# Asian Journal of Scientific Research

ISSN 1992-1454

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Asian Journal of Scientific Research 1 (2): 166-170, 2008
ISSN 1992-1454


# Mineral Content of Some Seaweeds from Sabah's South China Sea

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**Abstract:** The mineral content of some species *Caulerpa*, *Ulva*, *Sargassum*, *Eucheuma*, *Gracilaria*, *Gelidiella* and *Kappaphycus* was investigated. These are the major variety of seaweeds available in Sabah South China Sea (Malaysia) and contained high proportions of ash content (20.56- 40.5%). The green and brown seaweeds ash content (37.27-40.5%) was higher than the red seaweeds (20.56-22.41%). The iron content was rich in the sequence of *Gelidiella*>*Caulerpa*> *Sargassum*> *Euch*euma and its range was found to be 6.6-10.94 mg/100 g dry weight. The major seasonal deviation was found to be 9.25% Mg, 6.44% Ca and 5.3% Fe. This study was conducted to create a nutritional data for consumption and utilization in the industry.

**Key words:** Marine algae, nutritional composition, elemental analysis, seaweed

## INTRODUCTION

The seaweeds are used as animal and human food, soil manure, salt extractions (soda, iodine, etc.), colloid production (agar, alginates, carrageenan, furcellaran, etc.), cosmetics and pharmaceuticals. These represent an important economical resource mostly in the south East Asia countries where they are not only largely harvested but also intensively and largely employed in the human nutrition (Ruperz, 2002). Some seaweeds are used or indicated as an appropriate biomonitors to study the enviroument contamination (COST 48, 1987, 1989; Munda and Hundnik, 1991; Haritonidis and Malea, 1995; Malea and Haritonidis, 1999a,b; Caliceti *et al*., 2002 ). Seaweed crop was also used for nutrient and contaminant abatement (Croatto, 1982; Morand and Briand, 1996).

Sabah and Sarawak are two states in East Malaysia, which have a great potential for seaweed cultivation. There are several seaweed species found growing naturally on reefs of Semporna area, south of Sabah and in Banggi Island of the South China Sea and in Kudat area, in north Sabah. The major seaweed genera are *Sargassum*, *Eucheuma*, *Caulerpa*, *Gracilaria*, *Hypnea*, *Padina* and *Hydroclathrus* (McLachlan *et al*., 1972). Among these *Gracilaria changgi* and *Eucheuma* mainly serve as a raw material from which agar or carrageenan is extracted out for use in the food industries or in the production of tissue culture media (Glickman, 1987; Jahara and Phang, 1990; Bradford and Bradford, 1996). Reports on certain edible seaweed showed that they contain significant amounts of protein, vitamins and mineral essential for human nutrition (Jensen, 1993; Noda, 1993; Oohusa, 1993). People living in the coastal areas extensively consume fresh and dried seaweeds. The nutrients composition of seaweed varies and is affected by species, geographic area and season of the year and temperature of water (Jensen, 1993). These seaweeds are of nutritional interest as they are low calorie food, but rich in vitamins, minerals and dietary fibers (Ito and Hori, 1989; Chapman and Chapman, 1980). The minerals from seaweeds are useful in enhancing the metabolic reactions (enzymatic regulation of lipid, carbohydrate and protein metabolism). Magnesium is an important element in cardiovascular function.

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The microelements like Zn and Cu improve the catalytic, structural and regulatory functions stabilize membranes, hormones and nucleic acids. These also improve the blood clotting, energy conversion, pigmentation of hair, skin and eyes and had a possible economic relevance (Levine, 1984; Phillips, 1995; Moy and Walday, 1996).

The objective of this research was to investigate the mineral elemental content of seaweeds obtained from Sabah's South China Sea.

## MATERIALS AND METHODS

### Materials

Seven types of seaweed samples were collected from Kota Kinabalu (Sabah, Malaysia) market and other places in Sabah: *Caulerpa*, *Ulva*, *Sargassum*, *Eucheuma*, *Gigartina Gracilaria* and *Kappaphycs*. The samples were collected in the month of January and July 2004, two times in a year. There seaweeds were cut into small pieces and vacuum dried (Model 282A, Cole-parmer, USA) at 60°C then milled to partial size less than 1.0 mm and kept in airtight plastic bottle at room temperature until analysis. All determinations were performed at least in triplicate and data reported on a dry matter basis. All the reagents used were analytical grade of Merck Standard Solutions (Germany) and Fisher Chemicals (UK).

### Estimation of Ash Content

Homogenized seaweed sample of 25 g was taken and it was made to undergo drying in a thermo regulated incubator at 70°C over night. Removal of the organic matter was carried out by means of incineration in a high temperature furnace (Carbolite, England) at 550°C and then maintained 20 h until a white ash was obtained. Ashes were quantified gravimetrically.

### Mineral Content by Atomic Adsorption Spectrophotometer

Ash was dissolved in 2 mL of $HNO_3$ 1:1 (v/v) (analytical grade Merck, Germany) allowed for 18 h to dissolve completely and passed through a filter paper. Macro elements Na, K, Ca, Mg and micro elements Fe, Zn, Mn, Cu were determined by means of an atomic absorption spectrometer (HITACHI-Z-5000), equipped with hollow cathode lamps (AOAC, 1990; Arturo *et al*., 2001; Van Netten *et al*., 2000).

## RESULTS AND DISCUSSION

### Ash Content

The seaweed samples were first incinerated at 550°C for 18 h andthen at 900°C for 2 h, as previously reported for several seaweeds (Fleury and Lahaye, 1991). When ash was further calcined at 900°C, recovery was approximately three to six times lower. Hence the ash formation was selected ouly at 550°C for 18 h (Fleurence and Le Coeur, 1993) and the results are shown in Table 1. The ash

Table 1: Ash content of seaweeds collected in two months

| | | | Ash (g/100 g dry weight) | |
|---|---|---|---|---|
| Genus | Class | Species | January | July |
| *Caulerpa* (CU) | Green | spp. | 40.37±0.08 | 37.28±0.19 |
| *Ulva* (UL) | Green | spp. | 37.27±0.58 | 34.73±0.27 |
| *Sargassum* (SA) | Brown | spp. | 39.26±0.24 | 33.64±0.18 |
| *Eucheuma* (EU) | Red | *Denticulate* | 22.39±0.12 | 20.90±0.34 |
| *Gracilaria* (GR) | Red | spp. | 20.56±0.09 | 19.62±0.25 |
| *Gelidiella* (GE) | Red | *Acerosa* | 21.42±0.17 | 20.12±0.85 |
| *Kappaphycus* (KA) | Red | *Alvarezii* | 21.82±0.15 | 18.23±0.62 |

Mean values of triplicate determinations±Standard deviation, Incinerated at 550°C, 18 h

Table 2: Multi elemental data of Sabah seaweeds collected in the month of January' 2004

| | | | Element content (mg/100 g dry weight) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genus | Class | Species | Fe | Zn | Cu | Cd | Mg | Cr | As | Ca | K | Na |
| *Caulerpa* (CU) | Green | sp. | 7.14±0.27 | 3.41±0.35 | <0.55 | <0.2 | 949±2.05 | <0.8 | 7.67±0.15 | 943±2.05 | 4411±79.4 | 7042±21.8 |
| *Ulva* (UL) | Green | sp. | 4.65±0.41 | 1.87±0.07 | <0.55 | <0.01 | 560±4.85 | <3.0 | 3.67±0.20 | 708±2.12 | 6026±22.2 | 3901±71.6 |
| *Sargassum* (SA) | Brown | sp. | 6.83±0.07 | 3.74±0.30 | <0.55 | <0.01 | 953±2.52 | <2.0 | 1.67±0.15 | 1000±0.20 | 10040±32.1 | 4024±25.1 |
| *Eucheuma* (EU) | Red | *Denticulate* | 6.45±0.29 | 6.38±0.45 | <0.55 | <0.01 | 725±3.70 | <0.5 | 3.87±0.05 | 422±1.84 | 3636±72.6 | 4448±45.1 |
| *Gracilaria* (GR) | Red | sp. | 3.65±0.26 | 4.35±0.34 | <0.55 | <0.01 | 565±3.51 | <1.2 | 2.47±0.35 | 411±0.90 | 3417±76.3 | 5465±27.4 |
| *Gelidiella* (GE) | Red | *Acerosa* | 10.60±0.34 | 5.25±0.21 | <0.55 | <0.01 | 657±7.60 | <0.3 | 3.33±0.42 | 402±1.14 | 3034±41.6 | 3976±18.1 |
| *Kappaphycus*(KA) | Red | *Alvarezii* | 5.47±0.17 | 5.09±0.14 | <0.55 | <0.02 | 639±2.90 | <1.5 | 6.30±0.45 | 421±1.18 | 3877±25.1 | 3944±52.0 |

Mean values of triplicate determinations±Standard deviation

Table 3: Multi elemental data of Sabah seaweeds collected in the month of July' 2004

| | | | Element content (mg/100 g dry weight) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genus | Class | Species | Fe | Zn | Cu | Cd | Mg | Cr | As | Ca | K | Na |
| *Caulerpa (CU)* | Green | sp. | 6.45±0.49 | 3.53±0.25 | <0.45 | <0.2 | 1024±25.1 | <1.0 | 7.07±0.15 | 961±13.3 | 4604±90 | 7202±52.5 |
| *Ulva (UL)* | Green | sp. | 4.92±0.81 | 1.85±0.13 | <0.45 | <0.02 | 609.0±7.8 | <3.5 | 4.27±0.15 | 742±7.70 | 6159±52.1 | 4189±17 |
| *Sargassum (SA)* | Brown | sp. | 6.58±0.14 | 3.73±0.15 | <0.55 | <0.02 | 1050.±50.2 | <2.0 | 1.77±1.60 | 1130±32.7 | 9700±18 | 4334±27 |
| *Eucheuma (EU)* | Red | *Denticulate* | 6.05±0.24 | 6.63±0.35 | <0.30 | <0.01 | 842.0±9.42 | <0.7 | 3.93±0.15 | 442±10.5 | 3869±69.9 | 4551±57 |
| *Gracilaria (GR)* | Red | sp. | 3.62±0.12 | 4.50±0.20 | <0.55 | <0.02 | 580.0±10.5 | <1.0 | 2.53±0.30 | 424±5.25 | 3667±76.1 | 5579±19.1 |
| *Gelidiella (GE)* | Red | *Acerosa* | 9.60±0.18 | 5.58±0.13 | <0.45 | <0.01 | 749.0±3.06 | <0.8 | 3.40±0.45 | 431±13.2 | 3174±28.3 | 4134±26 |
| *Kappaphycus (KA)* | Red | *Alvarezii* | 5.25±0.18 | 4.82±0.10 | <0.55 | <0.01 | 684.0±10.4 | <1.2 | 6.70±0.20 | 464±22.5 | 4079±68 | 3905±42.9 |

Mean values of triplicate determinations±Standard deviation

content is high in green and brown seaweeds (37-41 g/100 g dry weight) and followed by red sea weeds (20-23 g/100 g dry weight). The difference in ash content was attributed to the rate of photosynthesis.

The range of ash values obtained in the present study were in agreement with previous results (Ruperez, 2002; Norziah and Ching, 2000). The over all difference in the ash content was 9.6%.

## Mineral Composition

The seaweeds contained high quantity of the macro-minerals (402-10070 mg/100 g) and the trace elements ranged (0.01-10.9 mg/100 g). The relative quantity of the bio-essential elements (Fe, Zn, Cu) followed as Fe> Zn>Cu. The analogous sequence was reported (Ganesan and Kannan, 1991). The iron content was fonnd to be highest in range of 9.6-11 mg/100 g as shown in *Gracilaria* (Table 2 and 3).

The Zinc metal content varied from 1.8 to 7 mg/100 g dry weight. The edible seaweed caulerpa contains Zinc 3.41±0.35 mg/100 g as shown in Table 2. It enhances the catalytic, structural and regulatory functions, Stabilizes membranes, hormones and nucleic acids (Norziah and Ching, 2000). The mineral elements content of copper, cadmium and chromium found to be between 0.01-3 mg/100 g. Copper acts as a cofactor in multiple enzymes, connective tissue formation, blood clothing, energy conversion, pigmentation of hair, skin and eyes. Chromium regulates the function of insulin and affects lipid metabolism. Most of the seaweeds showed that sodium, calcium, magnesium and potassium contents were elevated values in the range of 400-10070 mg/100 g. Calcium strengthens the bones, teeth structure and muscle contractions. It acts as a cofactor for extra cellular enzyme and proteins. Sodium and potassium act as electrolyte balance. Nevertheless, similar range was also observed as shown in Table 4 in the *Fucus vesiculosus*, *Laminaria digitata*, *Undaria pinnatifida*, *Chondras crispus and Porphyra tenera* type of seaweed (Ruperez, 2002).

## Seasonal Effects

The over all mineral content was varied about 6.9% as shown in Table 2 and 3. The seaweed elements variation depends on seaweed species, oceanic residence time, seasonal, enviroumental, physiological factors and type of processing and method of mineralization (Honya and Kinoshita, 1993). The seasonal parameters such as time, intensity of light, salinity and water temperature affect

Table 4: Summary of the published data on the mineral content of the seaweed

| | | Element content (mg/100 g dry weight) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Reference | Origin | Fe | Zn | Cu | Cd | Mg | Cr | As | Ca | K | Na |
| Van Netten *et al.* (2000) | British Columbia and Japan | 2 -52 | 0.4-3.7 | <1 | <1 | - | <1.5 | 1.7-8.8 | - | 53-437 | - |
| Mohd Hani Norziah *et al.* (2000) | Malaysia | 95.6±3.7 | 13.8.±4.1 | 0.8±0.1 | 0.3±0.1 | - | - | - | 651±5.2 | - | - |
| Ruperez (2002) | Spain | 3.3-11 | 1.75-7.2 | - | - | 665-1200 | - | - | 415-1010 | 3185-11 600 | 3630-7070 |
| This study | Sabah (Malaysia) | 6.5-11 | 2-7 | <0.55 | < 0.2 | 565-951 | <3 | 1.7-7.7 | 411-1001 | 3034-10070 | 3901-7060 |

the growth rate of seaweeds. Light is one of the main abiotic factors that regulates seaweed growth and distribution in the marine habitat Hanelt *et al.* (1997). The optimum salinity required for some seaweeds is about 28-34 parts per thousand (ppt) and in the water temperature range 25-30°C. The major seasonal elemental deviation was found to be 9.25% Mg, 6.44% Ca and 5.3% Fe as in shown Table 2 and 3.

## CONCLUSIONS

The seaweeds from the Sabah coast were analyzed for micro-elemental content. Some of the mineral elements were in moderate level and others were at high level. The data obtained from this study was compared to the literature values. The iron content was found to be in the sequence of *Gelidiella>Caulerpa> Sargassum> Eucheuma.* Its content was in the range 6.6-10.94 mg/100 g by dry weight. The seasonal elemental deviation was found to be 9.25% Mg, 6.44% Ca and 5.3% and the ash content varied with the season.

## ACKNOWLEDGMENT

We thank the Research and Development Center, University Malaysia Sabah for supporting this research and Ministry of Science Technology. Iunovation, through, grant No. 03/01/10/SF0003.

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