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Biochemical Composition of Some Brown Seaweeds from Hurgada Coast

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Abstract. The interest in biochemical studies of brown seaweeds stems from their rich array of important compounds which make them valuable for nutrition, fertilizers and medicinal applications. The biochemical analysis of five brown seaweeds—*Dictyota dichotoma, Hormophysa triquetra, Cystoseira myrica, Sargassum subrepandum* and *Sargassum latifolium* revealed valuable compounds. *Sargassum subrepandum* had the highest total soluble sugars (0.24±0.02 mg/g), while *Hormophysa triquetra* had the most non-soluble sugars (1.69±0.07 mg/g). *Sargassum latifolium* showed the highest alginic acid (31.130.42%) and total protein (8.7±0.2%). *Cystoseira myrica* contained significant mannitol (20.9%) and crude lipid (10.47±0.5%). Saturated fatty acids were found in four species, with linoleic acid present only in *Dictyota dichotoma* (66.5%). Sodium, potassium, calcium and magnesium levels were higher than phosphorus across all species, highlighting their potential for nutritional and medicinal use.

Keyword: brown seaweed, biochemical constituents, red sea, total lipids, minerals

Introduction

Seaweed is considered one of the most important marine resources, not only because it is part of the food chain of marine life, but also because it has been used as food, fodder and fertilizers (improve soil efficiency and increase plant productivity), in addition to being considered as raw material for many industries, including the pharmaceutical industry. Brown seaweeds are considered as an excellent source of bioactive compounds such as polysaccharides, dietary fibers, protein, essential fatty acids, vitamins and minerals, polyphenols and carotenoids (Olsson *et al*., 2020). *Sargassum polycystum* which represents one of the tropical edible seaweeds has different minerals such as Na, K, Ca, Mg Fe, Se and Mn which are necessary for the metabolic reactions of human health (Nazarudin *et al*., 2021). The biochemical composition investigation of brown seaweeds illustrated that *Sargassum linifolium* has aspartic, glutamic, alanine, leucine and proline as common amino acids, it also contains polyunsaturated ω6 and ω3 essential fatty acids, the major component of the ω6 fatty acids from brown algae was arachidonic acid (C20:4n-6) as illustrated by (Arakaki *et al*., 2023; Ismail, 2017). The fatty acid Hexadecanoic acid represents 42.48% of *Sargassum ilicifolium* lipids (Nazarudin *et al*., 2021). Protein, lipid and carbohydrate content of *Dictyota dichotoma*, *Turbinaria ornata* examined by (Parthiban *et al*., 2013). The most macro-elements present in *Cystoseira myrica* and *Padina pavonica* were K, Na and Ca, the extract of *Cystoseira myrica* showed high antioxidant capacities other than the seaweed examined (El-Shazoly and Fawzy, 2018). *Sargassum subrepandum* has 28.11% carbohydrates and *Cystoseira myrica* has shown high fiber (32.39%) content, while high ash content (50.91%) was recorded in Dictyota (Kasimala *et al*., 2020). In the present study biochemical composition of the tested brown seaweeds species collected from the beaches of Hurghada, (virgin area; research on the algal species present there is limited) investigated that these species can be used as food, fodder, fertilizers and in the pharmaceutical industry.

Materials and Methods

The algal collection. The examined seaweeds were collected by author from the Red Sea coast of Egypt, Hurghada city (27°09'28.6"N 34°48'39.9"E). The classification was done according to Aleem (1993). The algae were preserved in dried form in the herbarium of the faculty of science, Helwan University, Egypt. Exactly 1 Kg (wet weight) of each species was taken. The sample was thoroughly washed with seawater to remove epiphytes and dirt particles, followed by shade-drying at 70 °C to obtain a constant weight and pulverized in the grinder (size 2 mm). The ground samples were

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sieved to get uniform particle size, then kept in airtight container and stored in a freezer until further analysis.

Biochemical analysis. ***Estimation of carbohydrate.*** The extraction and determination of total soluble sugars, non-soluble sugar, mannitol and alginic acid were determined as described by Manns *et al*. (2014).

Estimation of protein. Estimation of total nitrogen and total protein was carried out by the Microkjeldahl method (Baker and Thompson, 1992).

Estimation of lipid. The extraction and determination of crude lipids were carried out according to the method used by Saini *et al*. (2021) while the determination of fatty acids was determined according to Knapp (1979).

Ash content. Ash content was determined using a muffle furnace at 600 °C for 3 h (Thiex *et al*., 2012).

Total nitrogen is estimated by the Microkjeldahl method (Baker and Thompson, 1992). The procedure of Phosphorus K and Na by flame photometer according to (Williams and Twines, 1960). Estimation of Ca and Mg by EDTA titration (Steagall, 1968).

Results and Discussion

Seaweed collected for examination are classified into 5 species; *Dictyota dichotoma*, *Hormophysa triquetra*, *Cystoseira myrica*, *Sargassum subrepandum* and *Sargassum latifolium*. The five species are different in their carbohydrate content, the data of total soluble and non-soluble sugars represented in Fig. 1 showed that; the highest value of soluble sugars 0.24±0.02 (mg/g) obtained by *S. subrepandum* followed by 0.21±0.01 recorded by *S. latifolium*, while Dictyota gave the highest value of non-soluble sugars 1.69±0.07 (mg/g), followed by *S. subrepandum* (1.18±0.05 mg/g) and the lowest value 1.05±0.05 by Cystoseira.

Alginic acid and mannitol were measured and represented in Fig. 2, where the highest percentage of alginic acid 31.13±0.4 obtained by *S. latifolium*, followed by *S. subrepandum* (27.36±0.4), while the percentage of mannitol gave the highest value (20.9±0.1) in Cystoseira and the lowest one (12.62±0.2) in Hormophysa.

The results of total nitrogen and total protein are illustrated in Fig. 3, which illustrated that; the highest percentage of total nitrogen and total protein respectively (1.33±0.1, 8.7±0.2) obtained by *S. latifolium*, followed by Dictyota (1.09±0.17, 8.2 ±0.14). My result agrees with (El-Shenody *et al*., 2019) who explained that *D. dichotoma* has a relatively high protein content of 7.28±0.25%, while the lowest value (1.09±0.17,

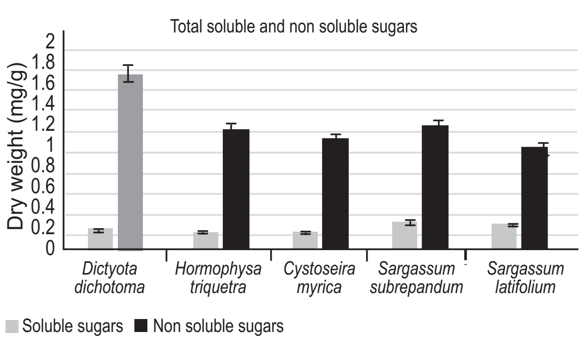

Fig. 1. Total soluble and non-soluble sugars represented as means of triplicate ± standard deviation by mg/gm dry weight of the 5 seaweeds.

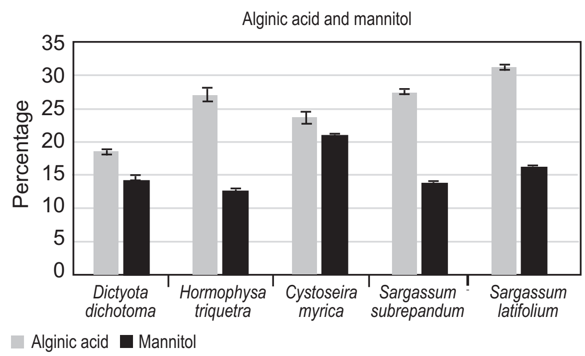

Fig. 2. Alginic acid and mannitol results are means of triplicate determination ± standard deviation for the five algal species.

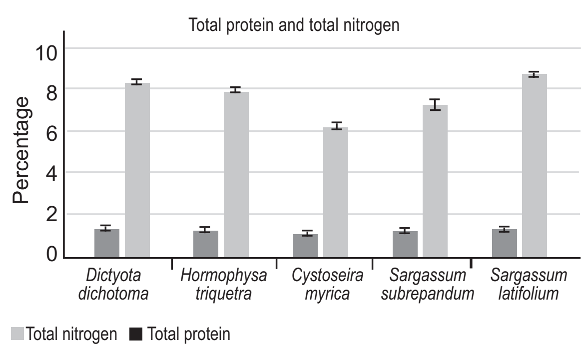

Fig. 3. Total protein and total nitrogen results are means of triplicate determination ± standard deviation for the five species.

6.29±0.26) in Cystoseira. The total protein content of the two species of Sargassum are 7.2 and 8.7 in *S. subrepandum* and *S. latifolium* respectively and these values fit with what (Helal *et al*., 2024) found for *S. dentifolium* which have 8.40% protein of dry weight.

The crude lipids percentage was different in between the tested species as shown in Fig. 4. The highest value (10.47±0.5%) was obtained by Cystoseira followed by *S. subrepandum* (9.43±0.15%), Hormophysa recorded the lowest value (7.53±0.17%). The fatty acid picture of the five studied algal species (Table 1) showed that valeric acid occurred in the largest quantity among 4

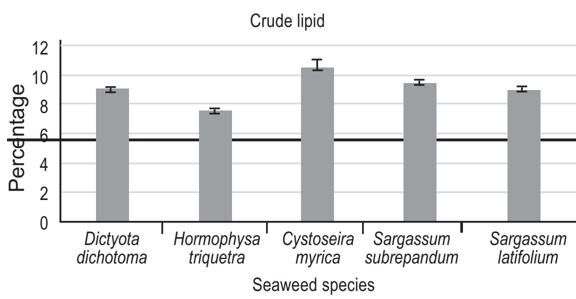

Fig. 4. Crude lipid results are means of triplicate determination ± standard deviation for the five species.

species (59.3, 58.9, 56.7 and 40.8%) in *S. subrepandum*, *C. myrica*, *H. triquetra* and *S. latifolium* respectively. However, it cannot be detected in *D. dichotoma*. The second most common fatty acid was butyric acid, which followed valeric acid in percentage (22.3, 20.2 and 17%) for *C. myrica*, *S. subrepandum* and *S. latifolium* respectively. Valeric acid (pentanoic acid) is a straight, saturated, short-chain fatty acid. Butyric and valeric acids and their esters, are mainly used in perfumes and cosmetics, as food additives because of the fruity flavor of the esters. Medically, these acids have several benefits, such as: modulating blood pressure (BP) regulation (Bolognini *et al*., 2016) and interfering with the sympathetic nervous system (Kimura *et al*., 2011). On the other hand, butyric acid products are used in the therapy of gastrointestinal diseases (Borycka *et al*., 2017). Meanwhile, *H. triquetra* contained caprylic acid (saturated, medium-chain fatty acid) with a high value (24.9%), caprylic acid reduced body fat, improved the lipid profiles and suppressed inflammatory cytokine production (Zhang *et al*., 2019).

H. triquetra has 10.8% linolenic acid, which is an omega-3 fatty acid, essential for animal nutrition. Linoleic acid was found only in *D. Dichotoma* with a very high percentage (66.5%) and in *H. triquetra* with a very low percentage (1.9%), while it was not detected in all other brown species. Linoleic acid is an omega-

Table 1. The fatty acid picture of the studied algal species data expressed as relative percentage

Type	Systematic name	Common name	*Dictyota*	*Hormophysa*	*Cystoseira*	*S. subrepandum*	*S. latifolium*
C_4	Butanoic acid	Butyric acid	-	-	22.3	20.2	17
C_5	Pentanoic acid	Valiric acid	-	56.7	58.9	59.3	40.8
C_6	Hexanoic acid	Caproic acid	-	-	1.7	1.2	1.2
$C_{6:1}$	4- Methylpentanoic acid	Isocaproic acid	17.5	-	-	-	15.5
C_7	Heptanoic acid	Enanthic acid	-	-	2.4	-	-
C_8	Octanoic acid	Caprilic acid	-	24.9	4.1	-	0.4
C_9	Nonanoic acid	Pelargonic acid	-	-	1.2	2.3	-
C_{10}	Decanoic acid	Capric acid	2.9	1.6	6.5	-	7.4
C_{11}	Henedecanoic acid	Undecyclic acid	0.6	4.1	-	-	-
C_{12}	Dodecanoic acid	Lauric acid	1.2	-	1.6	3.3	0.08
C_{13}	Tridecanoic acid	Tridecyclic acid	-	-	-	-	-
C_{14}	Tetradecanoic acid	Myristic acid	1.6	-	1.3	2.2	2.02
$C_{14:1}$	Tetradecenoic acid	Myristoleic acid	-	-	-	10.2	15.6
C_{16}	Hexadecanoic acid	Palmitic acid	0.9	-	-	1.3	-
C_{18}	Octadecanoic acid	Stearic acid	4.3	-	-	-	-
$C_{18:1}$	Octadecenoic acid	Cis-Vaccenic acid	3.6	-	-	-	-
$C_{18:2}$	Octadecadienoic acid	Linoeleic acid	66.5	1.9	-	-	-
$C_{18:3}$	Octadecatrinoic acid	Linolenic acid	-	10.8	-	-	-

Table 2. The percentage of ash and the major cations in the ten studied algal species (data expressed as mean of 3 replicates ± SD)

Algal species	Ash	Na	K	P	Ca	Mg
D. dichotoma	46±1	10.2±0.26	12.3±0.3	0.45±0.005	2.73±0.25	5.57±0.3
H. triquetra	37.7±0.58	9.4±0.4	4.66±0.19	0.044±0.005	3.06±0.11	5.76±0.12
C. myrica	40.7±0.58	10.2±0.06	5.23±0.15	0.055±0.006	2.36±0.11	2.73±0.07
S. subrepandum	34.9±0.23	10.1±0.15	12.1±0.36	0.12±0.02	3.77±0.15	3.62±0.1
S. latifolium	40.17±0.15	10.1±0.11	11.48±0.5	0.83±0.008	3.6±0.17	1.13±0.11

6, essential fatty acid for human nutrition, it cannot be synthesized by the human body (Ramsden *et al*., 2012).

The ash content detected in the five algal species is presented in Table 2 as well as the most important five different cations. Ash percentages ranged between 34.9±0.23 in *S. subrepandum* to the highest value of 46±1% in Dictyota, the same obtained by Kasimala *et al*. (2020), found that high ash content (50.91%) was recorded in Dictyota. Sodium gave approximately equal percentages, where *D. dichotoma* and *C. myrica* have the same percentage (10.2±0.26).

Moreover, *S. subrepandum* and *S. latifolium* had the same percentage (10.1±0.15 and 10.1±0.11%, respectively). The lowest percentage was recorded in *H. triquetra* (9.4±0.4%). Potassium content (Table 2) showed that *D. dichotoma* followed by *S. subrepandum* then *S. latifolium* attained the highest percentages being: 12.3±0.3, 12.1±0.36 and 11.48±0.5% respectively.

Meanwhile, the lowest percentage of potassium was determined in *H. triquetra* (4.66±0.19%). *S. latifolium* had the highest percentage of phosphorus (0.83±0.008%) and the lowest percentage occurred in the samples of *H. triquetra* (0.044±0.005%). The percentages of calcium ranged from 3.77± 0.15 in *S. subrepandum* to 2.36±0.11 in Cystoseira, Magnesium gave values ranged from 5.76±0.12 in Hormophysa to the lowest value of 1.13±0.11 obtained by *S. latifolium*. Our results agree with El-Shazoly and Fawzy (2018), who illustrated that the most significant macro-elements present in the brown seaweeds were K, Na and Ca, so these seaweeds can be used in industrial and pharmaceutical applications. The ion quotient ratio can be calculated, it affords better dietary and healthy characteristics than the simple Ca/Mg or Na/K ratios.

The ion quotient calculated in the 5 species is presented in Table 3, it ranged from 0.72 in *D. dichotoma*, to 1.57 in *C. myrica*. As the ion quotient generally varies between 2.5 and 4.0 in the human body as mentioned by El-Said and El-Sikaily (2013), so seaweeds are promising to be used in foods to decrease this range in the human body and reduce related diseases such as hypertension and heart disease.

Table 3. Ion quotient of seaweeds

Seaweed	Ion quotient
D. dichotoma	0.72
H. triquetra	1.19
C. myrica	1.57
S. subrepandum	0.88
S. latifolium	1.08

*Ion quotient= Na+ Ca^{+2}/Mg^{+2}+K.

Conclusion

The presence of large quantities of seaweed on the beaches and leaving them unused is considered a waste of natural resources. Therefore, this research provides an image of the chemical content of these abundantly present species, which may have a significant contribution in solving some nutritional problems for humans or animals, or using them in medical fields.

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