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Mineral and Protein Contents of some Marine Algae from the Coastal Areas of Northern Sri Lanka

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Abstract: Protein and mineral contents of twenty-five species of marine algae from the coastal areas of Northern Sri Lanka are reported. Species such as *Centroceros clavulatum, Ulva lactuca, Hypnea musciformis, Acanthophora delilei* and *Gracilaria edulis* are found to have high protein content which are comparable to that in food materials such as cereals, eggs and fish. Algae such as *Gracilaria edulis, Laurencia obtusa, Sargassum polycystum, Ulva lactuca* and *Gracilaria crassa* and *Thalasia hemprichi* (angiosperm) have fairly large amounts of nitrogen, phosphorus and potassium and hence could be used as fertilizers.

1. Introduction

Marine algae and sea grasses are two of the important groups of marine plants occurring in the sea. They contain several inorganic elements and a complex mixture of organic substances synthesised from them. Due to the presence of these chemical substances marine algae find a variety of uses, some of which are briefly indicated below.

Marine algae are used [3] to prepare alginic acid and agar. Fresh dried and processed seaweeds are utilised as human food [11, 14, 15] in Japan, Indonesia, China, Philippines, India and other south east Asian countries. Seaweeds such as *Porphyra, Ulva, Chlorella, Gracilaris* and *Chondrus* are commonly used as ingredients for soups and as meat flavourings. [11, 14, 15] Countries like Japan have large industries based on edible seaweeds. The algal carbohydrates are not easily digestible and hence the food value of the seaweeds depends on the minerals, trace elements, proteins and vitamins present in them. The seaweed meal is nutritious due to its high mineral and protein content. Seaweeds are used [11, 14, 15] to stock feed sheep and cattle in maritime districts.

Seaweeds contain reasonable quantities of nitrogen, phosphorus and potassium and they are extensively used, either directly or in the form of compost with cowdung as manure for vegetables in India.[13] In seaweeds, the minerals and trace elements occur in water soluble form [13] and hence these could be easily taken up by the plants. The carbohydrates and other organic constituents of the seaweeds are reported [13] to increase the moisture holding capacity of soils. The marine algae are also a good source of potash and soda.

During certain seasons fairly large quantities of seaweeds are found in the coastal areas of the Jaffna Peninsula. In order to make the best use of these seaweeds a knowledge of their chemical composition is essential. Therefore as an initial step, a study of the mineral, protein and vitamin contents of the seaweeds found in Northern Sri Lanka was started. Our results on the estimation of the moisture, ash and protein contents and of the amounts of some inorganic elements present in twenty five species of seaweeds are given below.

2. Experimental Methods and Materials

The seaweeds were collected from Mandaitivu, Nainativu and Keerimalai, washed well and air dried for three days. The moisture contents were determined by drying them in an oven at 105°C to constant weight. The ash contents were 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 and protein content was calculated by multiplying the total nitrogen content by 6.25.

2.1. Preparation of Test Solutions

Seaweed samples of known weights were ashed at 450°C and dissolved quantitatively in a known volume of 0.6M HCl and the resulting solutions were used to determine the amounts of sodium, potassium, calcium, magnesium and trace elements.

2.2. Determination of the amounts of Sodium and Potassium

Sodium and potassium were determined using a Corning Model 400 flame photometer using appropriate interference filters. The flame intensities for sodium were corrected for interference by calcium by the standard addition method. [17]

2.3. Determination of the amounts of Calcium and Magnesium

The amount of calcium present in seaweeds was determined[12] by titrating a known volume of the test solution with standard EDTA with Patton-Reeder's indicator and using potassium cyanide as the masking agent.

The amount of magnesium present in seaweeds was estimated as follows: The total amount of magnesium and calcium present was determined by titrating known volumes of test solution with standard EDTA solution with Eriochrome Black T as indicator and using potassium cyanide as masking agent.[12] The amount of magnesium is obtained by subtracting the amount of calcium present from this value.

2.4. Determination of Iron in Seaweeds

The test solution was prepared in 0.6M HCl as described above. The amount of iron present in the test solution was determined[8] by measuring the density of the colour produced by the addition of 1,10—orthophenanthroline on a Corning model 252 colorimeter using a 490nm filter.

2.5. Determination of Trace Elements

Amounts of trace elements copper, manganous, nickel, zinc, cadmium, cobalt and chromium were determined using the test solution [prepared as described above] on a Varian Model 1275 atomic absorption spectrophotometer.

2.6. Determination of the amount of Lead in Seaweeds

Samples of known weight were subjected to wet oxidation with concentrated nitric acid and concentrated sulphuric acid by the reported procedure. [10] The resulting solution was used to prepare the test solution. The amount of lead present was determined [10] using Corning Model 252 colorimeter after complexing with dithizone.

2.7. Determination of Phosphorus in Seaweeds

Dried seaweed samples [1-2g] were weighed accurately, ashed with magnesium nitrate,[6] the ash was dissolved in $2(NH_4)_2 SO_4$ (10ml) and the solution made up to 50ml. The amount of phosphorus present in this solution was determined[6] by measuring the density of the colour produced on complexing with vanadomolybdate reagent on a Corning Model 252 colorimeter using 430, 470 and 490nm filters.

2.8. Determination of Total Sulphur in Seaweeds

The amount of total sulphur in seaweeds was determined by the reported method.[6] Accurately weighed sample (1-2g) of seaweed was treated with concentrated nitric acid (10ml) and the mixture was allowed to stand overnight at room temperature. The resulting mixture was evaporated to dryness and the residue was ashed in a muffle furnace at 450° C. The ash was dissolved in a minimum volume of 25% nitric acid and the solution made up to 50ml in a volumetric flask. A known volume of this solution was treated with an excess of standard barium chloride. The unreacted barium chloride was determined by titration with standard EDTA. The amount of sulphate was estimated by the method of difference.

2.9. Determination of the amount of Chloride in Seaweeds

Accurately weighed powdered seaweed (1.2g) was ashed at 450° C with an equal weight of sodium carbonate. The ash was dissolved in minimum amount of 25% nitric acid and the solution made up to 50ml in a volumetric flask. The amount of chloride present in this solution was determined by Vollard method.[16]

3. Results and Discussion

The amounts of moisture, ash, total nitrogen and protein found in twenty five species of the seaweeds from the coastal areas of Northern Sri Lanka are given in Table 1. The results show that some of the algae such as *Gracilaria edulis*, *Gracilaria confervoides*, *Hypnea musciformis*, *Acanthophora delilei*, *Centroceros clavulatum* and *Ulva lactuca* have between 13-26% protein and this amount is comparable or even

somewhat higher than the reported[4] protein content of food materials like cereals, eggs and fish. Algal proteins are reported[11,14,15] to have many of the essential aminoacids including iodine containing aminoacids and hence the above seaweeds, are a good source for protein rich food. Also, the above species of seaweeds could be added to foods which are deficient in protein. In India *Gracilaria edulis* is used[11,14,15] in the preparation of soup.

TABLE 1. Moisture, Ash, Nitrogen and Protein contents of Seaweeds. All values are expressed as g/100g of air dried samples of seaweeds

Alga	*Locality*	*Date of Collection*	*Moisture*	*Ash*	*Nitrogen*	*Protein*
a. Rhodophyta						
1. Gracilaria edulis	Mandaitivu	10.12.82	3.69	38.46	2.28	14.25
	Nainativu	01.01.83	13.9	24.86	1.89	11.81
2. Gracilaria crassa	Mandaitivu	10.12.82	13.31	49.85	1.33	8.31
3. Gracilaria confervoides	Keerimalai	13.02.83	10.07	8.80	2.30	14.38
4. Laurencia obtusa	Mandaitivu	10.12.82	15.07	34.30	1.70	10.63
5. Jania natalensis	Mandaitivu	10.12.82	3.21	69.79	0.75	4.69
6. Hypnea musciformis	Mandaitivu	10.12.82	13.52	24.19	2.13	13.31
	Keerimalai	13.02.83	7.62	14.99	3.06	19.13
7. Acanthophora delilei	Keerimalai	13.02.83	9.98	25.94	2.69	16.87
8. Centroceros clavulatum	Mandaitivu	31.12.82	16.66	29.29	1.99	12.44
	Keerimalai	13.02.83	8.08	18.65	4.02	25.13
9 Gelidiella acerosa	Mandaitivu	31.12.82	14.12	12.07	1.67	10.44
b. Phaeophyta						
10. Padina pavonia	Mandaitivu	10.12.82	11.15	42.78	1.80	11.25
11. Turbinaria omata	Mandaitivu	31.12.82	19.43	24.63	1.38	8.63
12. Pocockiella variegata	Nainativu	01.01.83	13.37	19.82	1.18	7.38
13. Stoechospermum marginatum	Mandaitivu	13.02.83	13.09	21.94	1.49	9.31
14. Cystophyllum muricatum	Mandaitivu	13.02.83	13.84	35.14	1.45	9.06
15. Turbinaria conoides	Nainativu	01.01.83	14.13	16.95	0.93	5.81
16. Sargassum polycystum	Mandaitivu	31.12.82	17.07	35.51	1.61	10.06
	Nainativu	01.01.83	14.59	14.44	1.14	7.13
17. Sargassum tenerrimum	Mandaitivu	10.12.82	16.03	31.17	1.56	9.75
18. Hormophysa triquetra	Mandaitivu	13.02.83	13.06	46.91	0.91	5.69

(Contd.)

Table 1 (Contd.)

Alga	*Locality*	*Date of Collection*	*Moisture*	*Ash*	*Nitrogen*	*Protein*
c. Chlorophyta						
19. Struvea anastamosans	Mandaitivu	31.12.82	12.41	48.60	0.98	6.13
20. Codium sp.	Nainativu	01.01.83	16.41	26.22	1.41	8.81
21. Acetabularia crenulata	Casuarina	13.02.83	4.72	55.56	0.28	1.75
22. Chaetomorpha	Nainativu	01.01.83	17.27	38.92	1.44	9.00
sp.	Keerimalai	13.02.83	4.46	21.02	1.74	10.88
23. Ulva reticulata	Mandaitivu	13.02.83	11.56	20.11	1.57	9.81
	Nainativu	01.01.83	20.88	34.20	0.81	5.06
24. Ulva lactuca	Mandaitivu	10.02.82	12.73	29.71	3.17	19.81
	Casuarina	25.12.82	16.38	21.43	2.64	16.50
d. Angiosperm						
25. Thalasia	Mandaitivu	10.12.82	16.42	21.70	2.09	13.06
hemprichi	Nainativu	01.01.83	9.16	27.66	1.27	7.94

It is interesting to note that generally the seaweeds from the Keerimalai area have a higher protein content than those from the Mandaitivu coast, which in turn have a higher protein content than those from Nainativu coast.

Amounts of the minerals sodium, potassium, calcium and magnesium present in twenty five species of seaweeds were determined by the methods indicated above and our results are given in Table II. *Gracilaria edulis*, *Gracilaria crassa*, *Laurencia obtusa*, *Turbinaria ornata* and *Sargassum tenerrimum* have fairly large amount of potassium. *Jania natalensis*, *Acetabularia crenulata*, *Padina pavonia*, *Sturvea anastamosans*, *Thalasia hemprichi*, *Pocockiella variegata*, *Laurencia obtusa*, *Hypnea musciformis* and *Ulva reticulata* have reasonably large quantity of calcium. It is interesting to note that *Jania natalensis*, which is capable of accumulating calcium and depositing it in the form of a calcareous skeleton, has the highest amount of calcium. *Jania natalensis*, *Chaetomorpha sp*, *Padina pavonia*, *Laurencia obtusa*, *Ulva reticulata* and *Thalasia hemprichi* have more than 1% magnesium.

TABLE 2. Amounts of Sodium, Potassium, Calcium and Magnesium present in Seaweeds. All values are expressed in g/100g of air dried samples of seaweeds.

Alga	*Locality*	*Date of collection*	*Sodium*	*Potassium*	*Calcium*	*Magnesium*
a. Rhodophyta						
1. Gracilaria edulis	Mandaitivu	10.12.82	1.61	13.49	3.55	0.68
2. Gracilaria crassa	Mandaitivu	10.12.82	0.75	7.63	2.02	0.23
3. Gracilaria confervoides	Keerimalai	13.02.83	0.10	0.128	1.50	0.69

(Contd.)

(Table 2 Contd.)

Alga	*Locality*	*Date of Collection*	*Sodium*	*Potassium*	*Calcium*	*Magnesium*
4. Laurencia obtusa	Mandaitivu	10.12.82	1.22	4.32	4.99	1.35
5. Jania natalensis	Mandaitivu	10.12.82	0.70	0.28	23.85	2.71
6. Hypnea	Mandaitivu	10.12.82	0.50	0.58	4.83	0.38
musciformis	Keerimalai	13.02.83	0.13	0.106	3.00	0.74
7. Acanthophora	Keerimalai	13.02.83	0.10	0.106	1.57	0.45
delilei						
8. Centroceros	Mandaitivu	31.12.82	1.20	3.26	2.53	0.46
clavulatum	Keerimalai	13.02.83	0.10	0.103	2.97	0.72
9. Gelidiella	Mandaitivu	31.12.82	0.25	0.19	1.58	0.34
acerosa						
b. Phaeophyta						
10. Padina pavonia	Mandaitivu	10.12.82	0.59	1.13	10.96	1.36
11. Turbinaria	Mandaitivu	31.12.82	1.81	6.30	2.12	0.28
ornata						
12. Pocockiella	Nainativu	01.01.83	0.30	0.15	5.21	0.43
variegata						
13. Stoechospermum	Mandaitivu	13.02.83	0.25	1.10	2.08	0.07
marginatum						
14. Cystophyllum	Mandaitivu	13.02.83	0.10	0.58	2.46	0.15
muricatum						
15. Turbinaria	Nainativu	01.01.83	0.49	1.68	2.28	0.35
conoides						
16. Sargassum	Mandaitivu	31.12.82	2.62	3.93	3.15	0.56
polycystum	Nainativu	01.01.83	0.54	1.17	2.01	0.45
17. Sargassum	Mandaitivu	10.12.82	0.82	5.97	3.06	0.84
tenerrimum						
18 Hormophysa	Mandaitivu	13.02.83	0.09	0.68	2.67	0.42
triquetra						
c. Chlorophyta						
19. Sturvea	Mandaitivu	31.12.82	3.16	1.80	9.61	0.41
anastamosans						
20. Codium sp.	Nainativu	01.01.83	1.78	0.23	2.31	0.83
21. Acetabularia	Casuarina	13.02.83	0.14	0.27	16.06	0.39
crenulata						
22. Chaetomorpha	Nainativu	01.01.83	1.71	0.81	2.40	1.94
sp.	Keerimalai	13.02.83	0.21	0.10	2.88	1.27
23. Ulva reticulata	Mandaitivu	13.02.83	0.31	0.31	4.82	0.48
	Nainativu	01.01.83	0.77	0.38	3.79	1.35
24. Ulva lactuca	Mandaitivu	10.12.82	0.85	1.85	2.44	0.17
	Casuarina Beach	25.12.82	0.96	2.25	3.60	0.25
d. Angiosperm						
25. Thalasia	Mandaitivu	10.12.82	3.84	4.09	3.57	1.16
hemprichi	Nainativu	01.01.83	0.57	0.41	7.46	0.84

Our results on the colorimetric estimation of the amounts of iron and phosphorus are shown in Table III. It is seen that species such as *Gracilaria edulis*, *Padina pavonia*, *Pocockiella variegata*, *Chaetomorpha sp*, *Sargassum polycystum* and *Jania natalensis* are rich in iron. Also the seaweeds from the Nainativu and Mandaitivu areas generally have more iron content than those from Keerimalai area *Gracilaria edulis*, *Gracilaria crassa*, *Gracilaria confervoides*, *Hypnea musciformis*. *Codium sp*, *Chaetomorpha sp*, *Ulva lactuca* and *Thalasia hemprichi* have relatively large amounts of phosphorus.

TABLE 3. Amounts of Iron and Phosphorus present in seaweeds. All values are expressed in mg/kg of air dried samples of seaweeds.

Alga	*Locality*	*Date of Collection*	*Iron*	*Phosphorus*
a. Rhodophyta				
1. Gracilaria edulis	Mandaitivu	10.12.82	405	764
	Nainativu	01.01.83	1240	989
2. Gracilaria crassa	Mandaitivu	10.12.82	267	888
3. Gracilaria confervoides	Keerimalai	13.02.83	262	1168
4. Laurencia obtusa	Mandaitivu	10.12.82	674	514
5. Jania natalensis	Mandaitivu	10.12.82	940	206
6. Hypnea musciformis	Mandaitivu	10.12.82	658	259
	Keerimalai	13.02.83	409	1338
7. Acanthophora delilei	Keerimalai	13.02.83	102	225
8. Centroceros clavulatum	Mandaitivu	31.12.83	450	508
	Keerimalai	13.02.83	447	643
9. Gelidiella acerosa	Mandaitivu	31.12.82	344	395
b. Phaeophyta				
10. Padina pavonia	Mandaitivu	10.12.82	1266	477
11. Turbinaria ornata	Mandaitivu	31.12.82	372	252
12. Pocockiella variegata	Nainativu	01.01.83	1213	411
13. Stoechospermum marginatum	Mandaitivu	13.02.83	134	608
14. Cystophyllum muricatum	Mandaitivu	13.02.83	391	727
15. Turbinaria conoides	Nainativu	01.01.83	306	472
16. Sargassum polycystum	Mandaitivu	31.12.82	490	476
	Nainativu	01.01.83	373	469
17. Sargassum tenerrimum	Mandaitivu	10.12.82	925	540
18. Hormophysa triquetra	Mandaitivu	13.02.83	394	217
c. Chlorophyta				
19. Sturvea anastamosans	Mandaitivu	31.12.82	738	175
20. Codium sp.	Nainativu	01.01.83	602	877
21. Acetabularia crenulata	Casuarina	13.02.83	250	190
22. Chaetomorpha sp.	Nainativu	01.01.83	1179	951
	Keerimalai	13.02.83	593	716
23. Ulva reticulata	Mandaitivu	13.02.83	201	354
24. Ulva lactuca	Mandaitivu	10.12.82	219	1224
	Casuarina	25.12.82	542	633
d. Angiosperm				
25. Thalasia hemprichi	Mandaitivu	10.12.82	392	1326
	Nainativu	01.01.83	655	1316

The amounts of nitrogen, potassium and phosphorus present in selected species of seaweeds are shown in Table IV. It is interesting to note that *Gracilaria edulis*, *Laurencia obtusa*, *Padina pavonia*, *Ulva lactuca*, *Thalasia hemprichi*, *Gracilaria crassa*, *Sargassum polycystum* and *Sargassum tenerimum* have fairly large amounts of nitrogen, phosphorus and potassium and hence these could be used as fertilizers. Also other species which are rich in nitrogen, phosphorus or potassium could be mixed together to form a good fertilizer.

TABLE 4. The amounts of nitrogen, potassium and phosphorus present in selected species of seaweeds. All values are expressed in mg/kg of air dried samples.

Species	*Locality*	*Date of Collection*	*Nitrogen*	*Phosphorus*	*Potassium*
1. Gracilaria edulis	Mandaitivu	10.12.82	22800	764	134900
2. Gracilaria confervoides	Keerimalai	13.02.83	23000	1168	1280
3. Laurencia obtusa	Mandaitivu	10.12.82	17000	514	43200
4. Hypnea musciformis	Mandaitivu	10.12.82	21300	259	5800
	Keerimalai	13.02.83	30600	1338	1060
5. Acanthophora delilei	Keerimalai	13.02.83	26900	225	1060
6. Centroceros	Keerimalai	13.02.83	40200	643	1030
clavulatum	Mandaitivu	31.12.82	19900	508	32600
7. Gelidiella acerosa	Mandaitivu	31.12.82	16700	395	1900
8. Padina pavonia	Mandaitivu	10.12.82	18000	477	11300
9. Sargassum polycystum	Mandaitivu	31.12.82	16100	476	39300
10. Chaetomorpha sp.	Keerimalai	13.02.83	17400	716	1000
11. Ulva lactuca	Mandaitivu	10.12.82	31700	1224	18500
	Casuarina	25.12.82	24600	633	22500
12. Thalasia hemprichi	Mandaitivu	10.12.82	20900	1326	40900
13. Gracilaria crassa	Mandaitivu	10.12.82	13300	888	76300
14. Turbinaria ornata	Mandaitivu	31.12.82	13800	252	63000
15. Sargassum tenerrimum	Mandaitivu	10.12.82	15600	540	59700

Seaweeds also contain trace elements. These are a group of elements which are needed in infinitely small amounts and these are very essential for the growth of plants and animals. Some of the important trace elements are Fe, Cu, Zn, Mn, Co, B and Mo. Some of the trace elements form complexes with enzymes and catalyse in metabolic reactions. The element copper is found in the enzyme polyphenol oxidase and the respiratory pigment of invertebrates, homocyanin. The enzymes such as tyrosinase, laccase and ascorbic acid oxidase use copper to catalyse reactions.[1,9] Copper and cobalt are essential for health and productivity of animals. These two elements are associated with iron in the production of haemoglobin.[1,9]

The element cobalt, in addition to being an essential element of Vitamin B_{12} is important in the metabolism of sulphur containing aminoacids. Elements such as Zn, Mn, Mo, Cr and Cd are also involved in the biological processes.[13] Even though the trace elements have a vital function for human and animals they become toxic if present in relatively large amounts. The general recommended[10] limits for some of the elements are given below.

Element	Pb	Ni	Cr	Cu	Zn
Recommended limit/ppm	2	100	100	20	50

The amounts of Cu, Zn, Mn, Ni, Cd, Co and Cr present in twenty three species of marine algae were determined using Varian Model 1275 Atomic Absorption Spectrophotometer. The amount of lead present in these samples were determined colorimetrically after complexing with dithizone. No detectable amount of cobalt or chromium was found in any of these twenty three species. Our results, which are given in Table V, show that (i) *Padina pavonia* and *Sturvea anastomosans* have relatively large amounts of copper while the species *Stoechospermum marginatum*, *Sargassum polycystum* and *Thalasia hemprichi* have reasonable amounts of copper, (ii) the element zinc is found in relatively large amounts in *Sturvea anastomosans*, *Dictyota species*, *Padina pavonia*, *Stoechospermum marginatum* and *Hypnea musciformis* (iii) Manganese is found in relatively large amounts in red algae (iv) the species *Sturvea anastomosans*, *Gracilaria edulis*, *Centroceros clavulatum*, *Jania natalensis*, *Hormophysa triquetra*, *Sargassum polycystum* and *Thalasia hemprichi* have relatively high Ni content (v) the element Pb is found in relatively large amount in *Sturvea anastomosans*, *Gracilaria crassa*, *Gracilaria salicornia*, *Jania natalensis*, *Padina pavonia*, *Hormophysa triquetra* and *Sargassum polycystum* and (vi) Cadmium is found in the range 1 - 4 ppm.

Cadmium and lead are non-nutritive toxic elements. Seaweed species analysed have low cadmium level (1-4 ppm). However the level of lead is rather high. The statutory limit for Pb in food is 2 ppm.

Sturvea anastomosans, *Jania natalensis* and *Padina pavonia* have relatively large amounts of the toxic elements and these may be avoided as nutrients and fertilizers. Also it is apparent from the Table V that the seaweeds from the Mandaitivu coast are richer in trace elements than those from Nainativu.

TABLE 5. Amounts of Copper, Zinc, Manganous, Nickel, Lead and Cadmium present in seaweeds. All values are expressed as mg per kg (i.e. ppm) of air dried samples of seaweeds. (Date of collection is the same as in the Tables 1 & 2).

Alga	*Locality*	*Cu*	*Zu*	*Mn*	*Ni*	*Pb*	*Cd*
a. Rhodophyta							
1. Gracilaria edulis	Mandaitivu	5.3	9.2	397.3	24.0	8.3	3.3
	Nainativu	6.0	6.4	76.3	12.9	7.0	3.9
2. Gracilaria crassa	Mandaitivu	6.3	6.0	217.2	11.9	10.1	2.5

(*Contd.*)

(*Table 5 Contd.*)

Alga	*Locality*	*Cu*	*Zn*	*Mn*	*Ni*	*Pb*	*Cd*
3. Gracilaria salicornia	Mandaitivu (13.2.83)	3.4	6.6	62.0	15.5	9.9	1.3
4. Laurencia obtusa	Mandaitivu	5.2	6.4	129.7	14.3	8.6	2.2
5. Hypnea musciformis	Mandaitivu	2.7	11.9	149.6	14.5	8.7	1.3
6. Centroceros clavalatum	Mandaitivu	6.7	5.9	48.1	21.8	8.8	2.2
7. Gelidiella acerosa	Mandaitivu	2.7	7.3	102.8	12.3	5.7	2.4
8. Jania natalensis	Mandaitivu	3.0	6.9	87.6	32.2	19.3	3.1
b. Phaeophyta							
9. Padina pavonia	Mandaitivu	40.8	12.4	211.9	21.5	18.4	3.9
10. Stoechospermum marginatum	Mandaitivu	11.6	10.1	21.4	13.6	9.3	1.3
11. Cystophyllum muricatum	Mandaitivu	8.7	8.3	31.6	17.1	8.3	2.1
12. Dictyota sp.	Mandaitivu	7.2	14.5	37.2	16.3	8.1	2.0
13. Hormophysa triquetra	Mandaitivu	5.4	7.4	29.0	22.3	11.0	1.6
14. Sargassum polycystum	Mandaitivu	10.3	8.1	189.1	23.9	10.4	2.8
	Nainativu	5.6	5.4	29.0	6.9	6.9	1.6
15. Sargassum tenerrimum	Mandaitivu	7.9	7.6	138.6	13.6	9.3	2.4
16. Turbinaria ornata	Mandaitivu	4.0	4.5	27.9	9.7	5.4	1.6
17. Pocockiella variegata	Nainativu	5.0	6.9	63.5	16.2	10.1	2.5
18. Turbinaria conoides	Nainativu	3.1	3.0	22.6	7.6	7.4	2.1
c. Chlorophyta							
19. Sturvea anastamosans	Mandaitivu	20.7	20.2	110.2	37.3	18.5	2.4
20. Ulva reticulata	Mandaitivu	3.6	5.9	74.0	10.4	3.9	2.0
21. Chaetomorpha sp.	Nainativu	6.9	8.4	36.1	22.8	10.1	1.7
22. Codium sp.	Nainativu	4.5	10.4	45.1	9.7	9.3	4.3
d. Angiosperm							
23. Thalasia hemprichi	Mandaitivu	10.8	7.4	51.3	25.1	8.5	2.5
	Nainativu	8.4	7.3	70.9	19.8	13.4	2.5

Chloride ion which is a micronutrient and sulphur which is a macronutrient[2] are also found in seaweeds. Table VI gives the values obtained for the amounts of ionic chloride and total sulphur present in some seaweeds.

TABLE 6. Amounts of ionic chloride and total sulphur present in seaweeds. All values are expressed in g/100g of air dried seaweeds.

Alga	*Locality*	*Date of Collection*	*Ionic Chloride*	*Total Sulphur*
a. Rhodophyta				
1. Centroceros clavulatum	Mandaitivu	31.12.82	6.43	2.02
2. Gracilaria edulis	Mandaitivu	10.12.82	3.88	4.13
	Nainativu	01.01.83	1.58	2.79
b. Phaeophyta				
3. Sargassum polycystum	Mandaitivu	31.12.82	7.95	1.03
4. Sargassum tenerrimum	Mandaitivu	10.12.82	7.23	1.71
5. Pocockiella variegata	Nainativu	01.01.83	0.61	0.50
6. Stoechospermum marginatum	Mandaitivu	13.02.83	7.16	1.06
c. Chlorophyta				
7. Codium sp.	Nainativu	01.01.83	5.88	3.65
8. Chaetomorpha sp.	Nainativu	01.01.83	8.07	4.03
d. Angiosperm				
9. Thalasia hemprichi	Mandaitivu	10.12.82	5.34	0.58
	Nainativu	01.01.83	2.67	0.49

Our results show that *Pocockiella variegata* and *Gracilaria edulis* have relatively low amounts of ionic chloride. The species *Thalasia hemprichi*, *Pocockiella variegata*, *Sargassum polycystum* and *Stoechospermum marginatum* have relatively low amounts of sulphur.

4. Conclusion

Some species of seaweeds such as *Centroceros clavulatum, Gracilaria edulis, Gracilaria confervoides, Acanthophora delilei* and *Ulva lactuca* have relatively large amounts of protein and could be used for fortifying food items deficient in protein. Seaweeds such as *Gracilaria edulis, Laurencia obtusa, Padina pavonia, Ulva lactuca, Thalasia hemprichi, Gracilaria crassa, Sargassum polycystum* and *Sargassum tenerrimum* have fairly large amounts of the elements nitrogen, phosphorus and potassium and these could be used as fertilizers. *Gracilaria edulis* and *Gracilaria crassa* also have relatively large amounts of the trace elements. Attempts should be made to cultivate the above species of algae so that they could be profitably used.

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