Nutritional composition of seaweeds from the Northern Persian Gulf

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Seaweeds are one of the 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 (Chapman and Chapman, 1980; Arasaki and Arasaki, 1983). Marine algae distributed in the Persian Gulf especially around seashore of Busheher and Hormuzgan provinces in the south of Iran. The nutritional properties of the Persian Gulf seaweeds are not completely known yet, and they are usually estimated from their chemical composition alone. Although the seaweed biomass and diversity in the Persian Gulf are rich, they are under-utilized (Sohrabipor et al., 2004). 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 (Watanabe and Nisizawa, 1984; Nisizawa et al., 1987). To grow interest on marine algae, knowledge on biochemical and chemical composition and its nutritive value is essential. Marine macroalgae are good sources of protein, carbohydrate and fat. Seaweeds in general contain a large amount of carbohydrates (Darcy–Vrillon, 1993; Lahaye and Kaeffer, 1997). So far, there is no published study on nutritional composition of the Persian Gulf algae. Therefore, the present research analyzed the biochemical composition of some marine dominant macroalgae in the northern part of the Persian Gulf.

In this research, eight representative species of seaweeds including the Chlorophyceae (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 (Table 1). Samples were identified to genus and species based on examination of morphological and anatomical characteristics, and using taxonomic references (Magruder, 1988; Sohrabipor and Rabiei, 1996). 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, except in ash determination for which five replications was used. All values were reported relative to the dry weight of the marine algae. Mean values and standard deviation (SD) of the samples were calculated.

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	Bushehr (Helileh)
2	PHAEOPHYTA	SCYTOSIPHONACEAE	*Colpomenia sinuosa* (Mertens ex Roth) Derbes	Bushehr (Niro Havaei)
3	RHODOPHYTA	RHODOMELACE	*Acanthophora spicifera* (Wufen) Harvy	Hormozgan Lengeh Port
4	RHODOPHYTA	CHAMPIACEAE	*Champia parvula* (C. Agardh) Harvey	Bushehr Kharko Island
5	RHODOPHYTA	CORLINACEAE	*Hypnea cervicornis* J. Agardh	Hormuzgan Lengeh Port
6	RHODOPHYTA	GERACILARIACEA	*Gracillaria corticata* (J. Agardh)	Bushehr (Abshrin kon)
7	RHODOPHYTA	RHODOMELACEAE	*Jania rubens* (Linnaeus) lamourox	Bushehr Kharko Island
8	RHODOPHYTA	RHODOMELACEAE	*Laurencia papillosa* (C.Agardh) Grevill	Hormuzgan, Lengeh Port

Residual moisture content was determined by drying to a constant weight at loss in an oven at 80 °C. Ash contents of seaweeds were determined by heating the samples for 4h at 500°C following the Association of Official Analytical Chemists (AOAC, 1995). Ashes were quantified gravimetrically. Total protein content of marine algae was, determined using the Lowry method (Lowry, Rosebrough et al., 1951; Harrison and Thomas, 1988). The samples were digested in 1N NaOH, and then allowed to react with an alkaline copper citrate solution and reagent to measure protein concentration colorimetrically based on absorption at 660 nm in a Perkin Elmer V100, and compared to a bovine serum albumin standard. To evaluate total lipid content, lipid were extracted from the sample with 2:1 chloroform/ methanol (Floch et al., 1957).

In the present investigation, the percentage of ash was 41.37±0.53 and 38.77±0.97 in green seaweed and brown seaweed, respectively. Significant variation ($p<0.05$) was observed in ash content in red seaweed (Figure 1). The highest content of ash was observed in *Acanthophora spicifera* (44.5±1.5) and the lowest was in *Jania rubens* (31.47±0.99). The moisture content of the Persian Gulf marine algae ranged from 75.5 to 97.41%.

The highest soluble carbohydrate was measured in red seaweed *Gracillaria corticata*

(41.72%) and the lowest was in brown seaweed *Colpomenia sinuous* (11.3%) (Figure 2). Carbohydrate concentration in the red algae was higher than green and brown algae. Among the red algae, the highest value was in *G. corticata* and the lowest was in *A. spicifera.*

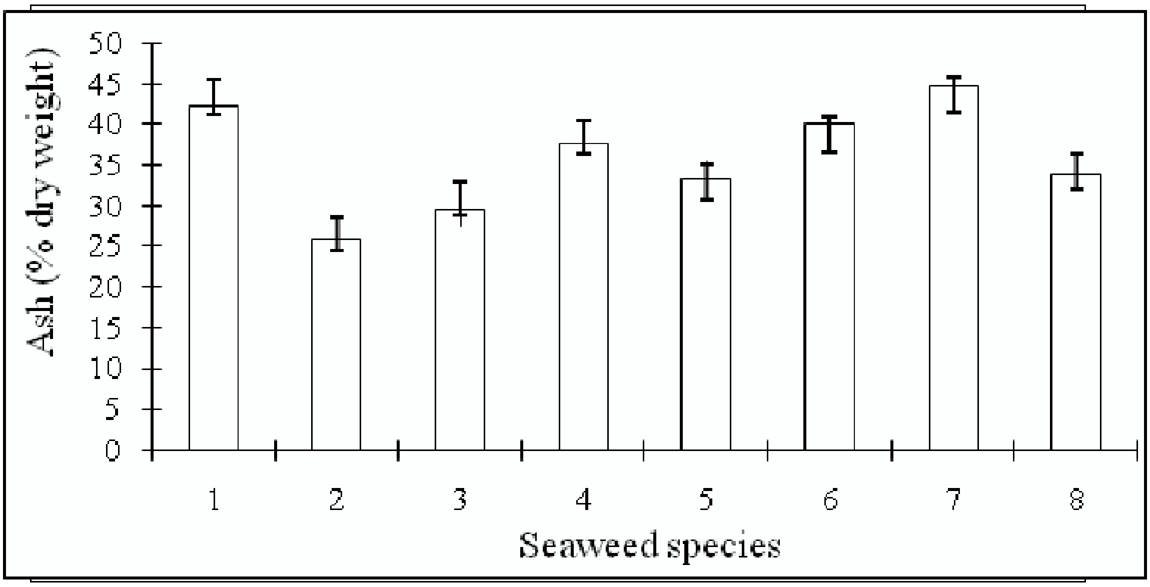

Figure 1. Mean ash content (%dry weight) of eight Persian Gulf seaweed (Mean ±SD; n=3).
Seaweed species: 1: *Caulerpa sertulariodes; 2: Colpomenia sinuosa; 3: Acanthophora spicifera; 4:Champia parvula; 5: Hypnea cervicornis; 6: Gracillaria corticata; 7: Jania rubens; 8: Laurencia papillosa.*

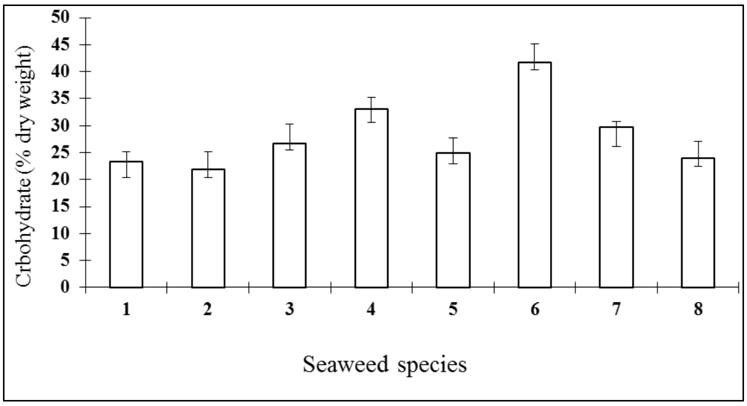

Figure 2. Mean soluble carbohydrate (%dry weight) of eight Persian Gulf seaweed (Mean ±SD; n=3).
Seaweed species: 1: *Caulerpa sertulariodes; 2: Colpomenia sinuosa; 3: Acanthophora spicifera; 4:Champia parvula; 5: Hypnea cervicornis; 6: Gracillaria corticata; 7: Jania rubens; 8: Laurencia papillosa.*

Total protein content ranged from 15.8±0.86 and 7.49± 0.51 in *Champia parvela* and Acanthophora, respectively (Figure 3). The protein content were 12.3±0.73 and 9±0.15 in green algae (*Caulerpa sertulariodes*) and brown algae (*Colpomenia*), respectively. The mean percentages of crude lipid in all marine algae were low. The percentage of lipid was 2.82±0.24 and 2.94± 0.45 in green and brown seaweeds, respectively. Lipid contents in red algae were 16±0.45% and 1.88±0.26% in *Gracillaria corticata* and *Jania rubens,* respectively (Figure 4).

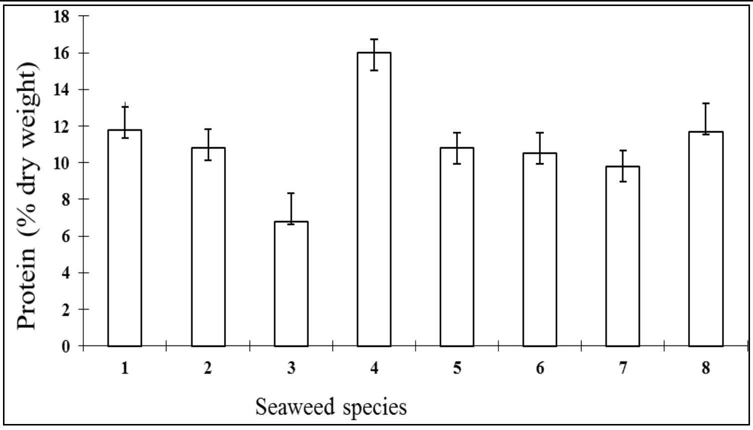

Figure 3. Total protein content in eight marine algae from the Persian Gulf. (Mean ±SD; n=3)
Seaweed species: 1: *Caulerpa sertulariodes; 2: Colpomenia sinuosa; 3: Acanthophora spicifera; 4:Champia parvula; 5: Hypnea cervicornis; 6: Gracillaria corticata; 7: Jania rubens; 8: Laurencia papillosa.*

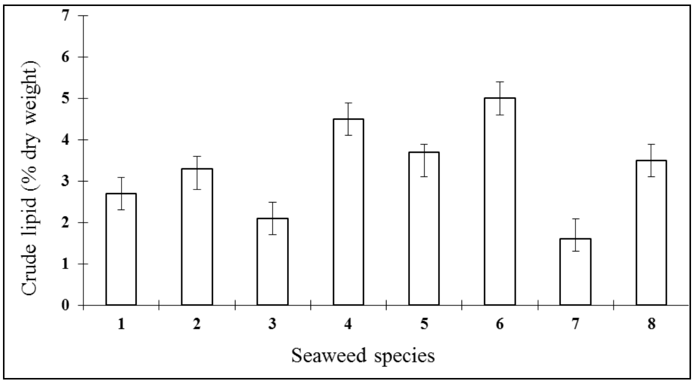

Figure 4. Crude lipid content of eight marine algae from the Persian Gulf (Mean ±SD; n=3).
Seaweed species: 1: *Caulerpa sertulariodes; 2: Colpomenia sinuosa; 3: Acanthophora spicifera; 4:Champia parvula; 5: Hypnea cervicornis; 6: Gracillaria corticata; 7: Jania rubens; 8: Laurencia papillosa.*

Nutritional and biochemical values of different seaweed have been studied by many researchers (Fleurence and Coeur, 1993; Ortega-Calvo etal., 1993; Rizk, 1997). On average, ash (mineral) was high in marine macroalgae (8-40%) (Rizk, 1997). USDA (2001) reported that ash content of the land vegetable (5-10g 100gdw^{-1}) is less than marine algae (40-80g 100gdw^{-1}). In the present research, ash ranged from 25.3 -44.7 g.100gdw^{-1} in red algae (*Janina rubens*). Ash values for seaweed species from Persian Gulf were similar to values for non-calcified species reported by other studies. However, brown algae *Colpomenia sinuosa* had higher ash content compared to that reported for most other *Colpomenia* populations (Portugal et al., 1983; Darcy-Vrillon, 1993; Fan et al., 1993; Kennish Williams, 1997). Similarly, the ash values for red algae (*Gracilaria* species) were higher than the published values for the same species from other parts of the world (Burkholder et al., 1971; Portugal et al., 1983; Fan et al., 1993; Robledo et al., 1997; Norziah and Ching, 2000). The protein content of marine algae varied among the species (Fleurence et al., 2002). Ratan and Chirapar (2006) reported that the protein fraction of green seaweed (*Caulerpa lentillifera* and *Ulva* *reticulata*) were 12.49 and 21.6 g/100g dw, respectively. Ito and Hori (1989) reported low protein content (3-15% dw) in brown seaweed and high protein content (10-47% dw) in green and red marine algae. The red seaweeds are interesting potential source of food protein. High protein levels and amino acid composition were found in the red seaweed (Fleurance, 1993). The use of algae with high protein levels in production of feeds for farmed fish and plants manner could be the good application of this marine algae resource. The mean percentages of protein values in this study were higher than the mean value (7.47%) in the red seaweed from Pakistan (Akhtar and Sultana, 2002), but lower than what reported from Chili (29±04%) (Colombo et al., 2006). In green algae the mean value was lower than the value (18.7%) from Pakistan seaweed (Akhtar and Sultana, 2002).

In this study soluble carbohydrate was calculated as carbohydrates content of marine algae. Arasaki and Arasaki (1983) stated that carbohydrates comprise 50–60% of the dry weight of seaweeds. This study found carbohydrates concentrations ranging from 4.5–39.9% dw. Similarly, Kennish and Williams (1997) reported 8.1–33.7% dw soluble carbohydrates in *Enteromorpha*, *Ulva* and *Porphyra*. Akhtar and Sultana (2002) reported carbohydrates concentrations of 32.9% in *Caulerpa*, 49.1% in *Colpomenia* and 32.3% in *Sargassum*. In present investigation soluble carbohydrate in *Caulerpa* and *Colpomenia* were lower than those reported by Akhtar and Sultana (2002). Macdermid and Stuercke (2003) reported soluble carbohydrate of 11.8, 15.2, and 16.0 in *Caulerpa*, *Gracilaria* and *Laurniaca*, respectively. Seaweeds are known to possess low levels of lipids (Arasaki and Arasaki, 1983; Darcy-Vrillon, 1993). A variety of methods have been used to assay total lipids, crude lipids, fats, or the 'ether extract' of seaweeds. Meaningful comparisons can only be made with results from studies that utilize the same procedures. In this study most of seaweed consistently contained less than 5% d.wt crude lipid. Colombo et al. (2006) reported that total fat in seaweed ranged from 2.8-33.0 mg g^{-1} dw which was highest amongst the published reports. Aguilera-Morales et al. (2005) found 2.24 % fat in *Entromorpha* spp. Macdermid and Stuercke (2003) found 2.4-2.9 % fat in *Gracilaria* spp. 2.1% dw in *Laurencia* spp. . The total lipid in *Caulerpa* was found to be 2.7% dw which is in the range of total lipid content for most seaweed as reported by Mabeau and Fleurence (1993). The percentages of fat in *Gracilaria* determined in this study agree with the result of Macdermid and Stuercke (2003). The total fat in *Colpomenia sinosa* found to be 3.1% which is agree with the result of the total fat in *Colpomenia* (3.15%). Hong and Hien (2004) found 2.3, 1.7, 1.0 and 1.9 % dw of lipid in *Caulerpa laurnica*, *Gracilaria and Hypnea*, respectively. In the present investigation, total lipid was lower than in *Caulerpa* but in line with *Laurnica*, *Gracilaria* and *Hypnea*.

In conclusion, the eight seaweeds analyzed for their nutritional compositions were found to be interesting potential sources of plant food proteins, carbohydrate and fat owing to their high levels. 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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