NUTRITIONAL COMPOSITION AND MINERAL CONTENT OF FIVE MACROALGAE FROM RED SEA

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Abstract

Nutritional and mineral compositions were evaluated for five seaweed species collected from Red Sea during the winter of 2008. These species were *Dictyota divaricata, Padina tetrastromatica, Sargassum subrepandum* and *Turbinaria triquetra* from Phaeophyta and *Caulerpa serrulata* from Chlorophyta. Moisture contents in algal samples were from 10.6g.100g^{-1} in *Caulerpa serrulata* to 23.6g.100g^{-1} in *Turbinaria triquetra*. Other species had moisture contents more close to *C. serrulata*. Total dietary fiber was the most abundant component in these algae (18.6% to 55.41%), followed by ash content (17.057 to 29.573 g.100g^{-1}) and carbohydrates (14.6 to 45.6 100g^{-1}). Proteins in all species were from 3.87% to 14.48%. *D. divaricata* had the highest content of total lipids (10.51%); meanwhile other species showed (4.24-1.62%). The five algal species contained large amounts of Na, Ca, K and Fe, moderate amounts of Zn, and were lower in Cu, Cd, Ni and Mn. Pb was measured as 0.001 ppm in *P. tetrastromatica* and was absent in the other species.
Keywords: Minerals; Nutritional Composition; Seaweeds; Red Sea.

Introduction

Marine macroalgae are, commonly known as seaweed, one of nature's most biologically active resources, as they possess a wealth of bioactive compounds. Many marine macroalgae have been used as ingredients in both medicinal and food preparations, traditionally, in different regions across the world (**Chandini *et al*., 2008**). Marine algae are known to be a source of healthy food due to their low content in lipids, high concentration in polysaccharides, richness in minerals, polyunsaturated fatty acids and vitamins (**Kornprobst**, **2005**; **Zubia *et al*., 2009**). There are 250 macroalgal species which have been listed as commercially utilized worldwide, among which 150 are consumed as human food (**Veena *et al*., 2007**). Macroalgae are a rich source of dietary fiber, of which water-soluble fiber constitutes approximately 50–85% (**Jiménez-Escrig and Sánchez-Muniz**, **2000**). Soluble dietary fiber lowers digestion and absorption of nutrients, and lowers cholesterol and glucose in blood (**Wong and Cheung**, **2000**). Insoluble dietary fiber increases fecal bulk and decreases intestinal transit

(ISSN: 1110-8649)

time (**Potty**, **1996**). Together with their low lipid content, seaweeds provide low energy (**Jurkovic *et al*.**, **1995**) and lower the incidence of diabetes, obesity, heart diseases, and cancers (**Southgate *et al*.**, **1990**). Essential minerals needed for human nutrition are present in marine algae (**Mabeau and Fleurence**, **1993**; **Ortega *et al*.**, **1993**). The content is ranged from 8 to 40%. This wide range is related to division, geographical location (**Abbas *et al*.**, **1992**; **Rizvi *et al*.**, **2001**), seasonal (**Basson and Abbas**, **1992**), and physiological variations (**Mabeau and Fleurence**, **1993**). In marine algae, mineral content is higher than that of land plants and animal products (**Ortega *et al*.**, **1993**). In most land vegetables, ash content ranges from 5 to 10% of dry weight (**USDA**, **2001**). Publications (e.g. **Abbas *et al*.**, **1992**; **Basson and Abbas**, **1992**; **Rizvi *et al*.**, **2001**) indicated that marine seaweeds contained high amounts of K, Ca, Mg, Fe, Zn, Mn, and Cu. According to **Matanjun *et al*.** (**2009**), these seaweeds contained 12.01–15.53% macro-minerals (Na, K, Ca and Mg) and 7.53–71.53 mg.100 g trace minerals (Fe, Zn, Cu, Se and I).

The present work was for evaluating the nutritional and mineral composition of five algal species from Red Sea.

Materials and Methods

Sample collection

Five algal samples were collected from intertidal and subtidal zones from Ghardaqa reefs at 27^o 11' to 27^o 09' N, 33^o 50' to 33^o 52' E during late December, 2008. These species were *Dictyota divaricata, Padina tetrastromatica, Sargassum subrepandum* and *Turbinaria triquetra* from Phaeophyta and *Caulerpa serrulata* from Chlorophyta. Fresh algal samples were thoroughly washed with distilled water to remove epiphytes, encrusting materials, and excess salt and stored in a deep freezer at -20°C.

Nutritional composition

Moisture and ash were measured by **AOAC** (**1995**), total carbohydrates by **Hedge and Hofreiter** (**1962**), total proteins by **Lowry *et al*.** (**1951**), crude fibers by **AOAC** (**1990**), total lipids by **AOAC** (**2000**). All measurements were recorded as g.100g^{-1} dry weight.

Minerals and trace metals

Minerals and heavy metals: Ca, Na, K, Zn, Mn, Fe, Cu, Cd, Ni, and Pb were measured by Flame atomic absorption spectrometry and the concentrations were expressed as mg.kg^{-1} dry weight as described by **Stewart** (**1974**) and **Page *et al*.** (**1982**).

Statistical analyses

The statistical analyses were performed using SPSS statistical package (SPSS Inc., Version 11.5). Significant differences among treatments were tested by analysis of variance. Least significant differences among means were calculated using Duncan test at the $P \leq 0.05$ probability levels. Means marked by different alphabetical letters are significantly different, whereas those marked by the same alphabetical letter are not significantly different.

Results

Nutritional composition

The proximate nutritional compositions of the five studied species are presented in Table 1. The results indicated high values of moisture, ash, protein, carbohydrates and fibers, while showed low values of total lipids. The moisture contents of dried algal materials were ranged from $10.6 g.100g^{-1}$dwt in *Caulerpa serrulata* to $23.6 g.100g^{-1}$dwt in *Turbinaria* triquetra. Other species had moisture contents more close to *C. serrulata*; the F-ratio was small but showed significant differences among species at high α-level (p-value 0.000). The greatest value in ash was measured as $29.573 g.100g^{-1}$dwt for *Turbinaria triquetra*, while the lowest was 17.057g.100g-1d.wt in *C. serrulata*. The highest value for total protein content were found in *C. serrulata* (14.48 g $100g^{-1}$ dwt), while the lowest value was in *Padina tetrastromatica* (3.87 g $100g^{-1}$ dwt). Total carbohydrate composition and dietary fibers showed the greatest range.

Table (1): Moisture, ash, protein, carbohydrates, total lipids and crude dietary fibers contents, expressed as $g.100g^{-1}$ dry weight, of the investigated algae. Each value is the Mean ± SE Mean of 3 replicates

Algal species	Moisture	Ash	Protein	Carbohydrate	Lipids	Fibers
C. serrulata	10.6^{c} ± 0.25	17.057^{e} ± 0.003	14.48^{a} ± 0.006	45.6^{a} ± 0.003	4.24^{b} ± 0.003	18.6^{e} ± 0.007
D. divaricata	12.58^{b} ± 0.22	26.407^{c} ± 0.009	8.89^{b} ± 0.020	14.6^{e} ± 0.006	10.51^{a} ± 0.009	39.54^{d} ± 0.009
P. tetrastromatica	13.37^{b} ± 0.11	21.207^{d} ± 0.009	3.873^{e} ± 0.009	15.54^{d} ± 0.003	3.92^{c} ± 0.009	55.41^{a} ± 0.003
T. triquatra	23.62^{a} ± 0.42	29.573^{a} ± 0.007	4.133^{d} ± 0.009	16.3^{c} ± 0.006	1.62^{e} ± 0.003	48.3^{b} ± 0.007
S. subrepandum	13.027^{b} ± 0.027	26.757^{b} ± 0.003	4.22^{c} ± 0.006	17.21^{b} ± 0.008	3.83^{d} ± 0.006	47.94^{c} ± 0.006
F-ratio	452.8	563995	171107.5	5315042	264812.4	4786560
p-value	0.000	0.000	0.000	0.000	0.000	0.000

Within the same column, means carrying different superscripts are significantly different from each others.

Dictyota divaricata had the lowest value (14.6 g 100g^{-1} dwt) of total carbohydrate and *C. serrulata* had the highest value (45.6 g 100g^{-1} dwt), while dietary fibers ranged from 55.41 in *P. tetrastromatica* to 18.6 g 100g^{-1} dwt in *C. serrulata*. The lipid content of all species was low especially in *T. triquetra* (1.62 g 100g^{-1} dwt). One species had markedly higher crude lipid content of 10.51 g 100g^{-1} dwt in *D. divaricata*.

Minerals and trace metals

The results in Table (2) showed that sampled algae contained large amounts of Na, Ca, K and Fe. The highest Na measured was 980.7 mg kg^{-1} in *T. triquetra*, while the lowest was 16.4 mg kg^{-1} in *D. divaricate*. The highest Ca measured was 1846.2 mg kg^{-1} in *P. tetrastromatica*, while the lowest was 269.2 mg kg^{-1} in *S. subrepandum*.

Table (2): Major minerals and trace elements measured as mg kg^{-1} in the studied algal species. Each value is the Mean ± SE Mean of 3 replicates

Elements	*C. serrulata*	*D. divaricata*	*P. tetrastromatica*	*T. triquetra*	*S. subrepandum*	F-ratio	p-value
Na	192.86^{c} ±0.001	16.413^{e} ±0.0003	418.548^{b} ±0.004	980.717^{a} ±0.004	172.343^{d} ±0.001	11 E+9	0.000
Ca	573.076^{d} ±0.007	1038.46^{b} ±0.012	1846.153^{a} ±0.021	1003.846^{c} ±0.02	269.23^{e} ±0.003	18 E+8	0.000
K	119.301^{d} ±0.003	73.073^{e} ±0.02	187.902^{c} ±0.003	814.245^{a} ±0.02	368.349^{b} ±0.02	46 E+7	0.000
Cu	1.85^{e} ±0.021	4.69^{d} ±0.003	5.65^{b} ±0.02	4.86^{c} ±0.01	6.52^{a} ±0.01	20 E+4	0.000
Cd	0.78^{d} ±0.01	1.35^{c} ±0.02	4.19^{a} ±0.04	0.69^{e} ±0.01	1.99^{b} ±0.04	37 E+2	0.000
Pb	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Ni	3^{c} ±0.1	4.71^{b} ±0.01	12.98^{a} ±0.01	2.82^{d} ±0.003	2.55^{e} ±0.02	12 E+4	0.000
Zn	13.19^{d} ±0.01	40.7^{a} ±0.1	13.82^{c} ±0.01	10.55^{e} ±0.02	14.69^{b} ±0.01	75 E+3	0.000
Fe	70.02^{d} ±0.01	201.3^{a} ±0.01	128.4^{b} ±0.02	86.97^{c} ±0.01	57.9^{e} ±0.03	11 E+6	0.000
Mn	5.64^{b} ±0.01	1.85^{e} ±0.012	3.54^{c} ±0.01	2.43^{d} ±0.01	6.13^{a} ±0.003	55 E+3	0.000

Within the same raw, means carrying different superscripts are significantly different from each others.

Potassium contents were between 73.0 mg kg^{-1} in *D. divaricate* to 814.2 mg kg^{-1} in *T. triquetra*. *D. divaricate* characterized by high Fe content 201.3 mg kg^{-1}, followed by *P. tetrastromatica* 128.4 mg kg^{-1}, *T. triquetra* 86.9 mg kg^{-1}, *C. serrulata* 70.02 mg kg^{-1}, then by *S. subrepandum* 57.9 mg kg^{-1}. Moderate amounts of Zn (10.6-40.7 mg kg^{-1}) were measured in sampled algae. Low amounts of Cu (1.9-6.5 mg kg^{-1}) and Mn (1.6-6.1 mg kg^{-1}) were measured. Cd was measured as 0.69-1.99 mg kg^{-1} and Ni was 2.8-13 mg kg^{-1}, meanwhile Pb was measured as 0.001 mg kg^{-1} in *P. tetrastromatica* and was absent in the other species.

Discussion

Nutritional composition

The nutritional composition of the five algal species investigated in this study showed considerable variations with high content of ash, carbohydrates, and crude fibers and low content of protein and lipids. The high ANOVA F-tests with p-level below 0.05 indicated significant evidence for such variations. The moisture contents were from 10.6 to 13.37% but *T. triquatra* had very high moisture content of 23.6%. **El-Manawy** (**2008**) found that the moisture ranged from 12.00 to 16.33 g.100g^{-1}d wt for macroalgae communities prevailed in the fringing reefs of Ghardaqah. The present range of moisture is sufficient to avoid the development of microorganisms if these algae are backed for commercial uses. **Mossel *et al*.** (**1975**) mentioned that dried vegetables contain moisture of 12-18% and dried fruits contain 18-25%. Dried seaweeds contained a considerable amount of Na as well as antimicrobial components that also prevent the development of microorganisms.

The coenocytes green alga *C. serrulata*, characterized by high carbohydrate content (45.66g.100 g^{-1}dwt) meanwhile the phaeophycean species had lower contents (14.6-17.26 g.100g^{-1}dwt). The membranous phaeophycean forms such as *D. divaricata* and *P. tetrastromatica* had carbohydrates lower than fleshy ones such as *T. triquatrq* and *S. subrepandum*. **Wong and Cheung** (**2000**), **Aguilera-Moralesa *et al*.** (**2005**) and **El-Manawy** (**2008**) found also high carbohydrates in chlorophycean species and low in phaeophycean algae but their measurements are lower than that found during the present study. Sampled algae contained considerable amounts of ash (17.1-29.6%). The lower value was found in the green species *C. serrulata*, while the brown species contain high ash contents. The obtained ash was comparable to that measured by **El-Manawy** (**2008**) but lower than green algae (20.9%-26%) measured by **Tewari** (**1972**) and **Lahaye and Jegou** (**1992**), and also lower than the brown algae *Macrocystis* *pyrifera* (34.2%) and *Sargassum sinicola* (37.2%) recommended for human consumption by **Manzano and Rosales** (**1989**).

The difference between the nutrient contents of the samples may result from the extraordinary capability of seaweed to accumulate elements present in water (**Carrillo *et al***., **1992**). **Barber and Chavez** (**1983**) pointed out that the difference in environmental factors (ex. temperature) greatly affect the nutrients transported to the surface water and consequently affects the metabolism of marine algae photosynthesis, reproduction, and growth. *C. serrulata* contained highest protein content (14.5%), followed by *D. divaricata* (9%), while the other three species showed low values around 4%. Protein in the samples of *C. serrulata* was similar to that reported by **Tewari** (**1972**) in *Enteromorpha prolifera* (12% to 15%) and to that of cereals like oats (13.3%) (**Morales de Leon *et al***., **2000**). Many publications, e.g. **Portugal *et al***. (**1983**), **Mabeau and Fleuence** (**1993**), **Fleurence** (**1999**) and **Wong and Cheung** (**2000**) found comparable levels of crude proteins in Phaeophyta. Variations in the protein content of seaweeds can be due to different localities, species, and seasonal periods. **Dawes** (**1998**) pointed out that seasonal changes in lipid, carbohydrate, and protein quantities are possible indicators of the physiologic state of the algae.

Wahbeh (**1997**) studied the amino acid and fatty acid profiles from Aqaba on the Red Sea, which could be the nearest to the locality of the present work. He found crude protein that is higher than the present values in Phaeophyta. Sampled algae characterized by low lipid content (1.6-4.2%) but one species *D. divaricata* had a marked higher content of 10.5% from Aqaba on the Red Sea. He also found total lipids of 4.4% in phaeophycean species such as *Padina pavonica*. Where as in **Chapman and Chapman** (**1980**) and **Haroon *et al***. (**2000**) found that lipids are within the range mentioned (1–4%) in many seaweed. The present lipid contents are very low with respect to milk, fish, and meat (**Morales de Leon *et al***., **2000**). The percentage of crude fibers was from 39.5-55.4% in brown algae and thus higher than carbohydrate, while it was 18.6% in *C. serrulata*.

The values determined for crude fibers were high and similar to those reported by **Jimenez-Escrig and Goni-Cambrodon** (**1999**) in green seaweed. Seaweeds contain large amounts of dietary fiber which are particularly rich in the soluble fraction (**Lahaye**, **1991**; **Darcy-Vrillon**, **1993**; **Mabeau and Fleurence**, **1993**). The chemical nature and physico-chemical properties of some common seaweed dietary fibers such as alginates, carrageenans and agars are quite well known, but most seaweed dietary fibers in particular the insoluble types and their physiological effects have still not received much attention (**Wong and Cheung**, **2000**; **Larsen *et al***., **2003**; **Aguilera-Moralesa *et al***., **2005**).

Minerals and trace metals

Marine algae are known to contain the essential minerals needed for human nutrition (**Mabeau and Fleurence**, **1993**; **Ortega *et al*.**, **1993**). The results showed that sampled algae contained large amounts of Na, Ca, K and Fe. All studied species showed highly significant difference in their contents with high F-ratio value. The highest Na measured was 980.7 mg kg^{-1} in *T. triquetra*, while the lowest was 16.4 mg kg^{-1} in *D. divaricate*. The highest Ca measured was 1846.2 mg kg^{-1} in *P. tetrastromatica*, while the lowest was 269.2 mg kg^{-1} in *S. subrepandum*. K contents were between 73.0 mg kg^{-1} in *D. divaricate* to 814.2 mg kg^{-1} in *T. triquetra*. *D. divaricate* characterized by high Fe content 201.3 mg kg^{-1}, followed by, *P. tetrastromatica* 128.4 mg kg^{-1}, *T. triquetra* 86.9 mg kg^{-1}, *C. serrulata* 70.02 mg kg^{-1}, then by *S. subrepandum* 57.9 mg kg^{-1}. Moderate amounts of Zn (10.6-40.7 mg kg^{-1}) were measured in sampled algae. Low amounts of Cu (1.9-6.5 mg kg^{-1}) and Mn (1.6-6.1 mg kg^{-1}) were measured. Cd was measured as 0.69-1.99 mg kg^{-1} and Ni was 2.8-13 mg kg^{-1}, meanwhile Pb was measured as 0.001 mg kg^{-1}in *P. tetrastromatica* and was absent in the other species. These differences could be related to the capacity of each alga to accumulate minerals and to environmental conditions (**O'Kelley**, **1974**; **Rodriguez**, **1995**; **Meza**, **1998**). Publications such as **Abbas *et al***. (**1992**), **Basson and Abbas** (**1992**) and **Rizvi *et al***. (**2001**) indicated that marine seaweeds contained high amounts of Na, K, Ca, Mg, Fe, Zn, Mn, and Cu. **Basson and Abbas** (**1992**) studied the mineral composition of algal species from Bahrain including *D. divaricate* and *S. boveanum*. These species contained Ca, K, Fe, Mn, and Ni contents higher than the present study and had lower content of Cd.

Robledo and Pelegrin (**1997**), **Rizvi *et al***. (**2001**) and **Takeshi *et al***. (**2005**) detect higher values for all minerals than the present data in related species. **Prasada Rao *et al***. (**1984**) studied mineral composition of algal species from India including *P. tetrastromatica* that contained values, for all minerals, lower than the present study. The same results were obtained by **Heiba *et al***. (**1990**), **Kureishy** (**1991**), **Manivannan *et al***. (**2008**), and **Karthikai *et al***. (**2009**) which detect lower mineral content in related species. It is observed that all these reports contain higher values of Pb, while it has not been detected in the current studied specie. The importance of mineral elements in human, animal and plant nutrition has been well recognized (**Underwood**, **1971**; **Darby, 1976**). Deficiencies or disturbances in the nutrition of an animal cause a variety of diseases and can arise in several ways (**Gordon**, **1977**). When a trace element is deficient, a characteristic syndrome is produced which reflects the specific functions of the nutrient in the metabolism of the animal (**Simsek and Aykut**, **2007**).

The present studied algae appeared to be a potential source for mineral supplements, especially when compared to the recommend daily allowance established by the USA FDA (Food and Drug Administration) and introduced by **Soetan *et al*.** (**2010**). The recommend daily allowance is 1500 mg Na, 1000 Ca, 2000-5000 K, 1.5-3 mg Cu but 10 mg may become toxic, 11-15 mg Zn, 18 mg Fe, and 2.5-5 mg Mn. The functions of minerals have been given for Ca, Na, K, Cu, Zn, Fe and Mn (**Hays and Swenson**, **1985**; **Chandra**, **1990**; **Szabo *et al*.**, **1999**; **Beard**, **2001**; **Tan *et al*.**, **2006**).

The Food and Drug Administration (FDA) declared that the long term exposure to Cd, Ni and Pb are toxic (**Soetan *et al*.**, **2010**). In the present study, Cd was measured as 0.69-1.99 mg kg^{-1} and Ni was 2.8-13 mg kg^{-1}, meanwhile Pb was measured as 0.001 mg kg^{-1} in *P. tetrastromatica* and was absent in the other species. Although cadmium is known to be toxic element with no biological role, some investigations have shown cadmium as enzyme activator at low dosages (**Lane and Morel**, **2000**). **Lozano *et al*.** (**2003**) studied the cadmium and lead in certified reference materials and found that the mean value was 5, 11.21 mg kg^{-1} respectively and indicated that high calcium intake can partially protect against cadmium assimilation. Zinc, selenium, iron and vitamin C can also help to increase cadmium excretion. Pectin and other fibers can reduce cadmium absorption, and a high protein diet is useful in reducing cadmium retention (**Zhao *et al*.**, **2005**).

Nickel may play a role in the maintenance of membrane structure, control of prolactin, nucleic acid metabolism or as a cofactor in enzymes. **Cabrera-Vique *et al*.** (**2011**) studied the nickel content of 170 food samples and detect nickel levels rang from 18.5 to 95 mg kg^{-1} and showed that the probability of exposure to health risks from these foods is overall small. **Uthus and Poellot** (**1996)** found that consuming of nickel up to 100mg per day is safe. Lead is considered as toxic metal and can cause a lot of health risks (**Soetan *et al*.**, **2010**). Many researches detect Pb in seaweeds in high values that may reach up to 55.9 ppm (**Robledo and Pelegrin**, **1997**; **Rizvi *et al*.**, **2001**; **Takeshi *et al*.**, **2005**).

Conclusion

The five algal species are considered a potential source of nutrition and mineral supplements. However, the nutritional composition of the seaweeds obtained here was based on chemical analyses only. Biological evaluation using human and animal feeding studies would be required to establish the nutritional value of these seaweeds, particularly the in vivo protein digestibility and bioavailability of the essential amino acids.

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تقدير القيمة الغذائية والأملاح المعدنية فى خمس أنواع من ا لأعشاب البحرية الموجودة في البحر الأحمر

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قدرت القيمة الغذائية فى المواد الجافة لخمس أنواع من الطحالب البحرية جمعت من البحر الأحمر وذلك في شتاء 2008. واشتملت على طحلب كوليربا سريولاتا من الطحالب الخضراء وعلى أربعة من الطحالب البنية هى دكتيوتا داى فريكاتا ، بادابنا تتراسترروماتيكا ، سرجاسيوم سبريياندوم ، تربيناريا تريكواترا. وقد كان مجموع الألياف الغذائية هو الأكثر ارتفاعا فى تلك الطحالب حيث تراوح بين 18.6٪ إلى 55.4٪ من المادة الجافة ، وتلى ذلك محتوى الرماد الممثل للمعادن الغذائية فبلغ 17.1 الي 29.6 جم لكل 100 جم من المادة الجافة و محتوى الكربوهيدرات الذى تراوح من14.6 الي 45.6 جم لكل 100 جم من المادة الجافة. تساوى محتوى البروتين فى الطحلب الأخضر مع ذلك الموجود بالحبوب كالقمح والذرة بينما قل فى الأنواع البنية فبلغ 9٪ فى الدكتيوتا وقل إلى مايقرب من 4٪ فى الثلاثة أنواع الأخري. تراوح مستوى الدهن من 1.6٪ إلى 4.2٪ فى أربعة أنواع بينما بلغ 10.5٪ فى الدكتيوتا. بلغت محتويات الرطوبة من 10.6 إلى 13.37٪ فى اربعة أنواع بينما تميزت التربيناريا برطوبة مرتفعة بلغت 23.6٪. اظهرت النتائج احتواء الطحالب علي كميات عاليه من الصوديوم والكالسيوم والبوتاسيوم والحديد ونسبة متوسطة من عنصر الزنك بينما سجلت عناصر النحاس والكادميوم والمنجنيز والنيكل نسب اقل مقارنتاً بباقي العناصر و في الوقت نفسه سجل عنصر الرصاص نسب ضئيله جداً (0.001 جزء في المليون) وذلك في طحلب البادابنا فقط بينما كان غائبا في باقي الانواع. وقد اظهرت النتائج ان الطحالب الخمسة تعد مصدر للغذاء و الاملاح المعدنية مما يعطيه ميزة غذائية تدفع العاملين فى مجال التغذية على استخدام هذه الطحالب فى غذاء الإنسان وعلف للحيوان.