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BORON CONTENT OF MARINE ALGAE FROM THE MANDAITIVU AND KIRINDA COASTS AND MINERAL CONTENT OF NINE SPECIES OF ALGAE FROM THE KIRINDA COAST

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Abstract : The boron content of eighteen species of marine algae collected from the Mandaitivu and Kirinda coasts is reported here. Boron is a micronutrient and is essential for plant growth. The feasibility of using algae such as *Gracilaria crassa, Gracilaria edulis, Gracilaria corticata, Centroceros clavulatum* and *Sarcodia ceylanica* which contain more than 200 ppm boron, as fertilizer to meet the boron and other mineral requirement is discussed. The iodine, phosphorus, iron, sodium, potassium, calcium, magnesium, chloride (ionic) and sulphur (total) contents of nine species of marine algae from the Kirinda coast are reported and the values are compared with those of the algae from the northern coast. *Gracilaria fergusoni* has the highest amount of iodine (3990 ppm) reported so far for marine algae from the Sri Lankan coasts.

1. Introduction

As a part of our study of the mineral content of marine algae the boron content of some species of marine algae was estimated. Boron is one of the essential micronutrients for plants. Some plant diseases like top sickness of tobacco, heart rot of beets, brown heart of turnips, internal brown spot of sweet potatoes, split roots in carrots have been reported to be due to boron deficiency.[10] Usually borax [$Na_2B_4O_7.10H_2O$] is used as a source of boron in fertilizers. In this paper the quantity of boron present in eighteen species of marine algae is presented. The feasibility of using these algae as fertilizers is discussed. Results on the amounts of iodine, protein and other minerals present in nine species of marine algae from the Kirinda coast are also reported.

2. Experimental Methods and Materials

The seaweeds were collected from Kirinda and Mandaitivu coasts. About 500 – 750g samples of each of the seaweed species were collected from three to four different places in the same locality, bulked together, washed and air dried for three days. The moisture content was determined by drying in an oven at 105°C to constant weight. The ash content was determined by ashing weighed quantities of samples at 450°C in a muffle furnace until constant weight was obtained. The total nitrogen was determined by the Kjeldhal method[8] and protein [crude] content was calculated by multiplying the total nitrogen content by 6.25.[8] Iodine content was estimated by the alcoholic potash method.[4,5] The amounts of sodium, potassium, calcium, magnesium, trace elements, phosphorous, chloride [ionic] and sulphur [total] were determined by the methods reported previously.[6] The amount of carbonate in ash was determined by a known procedure.[3]

2.1 Determination of the amounts of boron

Seaweed samples of known weight [0.5 – 1.0g] from powdered bulk samples were mixed with $Ca(OH)_2$ [2g], ashed at 450°C and dissolved quantitatively in a known volume of 0.6M HCl. The amount of boron present was determined using curcumin-oxalic acid reagent.[3] The intensity of the colour produced was measured on a LKB–ULTROSPEC UV-Visible spectrophotometer [model 4050] at 540 nm wavelength. This determination was carried out in triplicate [deviation 3 ppm].

3. Results and Discussion

The amounts of boron present in eighteen species of seaweeds are given in Table 1. The results show that some of the algae such as *G. edulis* (202 ppm) *G. crassa* (242 ppm), *G. corticata* (208 ppm), *S. ceylanica* (234 ppm) and *C. clavulatum* (273 ppm) contain over 200 ppm boron. This is more than double the highest amount of boron (100 ppm) found in the leaves of land plants. The high amount of boron in these algae may be due to the relatively large amount of boron present in seawater. The seawater collected from Mandaitivu in June 1984 contains 3.5 ppm boron, whereas the well water samples from Jaffna, Kopay, Thirunelvely and Kondavil contain less than 0.7 ppm boron.

Normally borax ($Na_2B_4O_7 . 10H_2O$) is used as a source of boron in fertilizer as it is water soluble and could be leached down easily. Normal crops require[10] 1–5 kg of boron per hectare. Algae containing boron in excess of 200 ppm could be used as fertilizer so as to provide the required

Table 1. Boron content of Seaweeds in ppm (i.e. mg/kg air dried Seaweed)

Alga	Locality	Date of collection	Boron
(a) Rhodophyta			
1. *Gracilaria edulis* (Gmel) Silva	Mandaitivu	12.02.84	202
2. *Gracilaria crassa* J. Agardh	Mandaitivu	12.02.84	242
3. *Gracilaria fergusoni* J. Ag.			
I	Kirinda	27.02.83	135
II	Kirinda	15.05.83	110
4. *Gracilaria corticata* J. Ag.	Kirinda	27.02.83	208
5. *Sarcodia ceylanica* Harvey	Kirinda	27.02.83	234
6. *Centroceros clavulatum* J. Ag.	Mandaitivu	12.02.84	273
7. *Laurencia obtusa* (Huds.) Lamouroux	Mandaitivu	12.02.84	126
8. *Spyridia aculeata* J. Ag.	Kirinda	27.02.83	114
9. *Acanthophora delilei* Lamour.	Mandaitivu	12.02.84	57
10. *Polyopas ligulatus* (Harv.) Schmitz	Kirinda	15.05.83	51
11. *Chnoospora fastigiata* J. Ag.	Kirinda	27.02.83	91
12. *Jania natalensis* Harv.	Mandaitivu	12.02.84	43
13. *Amphiroa* sp. Lamour	Mandaitivu	12.02.84	74
14. *Cheilosporum spectabile* Harv.	Kirinda	27.02.83	13
15. *Corynomorpha prismatica* J. Ag.	Kirinda	15.05.83	140
(b) Chlorophyta			
16. *Ulva reticulata* Forsskal	Mandaitivu	12.02.84	58
17. *Ulva lactuca* Linnaeus	Mandaitivu	12.02.84	88
18. *Ulva fasciata* Delile	Kirinda	27.02.83	56

amount of boron. These algae would also provide other mineral nutrients required for plant growth. Of the species having more than 200 ppm boron, *G. crassa*[6], *G. edulis*[6], *G. corticata* and *C. clavulatum*[6] (see Tables 2,3 & 4) have high N, P, K values and are most suitable for use as fertilizers.

Moisture, ash, insoluble ash (insoluble in 0.6 M HCl), carbonate (in ash), nitrogen and protein (crude) contents of nine species of seaweeds from the Kirinda coast are given in Table 2. *Cheilosporum spectabile,* which like *Jania natalensis*[6] is capable of accumulating calcium and depositing it in the form of calcareous skeleton,[9] has the highest amount of ash, insoluble ash, calcium and carbonate. *G. corticata, C. spectabile* and *Ulva fasciata* have a relatively large percentage of insoluble ash, possibly due to accumulation of silica. Some of the algae, for example, *Spyridia aculeata, Corynomorpha prismatica,* and *Polyopas ligulatus* have 12–15% protein and this amount, is somewhat lower than those for some of the species of algae from northern Sri Lanka.[6]

Table 3 shows the amounts of sodium, potassium, calcium, magnesium chloride (ionic) and sulphur (total) found in the nine species of seaweeds from the Kirinda coast. The sodium content of these nine species are generally much higher than that of the species from the northern coast of Sri Lanka.[6] *C. prismatica* has the highest amount (> 10%) of sodium. It is interesting to note that this species also has the highest amount of chloride ions (7.93%) and relatively high total sulphur content (3.47%). Except for the *C. spectabile*, the calcium content of the marine algae from the Kirinda coast is generally lower than that of the algae from the northern coast of Sri Lanka. The *C. spectabile* has calcium content (20.1%) comparable to that of *J. natalensis*[6] (23.85%) and *Amphiroa* sp.[7] (23.29%) from the northern coast of Sri Lanka. This is consistent with the ability of these species to accumulate calcium and deposit it in the form of calcareous skeleton mainly as calcium carbonate. *G. corticata* has potassium in amounts (13.0%) comparable to that found in *G. edulis* (13.49%) from the Mandaitivu coast.[6] This species also has relatively high amounts of ionic chloride (4.36%) and total sulphur (3.86%).

The iron, phosphorus and iodine contents of the nine seaweed species from the Kirinda coast are given in Table 4. *G. corticata, S. aculeata* and *C. spectabile* have a relatively large quantity of iron. The algae species collected from the Kirinda coast generally have a higher phosphorus content than those from the northern coast of Sri Lanka. *G. fergusoni* and *P. ligulatus* have phosphorus in excess of 2000 ppm which is much higher than that of any of the marine algae collected from the northern coast of Sri Lanka. A similar trend is observed for the iodine content. *G. fergusoni* has a higher iodine content than reported for any other marine algae from the Sri Lankan coast. The iodine content of this species is nearly double that of the principal natural source, the caliche deposit of northern Chile.[1]

Table 2 : Moisture, Ash, Insoluble ash, Nitrogen and Protein (crude) contents of Seaweeds from Kirinda Coast. (g/100g air dried Seaweed)

	Alga	Moisture	Ash	Insoluble ash	Carbonate in ash	Nitrogen	Protein
1.	*Gracilaria corticata*	16.4	42.7	8.60	2.53	1.71	10.67
2.	*Gracilaria fergusoni* I	22.4	32.2	3.63	1.31	1.52	9.51
	II	19.4	33.4	4.02	1.52	1.52	9.51
3.	*Sarcodia ceylanica*	28.1	24.8	2.79	0.94	0.97	6.05
4.	*Spyridia aculeata*	17.1	20.3	6.53	2.54	2.07	12.93
5.	*Corynomorpha prismatica*	26.3	36.9	1.57	2.92	2.39	14.93
6.	*Chnoospora fastigiata*	23.9	32.6	1.50	2.47	0.98	6.13
7.	*Cheilosporum spectabile*	2.7	83.3	24.1	33.53	0.39	2.46
8.	*Polyopas ligulatus*	18.0	12.9	0.86	0.93	2.03	12.68
9.	*Ulva fasciata*	19.7	27.1	11.86	2.07	1.21	7.59

NOTE : *G. fergusoni* (II) and *C. prismatica* were collected in May 1983 and all the other samples were collected in February 1983.

Table 3 : Sodium, Potassium, Calcium, Magnesium, Chloride (ionic) and Sulphur (total) contents of Seaweeds from Kirinda coast. (g/100g air dried seaweed)

Alga	Sodium	Potassium	Calcium	Magnesium	Chloride (ionic)	Sulphur (total)
1. *Gracilaria corticata*	2.29	13.00	1.56	0.46	4.36	3.86
2. *Gracilaria fergusoni* I	4.33	6.80	0.81	0.38	6.66	2.13
II	3.40	8.84	0.93	0.52	6.09	2.16
3. *Sarcodia ceylanica*	5.70	1.59	0.50	0.66	4.41	3.82
4. *Spyridia aculeata*	1.30	0.96	0.87	2.91	3.09	1.46
5. *Corynomorpha prismatica*	10.43	1.35	1.62	1.24	7.93	3.47
6. *Chnoospora fastigiata*	6.42	8.01	1.33	0.71	4.70	1.14
7. *Cheilosporum spectabile*	1.38	0.13	20.10	1.80	1.35	0.66
8. *Polyopas ligulatus*	3.06	1.99	0.06	0.46	1.92	1.37
9. *Ulva fasciata*	2.00	0.68	0.42	2.46	1.26	2.36

NOTE : *G. fergusoni* (II) and *C. prismatica* were collected in May 1983 and all the other samples were collected in February 1983.

Table 4 : Iron, Phosphorus and Iodine contents of Seaweeds from Kirinda coast in ppm (i.e. mg/kg air dried seaweed)

Alga	Iron	Phosphorus	Iodine
1. *Gracilaria corticata*	1356	1606	186
2. *Gracilaria fergusoni* I	468	1861	2109
II	373	2120	3990
3. *Sarcodia ceylanica*	311	1274	179
4. *Spyridia aculeata*	1074	1030	112
5. *Corynomorpha prismatica*	458	1623	297
6. *Chnoospora fastigiata*	166	1199	182
7. *Cheilosporum spectabile*	1390	268	156
8. *Polyopas ligulatus*	68	2410	435
9. *Ulva fasciata*	187	902	129

NOTE : *G. fergusoni* (II) and *C. prismatica* were collected in May 1983 and all the other samples were collected in February 1983.

Table 5 : The amounts of trace elements present in seaweed from Kirinda coast in ppm (i.e. mg/kg air dried seaweed)

Alga		Cu	Zn	Mn	Ni	Pb	Cd	Co	Cr
1. *Gracilaria corticata*		11	16	38	28	22	2	23	20
2. *Gracilaria fergusoni*	I	5	12	26	6	28	2	9	6
	II	7	17	24	4	29	3	8	5
3. *Sarcodia ceylanica*		9	25	26	5	15	2	10	5
4. *Spyridia aculeata*		11	25	69	23	14	4	13	6
5. *Corynomorpha prismatica*		8	14	46	12	12	1	16	7
6. *Chnoospora fastigiata*		6	13	4	6	11	2	18	10
7. *Cheilosporum spectabile*		2	7	17	8	28	3	27	4
8. *Polyopas ligulatus*		5	14	5	5	10	0.4	27	–
9. *Ulva fasciata*		8	10	13	5	8	no detectable amount	3	7

NOTE : *G. fergusoni* (II) and *C. prismatica* were collected in May 1983 and all the other samples were collected in February 1983.

Table 5 gives the amounts of the trace elements copper, zinc, manganous, nickel, lead, cadmium, cobalt and chromium present in the nine species of marine algae under investigation. The elements copper, zinc, manganese, nickel, cobalt and chromium are essential nutritive (in small amounts) elements but are toxic to human and animals if they are present in large amounts. The amounts of these elements found in the nine species of marine algae are within the recommended limits which are as follows:- copper, 20 ppm; chromium, 100 ppm; nickel, 100 ppm; zinc, 50 ppm.[8] Lead and cadmium are non-nutritive toxic elements. The level of cadmium in these species of seaweeds is low. However the lead content is well above the limit of 2 ppm. The lead content of the seaweeds from the Kirinda coast generally appears to be much higher than that of the seaweeds from the northern coast of Sri Lanka.[6] Compared to the seaweeds from the northern coast of Sri Lanka the seaweeds from the Kirinda coast have relatively high zinc, cobalt and chromium contents and low manganous and nickel contents. The element cobalt which is important in metabolising sulphur containing amino acid, is found in reasonable amounts (> 20 ppm) in *G. corticata, C. spectabile* and *P. ligulatus*. This element and chromium could not be detected[6] in the species of seaweeds collected from the northern coast of Sri Lanka. The mineral contents reported in this paper were determined on algal species collected during one season. Work is being carried out to study the seasonal variation of the mineral contents.

4. Conclusion

Seaweeds such as *G. edulis, G. crassa, C. clavulatum* from the Mandaitivu coast and *G. corticata* and *S. ceylanica* from the Kirinda coast have relatively large amounts of boron. These species are also rich in nitrogen, potassium, phosphorus and other minerals and could be used as fertilizers. *G. fergusoni* is rich in iodine and could be used for the manufacture of iodine. This species could also be used to supplement human diet and animal feed to provide the iodine which is required to control goitre disease. As expected the algae growing in Kirinda coast have a relatively low calcium content than those from the Mandaitivu coast. However they generally have higher sodium and phosphorus content. It is recommended that selected species of algae should be cultivated with the aim of using them as fertilising material.

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