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Mineral composition of edible seaweed *Porphyra vietnamensis*

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Abstract

Edible seaweed *Porphyra vietnamensis* growing along seven different localities of the Central West Coast of India was analyzed for mineral composition (Na, K, Ca, Mg, B, Pb, Cr, Co, Fe, Zn, Mn, Hg, Cu, As, Ni, Cd and Mo) by inductively coupled plasma atomic emission spectroscopy (ICP-AES). The concentration ranges found for each sample, were as follows: Na, 24.5–65.6; K, 1.76–3.19, Ca, 1.40–6.12; Mg, 4.0–5.90 (mg/g d wt); Pb, 0.01–0.15; Cr, 0.13–0.22; Co, 0.06–0.20; Fe, 33.0–298; Zn, 0.93–3.27; Mn, 4.22–10.00; Hg, 0.01–0.04; Cu, 0.54–1.05; As, 1.24–1.83; Ni, 0.02–0.25; Cd, 0.14–0.55; Mo, 0.02–0.03 and B, 0.02–0.07 expressed in mg/100 g dry weight. Mineral composition of *P. vietnamensis* was found relatively higher as compared to the land vegetables as well as to other edible seaweeds, and it is in concurrence with the recent macrobiotic recommendation for western countries. It could therefore be used as food supplement as a spice to improve the nutritive value in the omnivorous diet.

Keywords: Mineral composition; *Porphyra vietnamensis*; Edible seaweed; Inductively coupled plasma atomic emission spectroscopy (ICP-AES); Central west coast of India

1. Introduction

Eating patterns of people all over the world have recently undergone marked changes, due to the globalization of markets along with innovation in food technology. The macrobiotic diet, which came to Europe from Japan, contributed to the introduction of sea vegetables in their staple diet. Fresh seaweeds have been used directly as foodstuff in the Asian countries for centuries and are considered under-exploited resources (Chapman & Chapman, 1980; Tseng, 2004). About 221 seaweeds are utilized commercially world-wide of which 65% are used as human food (Zemke-White & Ohno, 1999). Most recently seaweeds have been utilized in Japan as raw materials in the manufacture of many seaweed food products, such as jam, cheese, wine, tea, soup and noodles (Nisizawa, Noda, Kikuchi, & Watamaba, 1987) and in the Western countries, mainly as a source of polysaccharides (agar, alginates, carrageenans) for the food and pharmaceutical industries (Indegaard & Ostgaard, 1991). Seaweeds are a rich source of minerals, especially macro and micronutrients necessary for human nutrition; however, the nutritional properties of seaweeds are usually determined from their biochemical composition alone viz. proteins, carbohydrates, vitamins, amino acids, etc. (Darcy-Vrillon, 1993; Mabeau & Fleurence, 1993). The mineral fraction of some seaweeds even accounts for up to 40% of dry matter (Ortega-Calvo, Mazuelos, Hermosín, & Sáiz-Jiménez, 1993), however, in some cases the mineral content of the seaweeds is recorded even higher than that of land plants and animal products (Ito & Hori, 1989).

The genus *Porphyra*, traditionally known as *nori*, in Japan *kim* in Korea and *zicai* in China, is a popular delicacy, due to its rich content of protein, vitamins, minerals and dietary fibers (Sahoo, Tang, & Yarish, 2002). This alga is also reported to contain iodine, bioactive substances and anti fungal compounds of therapeutic value (Hayee-Memon, Shameel, Usmanghani, & Ahmad, 1992; Shameel

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Table 1
Macro, micro and trace elements of *Porphyra vietnamensis* determined by ICP-AES

Mineral	Malvan (73.27 E and 16.03 N)	Deobag (74.08 E and 14.49 N)	Vagatore (73.45 E and 15.35 N)	Karvar Port (74.11 E and 14.38 N)	Dona Paula (73.47 E and 15.27 N)	Redy (73.42 E and 15.46 N)	Anjuna (73.43 E and 15.27 N)	Average ± SD
Na*	64.7 ± 0.4	24.5 ± 1.1	61.2 ± 10.8	50.1 ± 0.9	42.4 ± 5.9	65.6 ±;1.0	57.3 ± 2.0	52.3 ± 3.2
K*	3.19 ± 0.57	2.52 ± 0.80	2.55 ± 0.63	1.76 ± 1.0	3.05 ± 0.90	2.17 ± 0.30	2.18 ± 0.30	2.49 ± 0.64
Ca*	3.54 ± 0.87	2.67 ± 0.52	5.49 ± 0.66	1.40 ± 0.75	2.48 ± 0.70	1.73 ± 0.23	6.12 ± 2.14	3.35 ± 0.84
Mg*	5.68 ± 1.10	4.48 ± 0.50	4.70 ± 1.30	4.0 ± 0.50	5.15 ± 1.60	5.90 ± 1.20	4.74 ± 0.90	4.95 ± 1.01
Total	77.1 ± 3.0	34.2 ± 3.0	74.0 ± 13.4	57.3 ± 3.2	53.1 ± 9.1	75.4 ± 2.7	70.4 ± 5.3	63.1 ± 5.67
Pb	0.06 ± 0	0.07 ± 0.01	0.07 ± 0.01	0.01 ± 0	0.05 ± 0.02	0.15 ± 0	0.07 ± 0.01	0.07 ± 0.01
Cr	0.18 ± 0	0.13 ± 0	0.21 ± 0	0.22 ± 0	0.15 ± 0	0.16 ± 0	0.22 ± 0.03	0.18 ± 0.
Co	0.15 ± 0.01	0.14 ± 0	0.13 ± 0.02	0.06 ± 0.01	0.07 ± 0	0.08 ± 0	0.20 ± 0.01	0.12 ± 0.01
Fe	61.6 ± 0.2	81.5 ± 0.8	258 ± 2.9	33.0 ± 0.4	145 ± 0.4	80.4 ± 0.7	298 ± 1.5	137 ± 0.99
Zn	1.53 ± 0.01	2.32 ± 0.02	2.16 ± 0.03	1.85 ± 0	3.27 ± 0.02	0.93 ± 0.01	1.62 ± 0.01	1.95 ± 0.01
Mn	5.40 ± 0.01	6.50 ± 0.01	6.70 ± 0.06	10.0 ± 0.1	8.08 ± 0.01	4.22 ± 0.03	8.73 ± 0.02	7.09 ± 0.03
Hg	0.04 ± 0.01	0.01 ± 0	0.01 ± 0.01	ND	0.01 ± 0	ND	0.02 ± 0	0.02 ± 0
Cu	1.05 ± 0.01	0.66 ± 0.07	0.96 ± 0.05	0.63 ± 0	1.04 ± 0.01	0.54 ± 0	0.94 ± 0	0.83 ± 0.02
As	1.83 ± 0.4	1.30 ± 0.03	1.70 ± 0.14	1.71 ± 0.02	1.70 ± 0.02	1.24 ± 0.6	1.71 ± 0.06	1.60 ± 0.18
Ni	0.07 ± 0	0.11 ± 0.01	0.22 ± 0.01	ND	0.11 ± 0	0.02 ± 0.01	0.25 ± 0	0.13 ± 0.01
Cd	0.55 ± 0.03	0.43 ± 0	0.23 ± 0	0.22 ± 0	0.14 ± 0.01	0.23 ± 0.01	0.22 ± 0.01	0.29 ± 0.01
Mo	0.02 ± 0	0.03 ± 0	ND	ND	ND	ND	ND	0.03 ± 0
B	0.07 ± 0	0.05 ± 0.01	ND	0.03 ± 0	0.05 ± 0	0.02 ± 0	0.03 ± 0.01	0.04 ± 0
Total	72.6 ± 0.68	93.3 ± 0.96	270 ± 3.23	47.7 ± 0.53	160 ± 0.49	88.0 ± 1.36	312 ± 1.66	149 ± 1.27

ND* below the detection limit.
Mean values of triplicate determination ± standard deviation.

& Aftab, 1993). The *Porphyra* cultivation in Japan is a billion-dollar aquaculture industry with an average production of 400,000 tons (wet wt) per year (McHugh, 2003). The genus is represented by nearly 133 species from all over the world (Yoshida, Notoya, Kikuchi, & Miyata, 1997) with eight species from Indian waters (Anilkumar & Rao, 2005; Oza & Zaidi, 2001). *Porphyra vietnamensis* also known as *limu pahe'e* (Hawaiian name), an integral part of Hawaiian diet, is available in plenty along the Central west coast of India during Southwest monsoon [July–October] (Pereira, Kakode, & Dhargalkar, 2005).

Evaluation of minerals in any edible seaweed is important from both the nutritional and the toxicological point of view. However, very little is known about the mineral composition of *P. vietnamensis* (McDermid & Stuercke, 2003). In view of the preference of *Porphyra* diet over other seaweeds, mineral composition of *P. vietnamensis* was determined to evaluate for its use as a potential food ingredient.

2. Materials and methods

2.1. Sample collection

All the samples have been collected from unpolluted locations at seven different places along Central west coast of India viz. Malvan (73.27 E and 16.03 N), Redy (73.42 E and 15.46 N), Dona Paula (73.47 E and 15.27 N), Anjuna (73. 43 E and 15.27 N), Vagatore (73.45 E and 15.35 N), Deobag (74.08 E and 14.49 N) and Karvar Port (74.11 E and 14.38 N). The collection was made during low tide from upper littoral rocks of above mentioned locations in the third week of August 2005.

2.2. Mineral analysis by inductively coupled plasma atomic emission spectroscopy (ICP-AES)

Samples were brought to the laboratory and washed thoroughly with tap water to remove attached epiphytes and adhered dirt particles if any and dried in the shade. The material was kept in the oven at 110 °C for 12 h, pulverized in the grinder and sieved through a screen with an aperture of 0.5 mm. This powdered material was kept in airtight plastic bottles at room temperature until analysis. Samples were subjected to acid digestion and analyzed according to the procedure described by Farías, Arisnabarreata, Vodopivez, and Smichowski (2002). Mineralogical analysis was carried out using inductively coupled plasma atomic emission spectroscopy (ICP-AES, Perkin–Elmer, Optima 2000). All determinations were performed in triplicate and data represented on dry weight basis as mean values ± standard deviation.

3. Results and discussion

The variation observed in the mineral composition of *P. vietnamensis* at various places in the present study (Table 1)

Table 2
Intake of toxic elements in daily recommended dose of *P. vietnamensis*

Elements	Permissible daily dose (μg) [Concon, 1988; Phaneuf et al., 1999]	Recommended daily intake of *P. vietnamensis* (g/day)
Cd	50–150	17.2–51.7
As	21	1.3
Pb	250	357
Hg	40	200
Cr	350	194.4

is trivial and could be attributed to the different geographical locations. Among all the 17 minerals analyzed Na and Mo were found to be highest (5230 mg/100 g d wt) and lowest (0.03 mg/100 g d wt), respectively. Sample collected from Malvan ranked highest in total mineral content (7783 mg/100 g d wt), with least value recorded at Deobag (3513 mg/100 g d wt). The selected micro nutrients (Fe + Zn + Mn + Cu) were found to be higher (45.5–309 mg/100 g d wt) than any of the land vegetables as well as edible seaweeds like *Caulerpa lentillifera*, *Enteromorpha flexuosa*, *Monostroma oxysperum*, *Eucheuma denticulatum* and *Gracilaria parvispora* reported from Hawaii (McDermid & Stuercke, 2003) and *Undaria pinnatifida*, *Laminaria digitata*, *Fucus vesiculosus*, and *Chondrus crispus* reported from Spain (Kolb, Vallorani, Kozlek, & Stocchi, 2004; Rupérez, 2002).

As, Cd, Cu, Pb, Hg, Cr, Ni and Zn are relevant elements and are of immediate concern due to their potential toxicity for living organisms. Depending upon the permissible daily dose for different toxic elements (Concon, 1988; Phaneuf, Cote, Dumas, Ferron, & LeBlanc, 1999) recommended daily intake of this edible seaweed has been calculated and provided in Table 2. Cu + Zn content was in the range of 1.47–4.31 mg/100 g d wt, which is below the toxic limits allowed in macro algae for human consumption in countries like Japan and France (Indegaard & Minsaas, 1991). Based on toxicity of above mentioned elements it is therefore, recommended to use not more than 1.3 g d wt of *P. vietnamensis* as a spice. If 1.3 g d wt of *P. vietnamensis* is consumed, the daily intake of investigated elements viz. Cd, As, Cu, Pb, Hg, Cr, Ni and Zn would be 3.77, 20.8, 10.79, 0.91, 0.26, 2.34, 1.69 and 25.35 μg/day, respectively and this is as per the tolerable daily intake of these elements established by the FAO/WHO Expert Committee (Concon, 1988; US EPA, 1996; WHO, 1996). The present study indicates the possibility of *P. vietnamensis* to be used as a spice in food supplements to improve the nutritive value of the human diet.

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