to SFA (98%) higher than the SFA obtained by previous researchers.

Fatty acid composition of sea cucumber can be improved with inclusion level and types of feed ingredients having high content of 18:2n-6, like corn meal and soyabean meal. Fatty acid such as 20:1n-9, 20:2n-6 and 20:3n-3 found in sea cucumber indication the selectivity/or the biosynthesis of these fatty acids by aquatic species [21] and species *Apostichopus* japonicas after fed when they were less in diets [22].

4.1.1. Saturated Fatty Acids (SFAs)

Saturated fatty acids accounted 71.26% in three species of sea cucumber such as, *H. scabra*, *H. leucospilota* and *H. atra* collected from the east coast of Sabah, Sulu Sea. [12] were comparatively lower than the SFA (98.65) obtained in this study. Palmitic was the major SFA accounted for 49.57% in this study, but lower in percentage (52.66%) was obtained in sample from Sulu Sea *H. scabra* [12]. However, stearic acid in current study was comparatively higher (41.87%) than the acid obtained from Sulu Sea *H. scabra* [12]. Pentadecylic acid was detected in this study but not detected in the *H. scabra* of Sulu Sea [12]. Composition of fatty acid varies within the species and also habitat of the species. Availability of diet ingredients and dietary sources can accounted to changes in the fatty acid composition [22]. In this study, *H. scabra* fresh samples were collected from west coast of Sabah, South China Sea, albeit different places than study conducted by Ridzwan *et al.* [12]. Food sources and ambient temperature of different regions could affect the fatty acid composition of the sea cucumber [23]. Same species of sea cucumber, *Apostichopus japonicus* collected from different island at Japan (Ulleungdo and Dokdo) have different fatty acid compositions

[24]. Even, margaric acid (C17:1) was observed totally absent in *A. japonicas* collected from Ulleungdo Island but the aforesaid fatty acid was found in the same species of sea cucumber collected from Dokdo Island [24]. Similar to *H. scabra*, SFAs of 83.95% are the dominant fatty acids in body wall of *H. edulis* (**Table 1**) with palmitic acid as the major SFAs, taken up 43.63%. However, this result is incongruent with the previous study [25]. Based on their findings, the dominant SFA's are stearic acid (C18:0). Regardless, palmitic and stearic acid are major fatty acid found in organism categorized under animal kingdom [26].

4.1.2. Monounsaturated Acids (MUFAs)

Monounsaturated fatty acid (MUFAs), comprises of palmitoleic acid (C16:1) of 0.48% are only found in body wall of *H. scabra* but not H. edulis in this study. MUFAs compare to SFA and PUFA, were observed lower in this species of sea cucumber [12]. The presence of C16:1 fatty acid in the lipid is ostensibly originated from marine microalgae. Marine microalgae, for instance; diatom *Phaeodactylum tricornutum* contain high amount of palmitoleic acid [27]. The biomass of diatom or other phytoplankton when sink, replenish in the sediment of the sea bed and becoming the food source of sea cucumber which is a bottom sediment feeder [28]. However, this observation and analysis was not taken consideration in this study.

4.1.3. Polyunsaturated Acids (PUFAs)

Polyunsaturated (PUFA) was not detected in *H. scabra*, but was found in *H. edulis* accounted 16.05% (**Table 1**). PUFA in *H. scabra* was accounted of 21.06% [12]. PUFA, particularly arachidonic acid ($\omega - 6$) is absent in *H. scabra* samples. PUFA was a secondary fatty acid in *H. scabra*, followed by MUFA [12]). The oddity was probably due to the difference in derivatization protocol used. Ridzwan [12] utilized ester methylation procedure rather than silylation. Albeit both derivatization protocols were widely used, but methylation and its derivatized product fatty acid methyl esters (FAMEs) were more preferable in transforming fatty acids in the sea cucumbers [5] [12] [13]. The remarkably low crude lipid extraction from *H. scabra* could also beget the absence of PUFA in *H. scabra*. The amounts of fatty acids in sea cucumber are different with different solvent extractions techniques [5]. PUFA are known to be the domineering fatty acid in most invertebrate, including echinoderms [29]. Nevertheless, the PUFA elucidated in *H. edulis* resemble other species done by other researchers that ARA is the principal PUFA. ARA was the dominant PUFA in all eight commercial species: *Stichopus herrmanni*, *Thelenota ananas*, *Thelenota anax*, *Holothuria fuscogilva*, *H. fuscopunctata*, *Actinopyga mauritiana*, *A. caerulea* and *Bohadschia argus* [14]. Arachidonic acid content was remarkably higher than EPA in tropical holothurians, being the major fatty acid in almost of all the species [8]. *H. edulis* was distributed widely in the tropical region and ARA was higher (16.05%). In general *Sargassum* is the only typical natural feed of tropical sea cucumber reach in ARA [22]. Other possibility the synthesis of 20:4n-6 (ARA) in sea cucumber might be encouraged by the increase of levels of feed ingredients which have higher contents of 18:2n-6. PUFA desaturase and elongase activities might present in many marine invertebrates such as, sea urchin [30]. *Parastichopus californicus*, a cold water species that harvested in Alaska had higher EPA (22.60%) and lower ARA (7.10%) [7]. EPA constituted for 46.10% in body wall of fresh *Cucumaria frondosa*, the orange-footed sea cucumber, a temperate species in North-Atlantic Ocean [31]. Fatty acid composition on abyssal sea cucumbers, *Abyssocucumis abyssorum*, *Peniagone vitrea* and *Protankyra brychia*, also reported lower ARA compared to EPA [32].

4.2. Proximate Compositions

Proximate compositions were conducted concerning the nutritional value of the sea cucumbers since they are deemed as nutraceutical food resources. Grading of sea cucumber in marketed product are according to species, abundance, appearance, taste, color, thickness of the body wall and market demand, texture, constituency, dryness [33]. However, the nutritional values of the sea cucumber were regularly neglected. In this study, *Holothuria edulis* and *Holothuria scabra* were investigated whether their nutritional value reflects their commercial importance or not. *H. edulis* is a low commercial valued species while the *H. scabra* is a highly valued species.

The average moisture content of 85.56% ± 1.23% and 84.49% ± 1.10% were obtained in *H. edulis* and *H. scabra* respectively. Normally the moisture content in most of the sea cucumbers were in the range of 84% to 91% [24], 83% to 86% in *Isostichopus* sp [34], 81% to 85% for *H. tubulusa* [9], even higher than present study as reported 89% to 90% in *Parastichopus* sp [35] and 87% to 90% in *Cucumaria frondosa* [31]. Moisture percentages in various studies can be link to due to collection time of year, environmental factors, geographical variations and feeding behaviour of respective species [35]. Sea cucumbers generally contain higher moisture in their body wall than marine fish and shellfish [24] and deemed as tonic food that has high content of water and low fat [14].

Crude protein in fresh samples of sea cucumber contained lower percentage (7.48% in *H. edulis* and 5.45% in *H. scabra*) of crude protein. As sea cucumbers are mostly processed into bêche-de mer (dried sea cucumber) as item, their protein content could be relatively higher when measured on dry weight basis. Crude protein in present study measured on dry weight accounted for 70.35% and 51.21% in *H. edulis* and *H. scabra* respectively. Crude protein of 68.40% in freeze-dried *Parastichopus californicus* was reported [7]. The crude protein contained in *Isostichopus* sp varies within month (2.74% to 6.63% on wet weight basis) as the highest protein values were found to relate with breeding season [35] of sea cucumber. The crude proteins in different species were in the range of 2.5% to 13.8% in *Parastichopus* sp [34], 1.13% to 3.99% in *Apostichopus japonicas* [24] and relatively higher (16.644%) and 12.94% for *Thelenota pineapple* and *Acaudina molpadioides* respectively [36]. Seasonal variation could have effect on the chemical compositions of sea cucumber [9], as the percentage of protein (dry weight basis) dramatically fluctuations with the highest values from

June (6.17%) to October (4.64) at its maximum increase in July (6.63%) and the lowest of 2.74% in the month of April [35]. Crude protein of 9.53% and 5.78% of *H. scabra* in the spring and summer [37] indicating that these fluctuations may be related to the physiological characteristics, seasonal variations, the life cycle of the species and the and the study region.

Total lipid in both sea cucumber samples were generally low, 1.37% and 0.27% (dry weight basis) for *H. scabra* and *H. edulis* respectively. Most marine organism generally has low lipid content [36]. The total lipid content in both species was much lower than those obtained by other researchers. The total lipid for two species *Stichopus japonicas* was 0.56% to 2.3% and 0.28% to 0.33% for *Apostichopus japonicas* [24]. While lower than present study was also reported 0.27% for *Thelenota ananas* and 0.03% for *Acaudina molpadioides*. On the other hand lower value of 0.09%, 0.15% and 0.18% in total lipid were obtained from the species of *H. tubulosa*, *H. polii* and *H. mammata* respectively [9]. In general all holothurians may have wide variations in lipid concentrations (and polyunsaturated fatty acids) and these variations might be due to reproductive pattern and the type of species, feed and feeding pattern as well as on environmental conditions [24]. The variations of total lipid between *H. edulis* (0.27%) and *H. scabra* (1.37%) are probably due the temperature of water in respective habitat. Temperature fluctuations were known to be influential factor of lipid content of fishes [38]. Total lipids contents of *Apostichopus japonicas* under the fluctuating temperatures are lower than those under the corresponding constant temperatures [39]. *H. scabra* which prevalent in coastal sand flat where diet and seasonal temperature fluctuations happened, has lower total lipid than *H. edulis* which inhabit in reef flat where temperature is usually constant.

Ash content in *H. scabra* was observed higher (4.44%) than in *H. edulis* (1.27%). Ash content in the range from 3.16% to 3.81% [35] was above the values reported by [36] to *T. ananas* and *A. molpadioides*. However the values obtained in present study are lower than the ranged value (5.13% to 7.85%) obtained for *H. polii*, *H. tubulosa* and *H. mammata* [9]. The total ash content was apparently a measure of mineral content and other inorganic matter in biomass. The distinctive difference in ash content of both species was highly due to the deposition of ossicles in cellular vesicles of the body wall of sea cucumber [40]. Ossicles are composed of calcium carbonate which might contribute to the high mineral content in body wall of sea cucumber.

Both *H. edulis* and *H. scabra*, are deposit-feeders, widely distributed in the Indo-Pacific. *H. scabra* is mainly found in sandy to muddy coastal zones whilst *H. edulis* is ubiquitous in seagrass and coral reef areas [41]. As a benthic deposit feeder, microbial enriched detritus attribute much to their body compositions. Selectivity of food sources by holothurian do prevail and it has profound influence on body compositions. *Parastichopus parvimensis* does not directly utilize plant detritus which consist of large energy reserve prior to decomposition by bacteria or fungi, thus suggesting the importance of ecological niche of decomposer (bacteria and fungi) in replenish marine sediment [42]. The preferential habitat for *H. scabra* after observation on the gut content containing were mostly of muddy particles with size of 125 - 250 µ that high in organic matter [43]. Both *Stichopus tremulus* and *Mesothuria intestinalis* favor finer sediment and nutritionally rich, pigment-enhanced, food patches [44]. Diets of *Apostichopus japonicus* show that sea mud and seaweed combination diet with ratio of (7:3) has significant effect on the body composition and with addition of corn leaves, it will boost growth rate and feed conversion ratio [45]. In addition to diet temperature could affect the proximate body composition of sea cucumber. Crude lipid contents under the fluctuating temperatures were lower than those under the corresponding constant temperatures [39]. Thus, projections of further studies are essential to boost and improve the nutritional values of sea cucumber.

5. Conclusion

Results obtained from this study indicates that lipid content of sea cucumber were generally lower in amount compared to protein level in sea cucumber, a common trait of marine organism. *H. edulis* has higher crude protein than *H. scabra* which indicate that market value does not necessarily reconcilable with the nutritional value of sea cucumber. The presence of PUFAs in *H. edulis* also suggested that, a low market price sea cucumber contain beneficial fatty acids than those obtained in high valued species like *H. scabra*. The nutritional value of the sea cucumber does reflect its market value. This implies that *H. edulis* has the potential to be a supplementary food. Thus, low valued sea cucumber can be an alternative to mitigate the overexploitation condition.

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