Pakistan J. Sci. Ind. Res., Vol. 28, No. 2, April 1985.

ASCORBIC ACID AND DEHYDROASCORBIC ACID CONTENTS OF MARINE ALGAL SPECIES FROM KARACHI

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(Received December 2, 1984; revised March 11, 1985)

Ascorbic acid (AA) and dehydroascorbic acid (DHA) contents of 59 species of marine algae belonging to the Chlorophyceae, Florideophyceae and Phaeophyceae collected from Karachi, northern Arabian Sea, showed wide variations between the species studied. The amounts of AA and DHA were on the whole greater in species of brown seaweeds as compared to red and green seaweeds. With few exceptions, DHA was greater than AA. Vitamin C contents were remarkably high in all the species of *Sargassum* (Phaeophyceae) and *Ulva* (Chlorophyceae) tested and these may be utilized for the extraction of vitamin C on commercial scale.

INTRODUCTION

Seaweed is gaining wide popularity as an alternative source of food because it is cheap, readily accessible and occurs in considerable quantities in various parts of the world. The shortage of conventional food resources may pose a serious problem for the increasing world population and, as pointed out by Chapman and Chapman [1], the usage of seaweed may have to become widespread.

A part from major constituents, such as carbohydrates, proteins, fats and minerals, seaweed is known to be rich in various vitamins [1]. Determinations of ascorbic acid in seaweed have been carried out chiefly to study its role in the regulation of cell metabolism [2–7]. Liso, *et al.*, showed that in the red alga, *Pteroclaida capillacea,* ascorbic acid content is closely related to algal growth. Tsuchiya [8] and Black [9] have reviewed the literature on ascorbic acid contents of seaweeds. An important contribution in this field was made by Ishihara *et al.* [10] who observed significant variations in various species of algae.

A variety of seaweeds, some of which are plentiful, are available along the cost of Pakistan. Besides one paper by Saifullah [11] on a survey of the standing crop of seaweeds, no attempt has been made to determine the available tonnage of seaweed. Salim [12] described the seaweed communities at various levels in the intertidal area. Recently Qasim [13, 14] published information on chemical and biochemical constituents of abundant species of seaweeds from the Karachi coast. The present paper is concerned with the ascorbic acid and dehydroascorbic acid content of fifty-nine species of seaweeds belonging to Chlorophyceae, Floridcophyceae and Phacophyceae.

MATERIALS AND METHODS

Seaweeds were collected from Buleji, a rocky and partly sandy-cum-muddy beach about 18 km north-west of Karachi, during the period November 1982 to March 1983. The species investigated include both attached and drift plants. Each alga was thoroughly washed, blotted free of seawater and extraneous particles removed. The analyses were carried out on fresh samples. Five g. samples of each alga were ground in an electric grinder with 50 ml of metaphosphoric acid. In order to remove the residual gelatinous material, the homogenate was centrifuged at 20,000 g for 20 min. at 5°.

The total ascorbic acid content (AA+DHA) was determined by treating the extract with bromine to oxidize AA to DHA and evaluation of the latter as its phenylhydrazone derivative. DHA was analysed directly by means of its reaction with 2, 4-dinitro-phenylhydrazine. The difference between total AA and DHA gave the value of AA. Three samples of each alga were tested. The reaction medium employed was the same as that described by Roe and Osterling [15].

RESULTS

Chlorophyceae. Ascorbic acid (AA) and dehydro-

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ascorbic acid (DHA) contents of 20 species of green seaweeds belonging to genera are shown in Table 1. The green seaweeds were found to have DHA values ranging between 38 and 138 μg/g fresh weight (f.w.), whereas the AA content was in the range of 3 to 242 μg/g f.w. It is further evident from the table that in most of the species (17 out of 20) the amount of DHA was higher than AA. The three species of *Ulva*, namely, *U. fasciata, U. indica* and *U. Lactuca* were, however, exceptions, in which the reverse is true. Species of *Ulva* occur abundantly on the rocky beach of Buleji where they grow attached to rocks, often forming thick belts.

The amount of vitamin C (AA+DHA) varied greatly between the different species of seaweeds, the values ranging from 47 to 378μg/g f.w. The highest values (256-378 μg/g) were recorded in the species of *Ulva;* species of *Caulerpa ranked* came next in this regard. The lowest value of vitamin C was observed in *Bryopsis corymbosa.*

The data show that vitamin C contents of nine species belonging to the genera *Ulva, Caulerpa* and *Chaetomorpha,* ranged between 140 and 378 μg/g. These values are substantially higher than those of the remaining 11 species tested which showed contents ranging between 47 and 87 μg/g.

Florideophyceae. Total ascorbic acid and dehydroascorbic contents of 20 species of red seaweeds belonging to 15 genera are presented in Table 2.

The amount of DHA ranged between 30 and 186 μg/g f.w. It was observed that DHA values of only six species were higher than 100 μg/g. The highest amount of DHA was observed in two species of *Hypnea* and the lowest in *Coelarthrum muelleri.*

The AA content of red seaweeds ranged between 7 and 116 μg/g. It may be noted from the table that 5 species showed values which were higher than 50 μg/g. It is noticeable that the highest amount of AA was found in *Sarcodia dichotoma,* which also showed high values of DHA.

The data show that total vitamin C contents ranged between 37 and 267 μg/g. The highest value (267 μg/g) was recorded for *S. dichotoma.* Other species showing

Table 1. Ascorbic acid (aa) and dehydroascorbic acid (dha) contents of green seaweeds

(The values are expressed as μg/g fresh weight ± SD)

Species	Vitamin C (DHA + AA)	Dehydroascorbic acid (DHA)	Ascorbic acid (AA)
Bryopsis corymbosa	47.50 ± 1.25	44.37 ± 2.25	3.125
Caulerpa chemnitzia	173.33 ± 1.03	126.25 ± 1.58	47.08
C. scalpelliforms	140.45 ± 2.82	101.25 ± 3.24	39.20
C. taxifolia	186.66 ± 4.51	138.33 ± 10.91	48.33
C. peltata	154.36 ± 1.50	122.18 ± 1.87	32.18
C. racemosa	167.71 ± 1.87	129.37 ± 1.25	38.34
Chaetomorpha prosstarats	181.66 ± 7.49	130.83 ± 3.082	50.83
Cladophora fascicularis	70.0 ± 1.25	65.62 ± 1.25	4.38
C. fritschii	59.83 ± 2.23	51.66 ± 3.02	8.166
C. zoolingeri	86.88 ± 1.27	80.00 ± 1.2	6.875
Codium elongatum	67.91 ± 1.02	45.83 ± 1.290	22.08
C. latum	62.20 ± 3.06	38.66 ± 2.16	23.54
Enteromorpha compressa	87.49 ± 1.22	69.37 ± 0.12	18.125
E. intestinalis	80.00 ± 2.45	62.50 ± 2.5	17.50
E. prolifera	60.00 ± 1.53	47.50 ± 1.9	12.5
E. tubulosa	77.83 ± 5.13	51.66 ± 2.362	24.17
Ulva fasciata	278.33 ± 2.88	135.83 ± 5.773	242.50
U. indica	268.33 ± 1.29	107.08 ± 4.58	161.25
U. lactuca	256.87 ± 6.16	123.33 ± 2.04	133.54
Valoniopsis pachynema	69.99 ± 2.04	43.33 ± 2.04	26.66

Table 2. Ascorbic acid (AA) and dehydroascorbic acid (DHA) contents of red seaweeds

(The values are expressed as μg/g fresh weight ± SD)

Species	Vitamin C (DHA + AA)	Dehydroascorbic acid (DHA)	Ascorbic acid (AA)
Acanthophora spicifera	116.66 ± 1.29	66.66 ± 2.041	50.00
A. delilei	111.25 ± 2.05	96.25 ± 2.5	15.0
Agardhiella robusta	100.00 ± 1.35	70.00 ± 0.00	30.00
Botryocladia leptopoda	178.83 ± 1.02	123.50 ± 1.58	55.33
Champia parvula	92.61 ± 3.56	67.18 ± 3.125	25.43
Coelarthrum muelleri	37.46 ± 1.02	30.38 ± 2.04	7.08
Cystoclonium purpureum	177.91 ± 1.95	95.83 ± 13.53	82.08
Furcellaria lumbricalis	182.08 ± 0.52	70.00 ± 10.00	112.08
Gelidium pusillum	92.08 ± 2.14	63.125 ± 3.086	28.95
Gracilaria corticata	94.37 ± 5.62	75.00 ± 0.95	19.37
G. dentata	50.59 ± 1.52	37.91 ± 1.020	12.68
Halymenia polydactyla	170.0 ± 4.50	137.50 ± 0.0	32.5
H. porphyroides	116.25 ± 1.02	103.12 ± 1.25	13.125
Hypnea musciformis	211.75 ± 1.88	155.0 ± 0.00	56.75
H. valentiae	228.75 ± 1.36	186.25 ± 2.5	42.5
Laurencia filifoemis	104.38 ± 3.97	92.75 ± 1.50	11.625
L. pinnatifidia	70.91 ± 1.53	62.5 ± 1.58	8.41
Sarcodia dichotoma	267.07 ± 4.00	150.41 ± 1.881	116.66
Sarconema furcellatum	81.24 ± 5.70	67.08 ± 2.45	14.16
Sciaria indica	64.58 ± 6.89	39.16 ± 2.041	25.42

relatively high vitamin C contents are two species of *Hypnea: H. valentiae* and *H. musciformis.* The lowest amount of vitamin C (37 μg/g) was found in *Coelarthrum muelleri* which, as mentioned above, had the lowest AA and DHA contents. It is evident from the table that, with one exception (i.e. *Furcellaria lumbricalis)* all red seaweeds contained higher values of DHA than AA.

Phaeophyceae. Total ascorbic acid and dehydroascorbic acid contents of 19 species of brown seaweeds are detailed in Table 3.

The DHA content of brown seaweeds ranged between 16 and 323 μg/g. The highest amount was found in three species of *Sargassum,* viz. *S. bovianum, S. angustifolium* and *S. crassifolium,* which gave DHA yields ranging between 242 and 323 μg/g. Other brown seaweeds having DHA contents higher than 100 μg/g were *Cystoseira indica, Dictyopteris australis, lyengaria stellata* and *I. tetrastromatica.*

The AA content of brown seaweeds showed great variation, ranging between 6 and 323 μg/g. The highest value of AA, like that of DHA, is again encountered in species of *Sargassum.* The AA content of all other species was substantially lower than in Sargassum speicies. It is noteworthy that of the 19 species studied the AA contents of 11 species were less than 50 μg/g.

Wide variations in DHA and AA contents in species of brown seaweeds are also reflected in the vitamin C content which ranged between 22 and 541 μg/g. The highest vitamin C value was found in *Sargassum* species (447–646 μg/g). Other species having high amounts of vitamin C include *Dictyopteris australis,* (203 μg/g), *Ectocarpus confervoides* (200 μg/g), and *Iyengaria stellata (238* μg/g). It is evident from the table that the vitamin C yield is very low (less than 50 μg/g) from *Taonia atomaria, Petalonia debilis* and *Colpomenia sinuosa.*

DISCUSSION

The results of the present investigation show that the species of seaweeds studied generally contain more dehydroascorbic acid (DHA) than ascorbic acid (AA). There were, however, a few notable exceptions to this generalization. Six out of the 59 species of seaweeds tested showed

Table 3. Ascorbic acid (AA) and dehydroascorbic acid (DHA) contents for brown sea-weads

(The results are expressed as μg/gm of fresh weight ± SD)

Species	Vitamin C (DHA + AA)	Dehydroascorbic acid	Ascorbic acid
Colpomenia sinuosa	43.08 ± 5.18	27.08 ± 2.08	16.0
Cystophyllum muricatum	148.75 ± 2.04	82.5 ± 2.886	66.25
Cystoseira indica	167.5 ± 3.78	144.0 ± 2.922	23.50
Dictyopteris custralis	203.74 ± 2.51	169.58 ± 8.862	34.16
Dictyota dichotoma	96.66 ± 5.70	85.5 ± 3.47	11.16
Ectocarpus confervoides	200.0 ± 1.37	127.5 ± 8.21	72.5
Iyengaria stellata	238.75 ± 1.02	162.50 ± 2.738	76.25
I. tetrastromatica	164.26 ± 1.60	134.58 ± 2.458	29.68
Myriogloea grandis	64.99 ± 99	55.62 ± 2.20	9.37
Padina pavonia	76.45 ± 4.36	60.83 ± 2.041	15.625
P. tetrastromatica	73.75 ± 1.34	53.75 ± 4.107	20.00
Petalonia debilis	22.90 ± 5.14	16.45 ± 0.512	6.45
Sargassum bovianum	646.66 ± 3.06	323.33 ± 5.773	646.66
S. angustifolium	541.02 ± 7.19	284.12 ± 3.196	541.02
S. crassifolium	447.5 ± 1.83	242.5 ±11.90	205.0
Spathoglossum variables	141.66 ± 1.311	61.87 ± 0.684	79.79
Stoechospermum marginatum	70.66 ± 0.95	59.16 ± 1.290	11.50
Taonia atomaria	37.91 ± 2.58	23.75 ± 1.309	14.16
Zonaria variegata	87.5 ± 0.30	75.00 ± 0.00	12.5

higher values of AA than DHA; these species are *Ulva fasiata, U. indica* and *U. lactuca* (Chlorophyceae), *Furcellaria lumbricalis* (Florideophyceae), *Sargassum bovianum, S. angustifolium* and *S. crassifolium* (Phaeophyceae).

Ishihara *et al.* [10] reported higher values of AA in species of Phaeophyceae in comparison with the values for the Chlorophyceae and Florideophyceae. According to Tsuchiya [8], AA contents were on the whole higher in *Enteromorpha* spp. and *Ulva pertusa* (Chlorophyceae) than in *Gracilaris confervoides* (Florideophyceae). The AA value for *Pterocladia capillacea* from Italy was found to be 1500 μg/g dry weight in February [7], which compares favourably with the AA contents of the *Sargassum* spp. tested in the present investigation. Working on a red alga, *Pterocladia capillacea,* Liso *et at.,* [7] concluded that the AA/DHA ratio is a seasonal phenomenon and is correlated with growth. Their results showed that the amount of AA prevailed over that of DHA throughout the year. Their work was, however, related to the apical portions taken from the erect fronds of algae, whereas the present investigation was carried out on the whole plant. It is worth mentioning that the AA/DHA ratio reported by Liso *et al.* [7] contradicts that reported in one of their earlier publications [3] on the same species, in which they reported the dominance of DHA and AA in January and February.

The vitamin C contents of the seaweeds studied varied considerably from species to species. From the results presented, it may be seen that vitamin C contents of 59 species studied ranged between 47 and 378 (Chlorophyceae), 37 and 267 (Florideophyceae) and 22 and 541 μg/g dry weight (Phaeophyceae). The data show that brown seaweeds were on the whole more rich in vitamin C when compared with red and green seaweeds. The three species of *Sargassum* showed the highest amount of vitamin C. Other species containing relatively high amounts of vitamin C include three species of *Ulva (U. fasciata U. indica, U. lactuca), Sarcodia dichotoma* and *Iyengaria stellata.*

Acknowledgements. The authors are grateful to Dr. S.M. Saifullah, Department of Botany, University of Karachi, for his help in the identification of the species.

Thanks are also due to Mr. Khalid Anwar for his assistance with the field and laboratory work.

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