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The Seaweeds of Persian Gulf: A Potential Sources of Mineral

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Abstract: Marine macroalgae is one of the important sources of medical and nutrition materials in the world. Mineral content (Ca Mg, Mn, Fe, Cu, K, Zn and) of eight species of macroalgae including one green, one brown and six red seaweeds from intertidal areas of Persian Gulf were determined. The levels of minerals were 1107-2810, 327.2-1163.3, 300.4-463.5, 108.7-226.11, 2.14-4.34, 2.68-36.81, 2.42-4.93, 1.67-3.82, 0.12-1.03 and 1.64-3.93 μg g^{-1}dw for Ca, K, Mg, Fe, Mn, Zn, Cu, Pb, Cd and Ni, respectively. This study showed that seaweeds can be a potential source of plant minerals owing to their high levels.

Key words: Nutritional composition · Minerals · Seaweed · Persian Gulf

INTRODUCTION

Seaweeds are among important marine living resources in the world. These macroalgae have been a source of food, feed and medicine in the east as well as in the west, since ancient times [1, 2]. Marine algae distributed in the Persian Gulf especially around seashore of Bousheher and Hormozgan provinces in the south of Iran. Although the seaweed biomass and diversity in the Persian Gulf are rich, they are under-utilized [3]. In Asian countries, seaweeds are consumed as marine vegetable. However, most of people of Iran are not aware that the seaweeds can be used as human foods. Rarely seaweeds are used as animal feeds or fertilizers by the coastal villagers. Compared to land plants, the chemical composition of seaweeds has been poorly investigated and most of the available information only deals with traditional Japanese seaweeds [4, 5].

To grow interest on marine algae, knowledge on biochemical and chemical composition and its nutritive value is essential. The high mineral contents of marine macroalgae make them nutritionally valuable [1, 2]. So far, there is no published study on nutritional composition of the Persian red algae. Therefore, the present research analyzed the biochemical and minerals composition of some marine dominant red macroalgae in the northern part of the Persian Gulf.

MATERIALS AND METHODS

Eight representative species of seaweeds including the Chlorolhyceae (green algae one species), Rhodophyceae (red algae six species) and Phaeophyaceae (brown algae one species), were sampled in the northern part of the Persian Gulf in 2008. Samples were transported to the laboratory in insulated containers (Table 1). Samples were identified to genus and species base on examination of morphological and anatomical characteristics and using taxonomic references [6, 7]. Collected seaweed were washed with clean seawater and freeze- dried on a 5 L Holler freeze drier, then milled to particle size of less than 1.0 mm and kept in air-tight glass jars in a refrigerator at 4°C. All chemical experiments were conducted in triplicate on dried material weighed on MELON balance with readability to 0.1 mg. All values were reported relative to the dry weight of the marine algae. Mean values and standard deviation (SD) of the samples were calculated.

Metal concentration of the seaweed were obtained through a variety of extraction methods, however we used the digestion of algal tissue by HNO_3 and concentrated hydroxide [8]. Major mineral element (Ca, K, Mg) and trace element (Fe, Zn, Mn, Cu, Cd, Ni, Pb) were determined using a Varian 10 Plus Atomic Absorption Spectrophotometer with an air-acetylene burner. Standards of mineral elements were obtained from Merck.

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Table 1: The species names and collection areas of eight marine algae from the Persian Gulf.

No	Order	Family	Species	Collection areas
1	CHLOROPHYTA	CAULERPACEAE	Caulerpa sertulariodes (S.G.Gemelin) Howe	Boushehr (Helileh)
2	PHAEOPHYTA	SCYTOSIPHONACEAE	Colpomenia sinuosa (Mertens ex Roth) Derbes	Boushehr (Havaei)
3	RHODOPHYTA	RHODOMELACE	Acanthophora spicifera (Wufen) Harvy	Hormozgan Lengeh Port
4	RHODOPHYTA	CHAMPIACEAE	Champia parvula (C. Agardh) Harvey	Boushehr Kharko Islands
5	RHODOPHYTA	CORLINACEAE	Hypnea cervicornis J. Agardh	Hormozgan Lengeh Port
6	RHODOPHYTA	GERACILARIACEA	Gracillaria corticata (J. Agardh)	Boushehr (Abshrin kon)
7	RHODOPHYTA	RHODOMELACEAE	Jania rubens (Linnaeus) lamourox	Boushehr Kharko Ilands
8	RHODOPHYTA	RHODOMELACEAE	*Laurencia papillosa* (C.Agardh) Grevill	Hormozgan, Lengeh Port

Statistics: The results were expressed as means with standard deviation (SD). All statistical analysis was performed using the SPSS software package, version 11.5 (SPSS Inc. Chicago). Differences were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

Dietary Elements: Mineral concentration in eight seaweeds from Persian Gulf showed significant difference among the species (Table 2). Degree of accumulation varies between the essential metals like calcium, potassium, iron and manganese were the most abundant essential elements and cadmium and plumb and nickel were present in low concentrations in all species tested. Metals concentrations can be ranked according to their mean concentration in following decreasing order: Ca>K>Mg>Fe>Zn> Cu > Mn >Ni>Pb>Cd. This order maybe reflects the concentration of these metals in the water. The mean concentration of macro elements such as Ca, Mn, K were high in the marine algae. The lowest level of Ca was observed in red macroalgae ($1107\pm 88 \mu g.gdw^{-1}$). As expected, Ca showed the highest concentrations and the widest range in Rhodophyata studied the highest level was in *Jania rubens* ($2810\pm 84 \mu g\ gdw^{-1}$). Concentrations of Ca within genera were different. The total Ca contents in different algae species following this pattern: red algae >brown algae> green algae. Sanchez-Rodriguez *et al.* (13) reported particularly high Ca values in different species of macroalgae which in line with our studies. The concentration in *Padina durvialli and Laurencia papillosa* was two times higher than in our studies (13).

Within the Chlorophyta, Phaophyta and Rhodophyta, *A. spicifera* contained the highest potassium content ($1163.3\pm51 \mu g\ g^{-1}$ dry weight) while *J. rubens* the lowest ($327.2\pm14.3 \mu g\ g^{-1}$ dry weight). Bryan (14) stated that trace metals concentrations in the macroalgae are directly related to their concentrations in the surrounding water. Among all the 10 minerals analyzed in eight seaweed species Ca and Cd were found to be highest and lowest, respectively. The total K concentration in the algae species showed following pattern: red algae > green algae > brown algae (Table 2, Figure 1).

Among the red algae, *J. rubens* was found to be richest in Mg ($463.7\pm16.4 \mu g\ g^{-1}$ dry weight) and the lowest was in green algae *C. sinuosa* ($324.9\pm14.3 \mu g\ g^{-1}$ d.w.). Mg concentration in green and red algae was reported higher than the present study (15, 9) .The total Mg concentration in the algae species showed following pattern: red algae > green algae > brown algae.

Table 2: Average concentration (Mean±SD) of metals ($\mu g.gdw^{-1}$) in the seaweed analyzed.

Species	*C. Sertulariodes*	*C. sinuosa*	*A. spicifera*	*C. parvula*	*H. cervicornis*	*G. corticata*	*J. rubens*	*L. papillosa*
Groups	Chlorophta	Phaophyta	Rhodophyta					
Ca	1107.4±88	1602.7±34	2039.3±75	1259.4±39	1848±69	2039±76	2810±84	1206±39
K	733±31.40	385.9±19.2	1163.3±51	491.4±19.1	514.8±21.2	1163±31	327.2±14.3	843.4±21.6
Mg	388.8±12.4	324.9±14.3	375.4±13.5	334.7±9.40	424.7±21.6	375.5±13.1	463.7±16.4	300.4±12.8
Fe	189.5±9.4	156.4±5.2	200.7±11.2	124.4±8.1	226±11.7	200.7±7.9	153.5±8.7	108.7±5.1
Mn	4.62±1.21	2.99±0.73	4.34±1.21	2.14±0.85	4.07±1.20	4.34±0.33	2.33±0.27	3.56±0.52
Zn	6.38±1.93	7.07±1.69	2.68±0.38	4.46±0.87	7.68±1.1	2.68±0.19	4.41±0.83	36.81±2.3
Cu	2.37±0.58	3.87±0.68	2.42±0.47	2.52±0.56	4.93±0.92	2.42±0.38	3.06±0.25	3.20±0.64
Pb	3.82±0.09	2.0±0.55	2.53±1.21	1.99±0.94	2.08±0.63	1.67±0.58	1.84±4.19	2.86±1.46
Cd	1.03±0.93	0.19±0.14	0.14±0.05	0.10±0.03	0.13±0.07	0.12±0.10	0.14±0.68	0.25±0.19
Ni	2.49±0.43	3.70±1.37	2.61±1.29	2.71±1.39	1.64±0.48	2.98±0.64	2.27±0.79	3.93±0.83

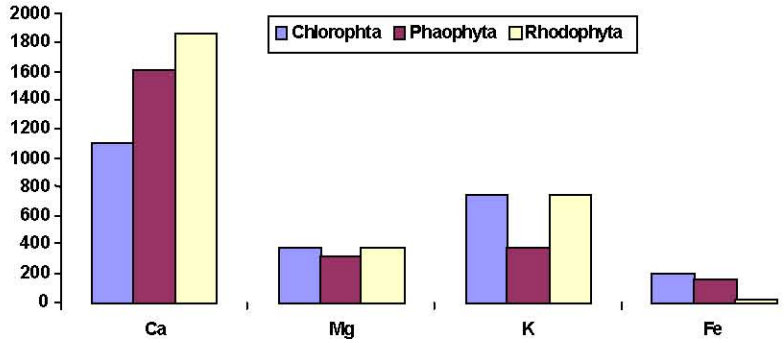

Fig. 1: Mean concentration (μg g^{-1} d.wt) of essential mineral elements plus iron in eight macroalgae of Persian Gulf.

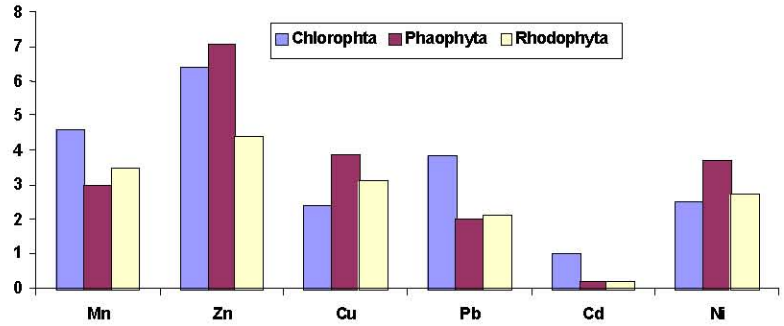

Fig. 2: Mean concentration (μg g^{-1} d.wt) of trace elements in eight macroalgae of Persian Gulf.

Concentrations of iron among the red and brown algae were lower than the range from literatures (13). The particularly high iron values in our results belong to species in the Persian Gulf never examined before. Comparison with the literatures indicates that Fe concentration in present study was lower form Loreto Bay in Mexico, Yemaen and Hawaei seaweed (13, 16). The total Fe concentration in the marine macroalgae showed following pattern: red algae > green algae > brown algae. The mean concentration of manganese in the green *algae C. sertulariodes* was 4.62±1.21 in brown algae *C. sinuosa* was 2.99±0.73 but in red algae ranged from 2.14±0.85 in *C. parvula* to 4.34±1.21 in *G. corticata*. Ruprez (15) reported the concentration of Mn in brown algae (Fecus 5.5±0.1 μg g^{-1}dw) was higher than our study but red algae was lower (Chondrus and Nori <0.5 μg g^{-1}dw). The total Mn accumulation in different algae species following this pattern: green algae >red algae >brown algae (Figure 2).

The mean concentration of cadmium in the green *algae C. sertulariodes* was 1.03±0.93 and in brown algae *C. sinuosa* was 0.19±0.14 but in red algae ranged from 0.10±0.03 in *C. parvula* to 0.25±0.19 in *L. papillosa*. The smallest mean concentration was in Cholorophyta and the greatest was observed in Rhodophyta. The total Cd accumulation in different algae species following this pattern: green algae > red algae>brown algae (Figure 2).

Mn and Cd show exceptionally high values but still lower than values reported from polluted areas in the Persian Gulf (17). Most of the trace elements present in the seaweed biomass are heavy metals (Cd,Ni,Pb,Zn,Cu), but their content is generally were below the toxic limits allowed in several countries (18). It emerge that red and brown algae have average concentration two times higher than green algae for all the metals (table 1).The variability of trace elemental composition of the algae within the groups was great. In green algae the mean concentration order of trace metals can be ranked following decreasing order Fe>Zn> Pb >Cu>Ni >Cd. In brown algae the mean concentration order of trace metals can be ranked following decreasing order Fe>Zn> Cu > Ni > Pb >Cd. In red algae, metals concentrations can be ranked according to their mean concentration in following decreasing order: Fe>Zn> Cu Pb > >Ni >Cd. Maximum amount of copper plus Zinc content allowed in macroalgae for human consumption in Japan and France (1.5-10 mg/100 g) was lower than Persian Gulf seaweed (18).

Apart from variations in algal mineral composition it is difficult to compare the value obtained in this study with the literature because of the mineralization method employed which are often omitted. Ruperez [15] reported the levels of major mineral elements(Mg and K) of 420, 732 and 3184 μg /100g dry weight in Chondrus (red

seaweeds), respectively. The levels of Ca, Mg and K in Wakame (brown seaweed) were 931, 1181 and 8699 mg/100g weight, respectively. The levels of major elements in this study showed that K content was less than those. Concentrations of most major elements of red seaweeds from Persian Gulf were similar to those reported for congener species in other studies [10, 11]. However, K content recorded in the Persian Gulf red seaweeds were less than present study. *A. spicifera* and Gracilaria species were higher than values reported in this study.

The concentration of trace elements varied among the red seaweeds from the Persian Gulf. Nabil and Rushdi, [12] reported that iron, zinc, manganese and copper contents in *G. foliifere* were 41.2, 6.35, 8 and copper 9.83 µg/100g dry weight, respectively. In present investigations iron contents of *G. corticata* was not higher than value reported by Nabil and Rushdi, [12]. The concentrations of Zn in the present study were higher than those from the Yamen coast; the concentrations were approximately two times lower for Zn. Fe, Cu, Mn and Zn in *Caulerpa racemosa*. In present study the concentrations of Cu, Mn and Zn were lower but the concentrations of Fe were approximately two times higher than Yemen seaweeds [12]. The high concentration of heavy metals support the suggestion that marine macroalgae could be a principal partner in the recycling of trace metals in coastal waters beside their role as substantial metal buffers in the ecosystem (19).

In conclusion, the eight seaweeds analyzed for their food compositions were found to be the potential sources of mineral supplements. The results of the present study concluded that these seaweeds can provide dietary alternatives due to improve the nutritive value of the human diet. Further study needs to be done on the utilization and sensory perceptions of these seaweeds.

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