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Fatty Acid Composition of Several Seaweeds of Sri Lanka

Edirisinghe EMRKB[1]*,Abeysinghe RMSM[2] ,
Department of Physical Sciences, Faculty of Applied Sciences,
Rajarata University of Sri Lanka, Mihintale [1,2]

ABSTRACT

Seaweeds are marine algae: saltwater-dwelling, simple organisms. It is a sustainable natural resource which has become a major food ingredient in many products. Also can identify about thirty four fatty acids in different quantities containing in seaweeds. This study was carried out to investigate the fatty acid composition of ten different, commonly available seaweeds in Sri Lanka. Ten seaweeds including Turbinaria conoides, Sargassum tenerrimum, Gracilaria salicornia, Gelidiella acerosa, Sargassum sp, Hormophysa cuneiformis, Padaina sp, Caulerpa serulata, Amphiroa sp and Halimeda opuntia were collected from Mandathive island of Jaffna peninsula in Sri Lanka. Fatty acids in FAMEs were separated by capillary column Gas chromatography using Agilent GC with a DB-WAX capillary column. In the results the most abundance fatty acids among these seaweeds were Tetradecanoic acid(C 14:0), Hexadecanoic acid(C 16:0), Palmitoleic acid(C 16:1), Oleic acid(C 18:1) and Linoleic acid(C 18:2). 11-eicosenoic acid(C 20:1) was the fatty acid which was contained only in Sargassum sp. Maximum number of fatty acids were contained in the sample of Sargassum sp. It was contained fifteen different fatty acids in different quantities. Minimum number of fatty acids were contained in the sample of Amphiroa sp and it was contained eight fatty acids. The study showed that the seaweeds contained both saturated and unsaturated fatty acids. The total amount of saturated fatty acid varies between 33.95% - 76.31% while total unsaturated fatty acid varies from 14.54% to 55.93%. Turbinaria conoides was contained the highest value of omega-3 fatty acids (19.22%). Hormophysa cuneiformis was contained the highest value of omega-6 fatty acids (22.07%). When consider the omega-3: omega-6 ratio which indicates the highest health benefits, the best seaweed which analyzed in study was Gracilaria salicornia because it has the ratio of 2.93.

KEYWORDS: *Fatty Acids, Gas Chromatography, Omega-3 Fatty Acids, Seaweeds*

[1] Corresponding author: Edirisinghe EMRKB: ranjith_e@hotmail.com

1 Introduction

It is well established that there is a huge variety of seaweeds in the sea beds around Sri Lanka. Seaweeds are plant-like organisms that generally live attached to rock or other hard substrates in coastal areas. They belong to three different groups, brown algae (*Phylum Ochrophyta*), red algae (Phylum Rhodophyta) and green algae (*Phylum Chlorophyta*). Distinguishing these three phyla, however, involves more substantial differences than colour. In addition to the pigmentation, they differ considerably in many ultra-structural and biochemical features including photosynthetic pigments, composition of cell walls, the fine structure of the chloroplasts and the fats and oil composition (Castro and Huber, 1997).

Mainly seaweeds are used for edible purposes in Japan, China and Korea. Seaweeds serve as food stuff in the Asian diet for centuries as it contains carotenoids, dietary fibers, proteins, essential fatty acids, vitamins and minerals (Prabhakar and Anandan, 2011). Many red and brown seaweeds are used to produce three hydrocolloids: agar, alginate and carrageenan. They are water-soluble carbohydrates that are used to thicken aqueous solutions, to form gels of varying degrees of firmness, to form water soluble films, and to stabilize some products, such as ice cream. Most agars are extracted from species of *Gelidium* and *Gracilaria.* Alginate is extracted from *Sargassum, Laminaria,* and *Lessonia* species. Carrageenan is extracted from *Kappaphycus* and *Eucheuma* species (Artain *et al*., 2007).

Also seaweeds can use as fertilizers and soil conditioners. Large algal masses has been composted and then used in trials for growing tomato plants in various types of soil in the countries such as Philippine. On the other hand, seaweeds increase water holding capacity and plant growth, so composting simultaneously solved environmental pollution problems and produce a useful organic fertilizer. When seaweed fertilizers applied to fruit, vegetable and flower crops, some improvements have included higher yields, increased uptake of soil nutrients, increased resistance to some pests such as red spider mite and aphids, improved seed germination, and more resistance to frost (Hong *et al.,* 2007).

Especially, in European countries such as United Kingdom, Norway and France seaweeds used as animal foods such as *Laminaria. Ascophyllum, Laminaria, Glacilaria,* and *Sargassum* are some seaweeds which are used to produce fuel. Extraction of seaweeds are often found on the cosmetic packages, particularly in face, hand and body creams or lotions. There are two main areas where seaweeds have the potential for use in wastewater treatment. The first is the treatment of sewage and some agricultural wastes to reduce the total nitrogen and phosphorus containing compounds before release of these treated waters into rivers or oceans. The second is for the removal of toxic metals from industrial wastewater such as cupper nickel, lead (Corilee *et al.,* 2012).

Currently there is an increasing trend to cultivate sea weeds in the world. The total global seaweed production in the year is now more than 15 million metric tons of which 15 to 20 percent was contributed by Indian Ocean region. The seaweed industry in world is mainly a cottage industry and is based only on the natural stock of agar yielding red seaweeds, such as *Gelidiella acerosa* and *Gracilaria edulis* and algin yielding brown seaweeds species such as *Sargassum* and *Tubineria*. India produces 110-132 tons of dry agar annually utilizing about 880-1100 tons of dry agarophytes. Annual align production is 360 to 540 tons from 3,600 to 5,400 tons dry alginophytes.

Fatty acids are molecules that long chains of lipid carboxylic acid found in fats and oils. The sources of fatty acids are animal and vegetable fats and oils. Mainly fatty acids occur as saturated and unsaturated (monounsaturated, polyunsaturated) forms. An essential fatty acid is a polyunsaturated fatty acid needed by the body that is synthesized by plants but not by the human body and it is therefore a dietary requirement. Omega-3 fatty acids (ω-3 fatty acids) are polyunsaturated fatty acid with a double bond (C=C) at the third carbon atom from the end of the carbon chain. The fatty acids have two ends, the carboxylic acid (-COOH) end, and the methyl (CH_3) end. The three types of $\omega -3$ fatty acids involved in human physiology are α-linoleic acid (ALA) which found in plant oils, Eicosapentaenoic (EPA) and Docosahexaenoic (DHA) which both commonly found in marine oils. Sources of animal $\omega -3$,EPA and DHA fatty acids include fish oils, egg oils, squid oils and sources of plant oils containing the $\omega -3$,ALA fatty acid include walnut, edible seeds, clarysage seed oil, and algal oil. Marine algae and phytoplankton are primary sources of $\omega -3$ fatty acids (Rustan and Drevon, 2014). Supplementation with ω-3 fatty acids does not appear to affect the risk of death, cancer or heart disease (Brownlee *et al*, 2012).

The ratio of ω6 to ω3 fatty acids is very important as a neutraceutical for human intake as both of these compete the same enzyme to synthesize prostaglandins derived from both ω3 and ω6 families. It has been reported that several seaweeds have balanced ratio of ω3 and ω6 fatty acid (Tabarsa and Ramezanpour, 2012).

Three types of seaweeds are recognized: the green, brown, red algae. Though their pigment composition is used in there classification, there actual color may not mean much since it tends to very a great deal.

Most green algae (division Chlorophyta) are restricted to fresh water and terrestrial environment. Only around 10% of the estimated 6000 to 7000 species are marine. However, this does not mean that green

algae are uncommon in the sea. Some species are dominant in environments with white variations in salinity such as bays, estuaries and in isolated tide pools on rocky coasts (Sumich, 1999).
Seaweeds contain many nutrition such as protein, lipid, carbohydrate and fibers. Generally total lipid content of seaweed is about 0.7-2.2% of the dry weight. Among lipids the total phospholipid content is from 10.5-45.12%. Six phospholipids are discovered by thin layer chromatography (TLC). The dominant phospholipids are phosphatidylcholine (PC), phosphatidylethanolamine (PE), phosphatidylserine (PS), phosphatidylinositol (PI), phosphatidylglycerol (PG), and phosphatidylacid (PA). Interspecific and inter generic variations in phospholipid composition and content are not small. About thirty-four fatty acids can found by analyzing seaweeds. In red algae 33 fatty acids, green algae 29 fatty acids and brown algae 28 fatty acids are existing(Abdullah *et al*, 2013). Among them, the composition of fatty acids in red algae (Rhodophyta) is higher than in green algae (Chlorophyta) and true brown algae (Phaeophyta). (Ambrozova *et al*, 2014). It is known that algae accumulate PUFA (poly unsaturated fatty acids) when there is decrease in the environment temperature (Sethi, 2012).
In general, inter and intra-generic species variations in fatty acid content are not large. However, seasonal differences in the qualitative and quantitative composition of fatty acids, especially with regards to the polyunsaturated ones, are relatively clear (Rustan and Drevon, 2014). The ω3 to ω6 ratio of seaweed is closely matched a factor that has been found to be important in a balanced diet. Both ω3 and ω6 fatty acids are essential; human must consume them in the diet. ω3 and ω6 compete for the same metabolic enzymes, thus the ω6: ω3 ratios will significantly influence the ratio of the ensuing eicosanoids. This means ω3 and ω6 should be consumed in a balanced proportion, with the ideal ratio of ω6: ω3 ranging from 3:1 to 5:1. (Khotimchenko *et al,* 2002).

Objectives of the study are to determine the fatty acid profile of commonly available seaweeds in Sri Lanka; to determine ω-3 fatty acids in seaweeds and to compare ω3 to ω6 ratio of seaweeds and determine the suitability for consumption.

2 Methodology

Ten seaweed samples were collected from Mandathivu Jaffnaand identified as *Turbinaria conoides*, *Sargassum tenerrimum*, *Gracilaria salicornia*, *Gelidiella acerosa*, *Sargassum* sp. *Hormophysa cuneiformis*, *Padaina* sp. *Caulerpa serulata*, *Amphiroa* sp.and *Halimeda opuntia*. Samples were stored in ice and transported to the Chemistry laboratory of Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka. The samples were dried in an oven for 24 hrs at 105°C. About 10g of blended dry sample was weighed and placed inside a thimble. Weight of the round bottom flask was measured and the sample was extracted continuously with petroleum ether (RESEARCH-LAB FINE CHEM INDUSTRIES, 674A230513) by using soxhlet condenser for two days. Petroleum ether was evaporated by using Rotavapor (Heidolph, Laborota 4000) and the sample was concentrated (temperature of water bath in Rota vapor was kept around 45℃). Moisture was removed by keeping the sample in an oven around 45℃. Then the flask was weighed which contains the sample. The sample was dissolved in a minimum volume of petroleum ether and was transferred in to a vial (Li, 2014).
Fatty acid methyl ester (FAME) of these lipids were prepared by base hydrolysis followed by trans esterification (Berner and Berner 1994). About 50mg of extracted lipid sample was weighed in to screw cap tube. Then 1mL of 0.5moldm^{-3}methanolic sodium hydroxide was added and tighten the cap firmly. Tubes were warmed in the boiling water bath until the oil dissolved for about 5mins. Then the solution was cooled and 1.5mL of Boron trifluoride reagent and 0.5mL of hydroquinone solution was added. The cap was tighten firmly and again the solution was warmed in the boiling water bath for 5mins. The solution was cooled and 5mL of saturated sodium chloride and2.5mL of n-heptane was added to it. Then it was shaken vigorously for 30s and kept until separate the phases. The organic phase was transferred in to an injection vial and kept at -18℃.
Fatty acids in FAMEs were separated by capillary column Gas chromatography using Agilent GC (Agilent 7890B, AOC-20I, Japan) with a DB-WAX capillary column (length 30 m, 0.25 mm ID, 0.25 μm film thickness). Helium was used as the carrier gas at a rate of 50ml/min. The split ratio was maintained at 1:50. The temperature program used in the oven was from 150 °C to 225 °C over 40 minute period. The injection and the detector ports were operated at 240 °C and 250 °C respectively. The separated compounds were detected using a hydrogen flame ionization detector. The obtained peaks were identified and quantitatively determined by comparing retention times of methyl esters in a standard mixture from Larodane fine Chemicals AB, Sweden.

3 Results And Discussion

The fat amount and the fatty acid composition of some seaweeds which commonly available in Sri Lanka was comparatively studied in this study.

According to the table 1, the highest percentage (2.19%) of fat and oil contains in the sample of *Halimeda opuntia*. *Hormophysa cuneiformis* contains the lowest percentage (0.40%) of fat and oil. Also we can say that these seaweeds are not highly contain with fat and oils.

Table 2: Fat percentages of Seaweeds

Sample Name	Amount of Fat (%)
M1-*Turbinaria conoides*	1.15
M2-*Sargassum tenerrimum*	2.19
M3-*Gracilaria Salicornia*	1.76
M4-*Gelidiella acerosa*	2.16
M5-*Sargassum* sp.	2.07
M6-*Hormophysa cuneiformis*	0.40
M7-*Padaina* sp.	1.76
M8-*Caulerpa serulata*	2.03
M9-*Amphiroa* Sp.	1.22
M10-*Halimeda opuntia*	4.35

Table 2 shows that the area percentages of each fatty acid containing in *Turbinaria conoides*, *Sargassum tenerrimum, Gracilaria salicornia, Gelidiella acerosa, Sargassum* sp, *Hormophysa cuneiformis, Padaina* sp, *Caulerpa serulata, Amphiroa* Sp and *Halimeda opuntia*. According to the tables every seaweed was contained number of fatty acids in different quantities. Fatty acid composition was varied in seaweeds between Lauric acid (C12:0) to Eicosapentanoic acid (C20:5). Area percentage of Lauric acid (C12:0) was contained in *Glacilaria salicornia* (1.49%), *Gelidiella acerosa* (1.29%), *Sargassum sp* (0.38%), *Caulerpa serulata* (0.53%), *Amphiroa sp* (2.23%), *Halimeda opuntia* (4.51%). The highest, and lowest percentages of Lauric acid was ~~ca~~ontained in *Halimeda opuntia* and *Sargassum* sp. Tetradecanoic acid (14:0) was contained in all seaweed samples and *Halimeda opuntia* (4.51%), *Gracilaria salicornia* (2.13%) are the highest and lowest percentages of Tetradecanoic acid respectively. Tetradecanoic acid also contain in *Turbinaria conoides* (3.90%), *Sargassum tenerrimum* (5.84%), *Gelidiella acerosa* (4.43%), *Sargassum* sp (4.60%), *Hormophysa cuneiformis* (4.29%), *Padaina* sp (7.24%), *Caulerpa serulata* (3.42%), and *Amphiroa* Sp (5.22%). Pentadecanoic acid (15:0) was included only four samples. They were *Sargassum* sp (0.53%), *Padaina* sp (0.72%), *Amphiroa* sp (1.66%) and *Halimeda opuntia* (1.74 %). Maximum and minimum area percentages of Pentadecanoic acid were included in *Halimeda opuntia* and *Sargassum* sp respectively.

According to the fatty acid composition, Hexadecanoic acid (C16:0) was the most abundant fatty acid. It was consist in every species which was used to analyze and the amount also higher than the other fatty acids. *Amphiroa* Sp (63.14%) was the species which has the highest amount of Hexadecanoic acid and *Hormophysa cuneiformis* (28.15%) was the species which has lowest amount of Hexadecanoic acid through the studied samples. However, Hexadecanoic acid also contained in *Turbinaria conoides* (32.60%), *Sargassum tenerrimum* (33.63%), *Gracilaria salicornia* (29.56%), *Gelidiella acerosa* (54.20%), *Sargassum* sp (38.42%), *Padaina* sp (30.95%), *Caulerpa serulata* (57.43%) and *Halimeda opuntia* (34.16%) in different quantities. Maximum amount of Palmitoleic acid (C16:1) was found in *Sargassum* sp (5.83%) and *Gracilaria salicornia was contained minimum amount* (1.84%). Furthermore Palmitoleic acid was comprised in *Turbinaria conoides* (3.15%), *Sargassum tenerrimum* (3.25%), *Gelidiella acerosa* (5.70%), *Hormophysa cuneiformis* (2.16%), *Padaina*sp (3.46%), *Caulerpa serulata* (4.47%), *Amphiroa* Sp (2.61%) and *Halimeda opuntia* (2.28%).

Table 2: Amount of fatty acids (%)

Name of fatty acid		M1-*Turbinaria conoides*	M2-*Sargassum tenerrimum*	M3-*Gracilaria salicornia*	M4-*Gelidiella acerosa*	M5-*Sargassum* sp.	M6-*Hormophysa cuneiformis*	M7-Padaina sp.	M8–*Caulerpa serulata*	M9-*Amphiroa* Sp	M10-*Halimeda opuntia*
Lauric acid	C 12:0			1.49	1.29	0.38			0.53	2.23	4.79
Tetradecanoic acid	C 14:0	3.90	5.84	2.49	4.43	4.60	4.29	7.24	3.42	5.22	7.85
Pentadecanoic acid	C 15:0					0.53		0.72		1.66	1.85
Hexadecanoic acid	C 16:0	32.60	33.63	34.48	54.20	38.42	28.15	30.95	57.43	63.14	36.26
Palmitoleic acid	C 16:1	3.15	3.25	2.15	5.70	5.83	2.16	3.46	4.47	2.61	2.42
Stearic acid	C 18:0		2.93	5.97	4.02	1.36	1.52	3.20	1.73	4.05	8.11
Oleaic acid	C 18:1	13.61	13.73	9.62	13.54	12.23	11.62	25.49	3.73	8.58	14.92
Vaccenic acid	C 18:1			2.16	1.46	0.41		0.51	1.82		1.91
Linoleic acid	C 18:2	7.27	5.53	3.09	2.97	4.60	11.33	4.86	5.80	3.35	4.18
Linolenic acid	C 18:3	10.10	5.12		1.54	4.67	1.60	2.71	5.92		0.74
Octadecatetraenoic acid	C 18:4	5.03	4.28	9.07		3.17	0.74	3.25			
Arachidonic acid	C 20:0			1.41		0.33					
11-eicosenoic acid	C 20:1					0.90					
Arachidonic acid	C 20:4	12.68	14.89		3.05	11.15	10.74	2.78	0.78		
Eicosapentaenoic acid	C 20:5	4.10	2.11			2.08	3.24		0.89		
Total identified		92.43	91.31	71.94	92.20	90.65	75.39	85.17	86.51	90.85	83.03
Total saturated		36.50	42.40	45.85	63.94	45.61	33.95	42.11	63.10	76.31	58.86
Total unsaturated		55.93	48.91	26.09	28.26	45.04	41.43	43.05	23.40	14.54	24.18
Total monounsaturated		16.76	16.98	13.93	20.70	19.37	13.78	29.46	10.01	11.19	19.26
Total polyunsaturated		39.17	31.93	12.16	7.56	25.67	27.65	13.59	13.39	3.35	4.92
Total ω-3		19.22	11.51	9.07	1.54	9.92	5.58	5.96	6.81	0.00	0.74
Total ω-6		19.95	20.42	3.09	6.02	15.75	22.07	7.64	6.59	3.35	4.18
ω3/ω6		0.96	0.56	2.93	0.26	0.63	0.25	0.78	1.03	0.00	0.18

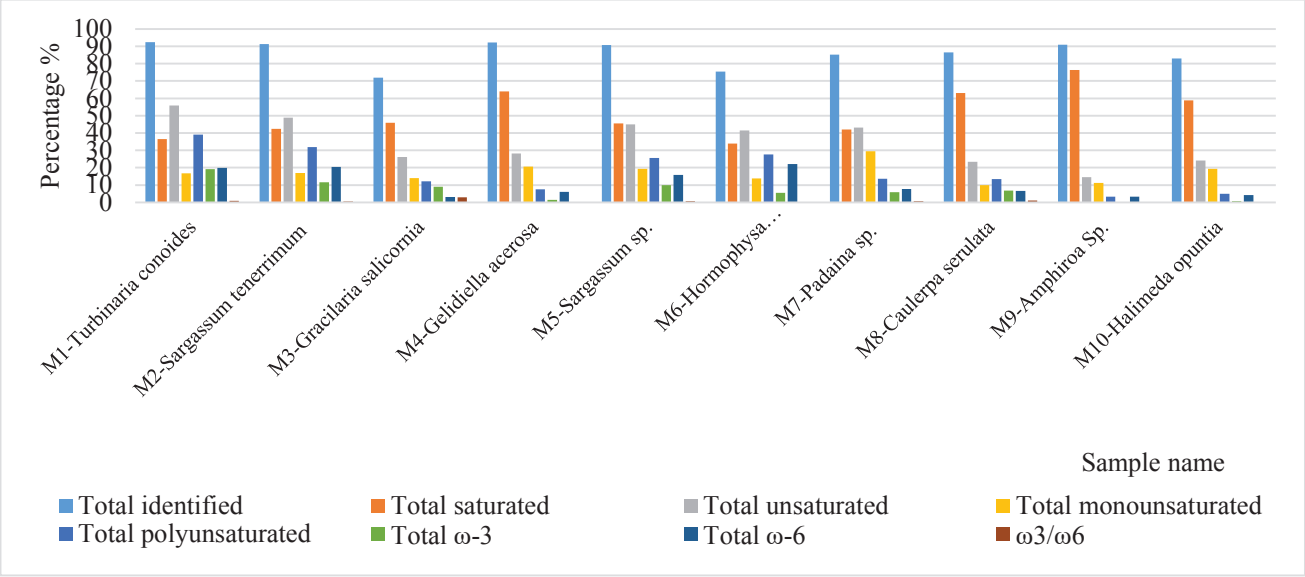

Figure 1: Fatty acid composition of Seaweeds

Stearic acid (C18:0) is a saturated fatty acid and also contains in seaweed samples. The amount of Stearic acid was higher in *Halimeda opuntia* (7.65%) and lower in *Sargassum* sp (1.36%). Moreover *Sargassum tenerrimum* (2.93%), *Gracilaria salicornia* (5.12%), *Gelidiella acerosa* (4.02%), *Hormophysa cuneiformis* (1.52%), *Padaina* sp (3.20%), *Caulerpa serulata* (1.73%) and *Amphiroa* Sp (4.05%) were contained Stearic acid. According to the above table2 Oleic acid (C18:1) was restrained in high quantities by comparing with other fatty acids. Oleic acid also can see in all seaweed samples which used for the study. Maximum area percentage was showed in *Padaina* sp (25.49%) and minimum area percentage was showed in *Caulerpa serulata* (3.73%). The other seaweed samples such as *Turbinaria conoides*, *Sargassum tenerrimum, Gracilaria salicornia, Gelidiella acerosa, Sargassum* sp, *Hormophysa cuneiformis, Amphiroa* Sp and *Halimeda opuntia* also showed the area percentages of Oleic acids 13.61%,13.73%, 8.24%, 13.54%, 12.23%, 11.62%, 8.58% and 14.06% respectively. Vaccenic acid (C18:1) was contained in 6 seaweed samples such as *Gracilaria salicornia, Gelidiella acerosa, Sargassum* sp, *Padaina* sp, *Caulerpa serulata and Halimeda opuntia* in area percentages of 1.85%, 1.46%, 0.41%, 0.51%, 1.82% and 1.80% consecutively. The highest value was showed in *Gracilaria salicornia* and the lowest value was showed in *Sargassum* sp.

All the 10 samples consisted Lenoleic acid (C18:2) in different quantities. *Hormophysa cuneiformis* (11.33%) contained the maximum area percentage and *Gracilaria salicornia* (2.65%) was contained the minimum area percentage of Lenoleic acid. *Turbinaria conoides* (7.27%), *Sargassum tenerrimum* (5.53%), *Gelidiella acerosa* (2.97%), *Sargassum* sp (4.60%), *Padaina* sp (4.86%), *Caulerpa serulata* (5.80%), *Amphiroa Sp* (3.35%) and *Halimeda opuntia* (3.93%) are the other samples which Lenoleic acid was contained. According to the table Lenolenic acid (C18:3) was contained in 8 samples and those were *Turbinaria conoides* (10.10%), *Sargassumtenerrimum* (5.12%), *Gelidiellaacerosa* (1.54%), *Sargassum*sp (4.67%), *Hormophysacuneiformis* (1.60%), *Padaina* sp (2.71%), *Caulerpa serulata* (5.92%) and *Halimeda opuntia* (0.70%). The highest area percentage was showed in *Turbinariaconoides* and lowest area percentage was showed in *Halimeda opuntia.*Octadecatetraenoic acid (C18:4) also contain in *Turbinaria conoides*, *Sargassum tenerrimum, Gracilaria salicornia, Sargassum* sp, *Hormophysa cuneiformis* and *Padaina* sp with the area percentages of 5.03%, 4.28%, 7.77%, 3.17%, 0.74% and 3.25% respectively. Maximum area percentage of Octadecatetraenoic acid was showed in *Gracilaria salicornia* and minimum area percentage of Octadecatetraenoic acid was showed in *Hormophysa cuneiformis.*

According to the table 2 Arachidoic acid (C20:0) was consist only in *Gracilariasalicornia* (1.41%) and *Sargassum* sp (0.33%). Also 11-eicosenoic acid (C20:1) was contained only in *Sargassum* sp (0.90%). Seven seaweed samples had Arachidonoic acid (C20:4) in different quantities and they were *Turbinariaconoides* (12.68%), *Sargassum tenerrimum* (14.89%), *Gelidiella acerosa* (3.05%), *Sargassum* sp (11.15%), *Hormophysa cuneiformis* (10.74%), *Padaina* sp (2.78%) and *Caulerpa serulata* (0.78%). The maximum amount consisted in *Sargassum tenerrimum* and minimum amount consisted in *Caulerpa serulata.* Eicosapentaenoic acid (C20:5) contained in several samples such as *Turbinaria conoides*,

Sargassum tenerrimum, Sargassum sp, *Hormophysa cuneiformis* and *Caulerpa serulata* with area percentages of 4.10%, 2.11%, 2.08%, 3.28% and 0.89% respectively. The highest and lowest area percentages were contained in *Turbinaria conoides* and *Caulerpa serulata* in sequence.

As per the data given in table 2, several ω-3 fatty acids such as Linolenic acid, Octadecatetraenoic acid and Eicosapentaenoic acid were identified. Total calculated ω-3 fatty acid area percentage can be shown as following. *Turbinaria conoides* (19.22%), *Sargassum tenerrimum* (11.51%), *Gracilaria salicornia* (7.77%), *Gelidiella acerosa* (1.54%), *Sargassum* sp (9.92%), *Hormophysa cuneiformis* (5.58%), *Amphiroa* Sp (5.96%), *Padaina*sp (6.81%) and *Halimeda opuntia* (0.70%). According to the findings *Caulerpa serulata* was not contained ω-3 fatty acids. In several samples it is possible to identify some ω-6 fatty acids such as *Turbinaria conoides* (19.95%), *Sargassum tenerrimum* (20.42%), *Gracilaria salicornia* (2.65%), *Gelidiella acerosa* (6.02%), *Sargassum* sp (15.75%), *Hormophysa cuneiformis* (22.07%), *Amphiroa* Sp (7.64%) *Padaina* sp (6.59%), *Caulerpa serulata* (3.35%) and *Halimeda opuntia* (3.93%). *Caulerpa serulata* was not contained ω-3 fatty acids but it was contained ω-6 fatty acids. The highest ω3: ω6 ratio was recorded in *Gracilaria salicornia* (2.93) which given highest health benefits (Dawczynski and Jahreis, 2007).

4 Conclusion

The most abundance fatty acids among these seaweeds which were studied were Tetradecanoic acid, Palmitoleic acid, Oleic acid, Hexadecanoic acid and Linoleic acid. 11-eicosenoic acid was the fatty acid which was contained only one variety. Maximum number of fatty acids were contained in *Sargassum* sp. It was contained 15 fatty acids in different quantities. Minimum number of fatty acids were contained in the *Amphiroa* Sp and it contained 08 fatty acids. The study shows that the seaweeds contained both saturated and unsaturated fatty acids. The total amount of saturated fatty acid varies between 33.95% - 76.31% while total unsaturated fatty acid varies from 14.54% to 55.93%. *Turbinaria conoides* contained the highest value of ω-3 fatty acids (19.22%). *Hormophysa cuneiformis* contained the highest value of ω-6 fatty acids (22.07%). When consider the ω3: ω6 ratio, Gracilaria *salicornia* (2.93) indicated the best health benefits.

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