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VITAMIN C CONTENT OF SOME ALGAL PLANTS FROM THE MEDITERRANEAN SEA SHORE OF ALEXANDRIA: I- SEASONAL VARIATIONS.

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ABSTRACT

For about one year, regular monthly determinations of vitamin C content in some marine algae growing along the Mediterranean Sea shore of Alexandria were conducted. Also the variations in AA/DHA ratios were estimated throughout the whole period of investigation. The results revealed that the brown algae contained the highest values of vitamin C, the red algae contained intermediate values while the green algae contained the lowest values of this vitamin. The AA/DHA ratio in the investigated algae varied considerably from one species to another and also for the same species throughout the whole period of investigation depending on the algal growth condition.

INTRODUCTION

Both ascorbic acid (AA) and its oxidation product, dehydroascorbic acid (DHA) are normal constituents of plants, but under most conditions of growth, the reduced form (AA) is the predominant one (Loewus, 1980). The physiological role of ascorbic acid in plants has been surveyed by many workers and there are growing indications that ascorbic acid has several roles that are important to economy of the plant (Mapson, 1958; Edgar, 1970; De Lee et al., 1973; khan and Kolattukudy, 1974; Arrigoni et al., 1976 and Loewus, 1980).

The content of ascorbic acid in most seaweeds varies markedly with the season, (Jensen, 1964; Liso et al., 1978 and Munda, 1987).

The present work investigates seasonal variations in the total vitamin C content (AA+DHA) together with the changes in the ratio between ascorbic acid and dehydroascorbic acid (AA/DHA) of 25 species related to Chlorophyceae, Rhodophyceae and Phaeophyceae collected from the Mediterranean Sea shore of Alexandria during the period from October 1988 to February 1990.

MATERIALS AND METHODS

Algal Collection:

Algal species were collected from five localities along the Mediterranean Sea shore of Alexandria at Abu-Kir, Miami, Sidi Bishir, Stanley Bay and Shatby. Regular monthly visits were made to each locality during the period from October 1988 to February 1990. Numerous healthy plants were picked out during each visit from different areas each locality and washed several times with sea water to remove sand particles, then conveyed to the laboratory in plastic bags filled with sea water.

Vitamin C Determination:

Immediately after picking, epiphyte free fronds of each alga were thoroughly washed, blotted free of sea water and extraneous particles removed. Subsequently 2 gm fresh material from each alga were ground in a mortar with 25 ml of 5 % metaphosphoric acid, using quartz sand. In order to remove the residual gelatinous materials, the homogenate was centrifuged at 7,000 r/m for 20 minutes at 5^{o} C.

DHA was assayed directly by means of 2,4-dinitrophenyl hydrazine reaction. The AA determination was obtained by the difference between two values:

$$AA = (Total\ AA)-(DHA)$$

Total AA (AA+DHA) was obtained by treating the extract with bromine to oxidize AA to DHA and by evaluating the latter as phenylhydrazone. The reaction medium employed was the same as described by Roe and Oesterling (1944).

For the identification of the algal species the taxonomic references were consulted in addition to the herbarium specimens of late Prof. A.H. Nasr (Botany Dept., Alexandria University).

RESULTS

The data concerning the monthly and seasonal variations in the total values of vitamin C content and the AA/DHA ratios obtained from the spectrophotometric analyses of the investigated algae were presented in Tables 1, 2 & 3 while the seasonal variation of the same parameters were plotted as histograms in Figs. 1, 2 & 3. From these data it appeares that the brown algae contained the highest values of vitamin C, the red algae contained intermediate values while the green algae had the lowest values. Dictyota dichotoma was the alga that contained the highest content of vitamin C during July (613.5 Mg/g.f.w.) compared with the other investigated algae while the lowest value (9.7 mg/g.f.w) was recorded in **Colpomenia sinosa** during March. With the exception of **Padina pavonica, Nemalion helminthoides** and **Laurencia pinnatifida** which reached their highest vitamin C contents during spring, almost all of the investigated algae reached their highest vitamin C contents during summer or autumn. On the other hand, most of the investigated algae reached their lowest vitamin C contents during spring or winter.

The AA/DHA ratio in the investigated algae varied considerably from one species to another and also for the same species troughout the whole period of investigation. The maximum ratio (26.64) was recorded in Ceramium ciliatum during October, while the minimum ratio (0.03) was recorded in Cystoseira foeniculacea during July.

DISCUSSION

The content of vitamins in algae especially vitamin C had been intensively studied by many workers. Chinoy (1967 and 1969) had pointed out that AA is playing an important role in the differentiation of plants. Also, an increased AA content was found in organogenetic centers of plant apices during differentiation. Liso et al. (1978) concluded that the AA system is a seasonal phenomenon in the red alga Pterocladia capillacea and is closely related to the algal growth. Our results revealed that the increase of vitamin C content together with the increase in AA/DHA ratio in the investigated algae was noticed during the growth season of these algae (summer or autumn). Summer was the most favorable growth season for most algae present along Alexandria sea shore (Nasr, 1940; Mohsen, 1958; Metwalli, and 1966 Shaalan, 1971).

The results also revealed that in the algae species Cladophora pellucida, Enteromorpha intestinalis (cglorophyceae); Dictyota dichotoma, Colpomenia sinosa (Phaeophyta); Pterocladia capillacea, Hypnea musciformis (Rhodophytea) the maximum vitamin C content together with the highest value of AA/DHA ratio were obtained during their juvenile stages. This may reflect the main role of ascorbic acid in cell division and differentiation of thesealgae.

Edgar (1970) suggests that dehydroascorbic acid function as a mitotic inhibitor in vivo, while castillo et al. (1986) suggested that ascorbic acid might be involved in cell-wall regeneration.

Also, Munda (1987) noted that, in Ulva rigida, Enteromorpha species and Ectocarpus siliculosus, the maximum values of ascorbic acid content came out from a new generation of plants.

In Cystoseira foeniculacea a sudden and considerable drop in both total vitamin C content and AA/DHA ratio was noted during October, where the organism was unhealthy and heavily loaded with epiphytes.

Although in many of the investigated algae maximum content of vitamin C coincided with maximum AA/DHA ratio yet, some algae species (ex. Caulerpa prolifera, Halimeda tuna, Padina pavonica, Cystoseira foeniculacea, Corallina mediterranea and Laurencia species) showed a reverse trend.

Table 1

Monthly and seasonal variations of total (AA+DHA) vitamin C contents (T) ug g^{-1} f.w. and AA/DHA ratio (R) in some Chlorophycophyta species.

		Ulva fasciata	Ulva lactuca	Enteromorpha intestinalis	Enteromorpha linza	Cladophora Pellucida	Caulerpa racemosa	Caulerpa prolifera	Codium tomentosum	Codium elongatum	Halimeda tuna
Jan.	T	121.7	166.5	20.5	115.8	94.8	83.7	49.4	15.3	43.2	71.1
	R	1.12	0.59	0.27	1.25	0.81	0.66	0.45	0.94	0.39	1.21
Feb.	T	83.3	154.9	22.0	55.6	73.6	39.0	25.2	19.2	29.8	89.9
	R	1.12	0.84	0.52	1.77	0.46	1.28	0.66	0.57	0.52	0.68
Mar.	T	1.12	139.4	24.6	38.4	66.4	44.8	27.8	20.8	16.5	101.5
	R	0.55	2.56	0.22	1.72	0.27	0.48	0.54	0.64	0.39	0.58
Winter mean	T	76.0	135.6	22.3	70.0	78.3	59.2	34.2	18.5	29.8	87.7
	R	1.05	1.02	0.32	1.45	0.51	0.74	0.52	0.43	0.43	0.75
Apr.	T	28.5	128.6	21.4	23.2	60.1	26.4	40.5	27.0	22.2	116.4
	R	1.48	0.20	0.53	4.04	0.50	1.11	0.39	0.42	0.39	0.15
May.	T	29.3	48.3	23.0	20.4	53.4	17.9	46.8	27.4	27.4	129.8
	R	0.38	3.51	0.47	0.36	0.11	0.92	0.26	0.48	0.17	0.30
Jun.	T	47.2	41.2	23.0	87.0	48.0	20.0	64.5	46.5	32.5	135.0
	R	0.62	7.28	0.52	0.74	0.19	0.65	0.18	1.07	0.25	0.83

Spring	T	35.0	72.8	22.5	43.6	53.9	21.4	50.6	33.6	27.5	127.1
mean	R	0.69	0.78	0.51	0.84	0.26	0.89	0.26	0.68	0.26	0.39
Jul.	T	64.5	40.5	22.5	131.5	42.6	49.5	65.5	49.0	65.1	153.5
	R	0.32	0.80	0.61	1.09	0.08	0.21	0.20	0.15	1.03	0.25
Aug.	T	82.5	43.8	48.5	147.7	51.0	63.2	89.1	57.0	81.4	143.0
	R	0.77	0.33	0.18	2.11	0.20	0.31	0.56	0.20	0.59	0.22
Sep.	T	88.5	44.2	61.4	263.7	78.5	79.5	244.2	197.1	118.7	142.7
	R	0.38	0.39	0.35	1.88	2.30	0.58	1.2	12.05	1.35	1.03
Summer	T	78.5	42.8	40.8	181.0	57.2	64.1	99.6	101.0	88.4	139.7
mean	R	0.48	0.34	0.22	1.69	0.63	0.38	0.29	1.89	0.98	0.42
Oct.	T	102.2	170.6	141.6	190.0	79.7	93.8	69.2	116.0	89.5	139.6
	R	0.48	6.19	5.78	0.81	8.16	1.05	2.44	8.75	19.34	0.21
Nov.	T	139.5	172.9	274.6	154.5	121.0	98.4	59.7	92.4	63.3	107.5
	R	0.63	3.5	5.6	0.62	2.59	1.73	0.44	0.74	2.13	0.12
Dec.	T	156.4	182.9	45.7	140.4	124.4	112.7	45.9	53.3	61.5	94.3
	R	0.77	0.11	0.25	0.81	0.04	10.20	0.06	0.29	0.79	0.30
Autumn	T	129.4	175.3	153.9	161.6	105. 5	101.6	58.2	87.2	71.5	113.8
mean	R	0.64	1.3	3.7	0.75	1.07	1.29	0.68	1.46	2.63	0.20

Table 2

Monthly and seasonal variations of total (AA+DHA) vitamin C contents (T) ug g^{-1} f.w. and AA/DHA ratio (R) in some Phaeophycophyta species.

		Ectocarpus siliculosus	Dictyota dichotoma	Padina pavonica	Colpomenia sinosa	Cystoseira foeniculacea	Sargassum salicifolium
Jan.	T	83.4	175.6	153.7	15.0	207.5	172.8
	R	0.60	0.09	2.76	0.22	0.18	2.60
Feb.	T	59.7	147.3	104.8	13.5	185.4	170.1
	R	0.90	0.28	1.07	0.35	0.61	0.81
Mar.	T	53.6	114.0	65.7	9.7	135.1	163.6
	R	1.04	0.52	0.10	0.52	0.17	0.52
Winter	T	65.5	149.4	108.0	12.8	176.0	168.8
mean	R	0.79	0.24	1.80	0.33	0.30	1.03
Apr.	T	37.8	262.5	88.9	17.5	150.9	106.4
	R	0.54	0.21	0.37	0.97	0.28	0.12
May.	T	24.3	213.4	166.9	16.6	221.7	107.8
	R	0.38	0.26	0.58	1.34	0.16	0.72
Jun.	T	32.2	361.8	86.4	18.9	252.8	170.5
	R	0.27	0.12	0.79	0.65	0.17	0.07

Spring mean	T	31.4	279.2	114.0	17.7	208.4	128.2
	R	0.06	0.18	0.57	0.92	0.19	0.21
Jul.	T	39.1	316.5	136.0	25.2	400.0	183.5
	R	0.35	0.80	0.68	0.66	0.03	0.06
Aug.	T	42.0	350.5	---	32.5	539.5	204.0
	R	0.25	0.10	---	2.2	0.04	0.07
Sep.	T	104.4	349.1	---	132.0	480.8	228.5
	R	1.14	0.5	---	7.10	0.27	0.17
Summer mean	T	61.8	437.7	45.3	63.3	473.4	205.4
	R	0.67	0.38	0.68	3.55	0.11	0.11
Oct.	T	102.9	312.9	---	118.6	126.2	316.9
	R	3.59	0.36	---	6.28	0.16	1.83
Nov.	T	100.1	413.9	194.0	61.3	466.6	108.8
	R	1.84	0.36	1.64	0.49	1.08	0.21
Dec.	T	94.5	290.6	85.0	33.7	458.7	194.9
	R	1.4	0.15	1.22	0.64	0.09	1.59
Autumn mean	T	98.5	339.1	93.0	71.2	350.5	436.1
	R	2.08	0.29	1.50	1.74	0.39	3.72

Table 3.

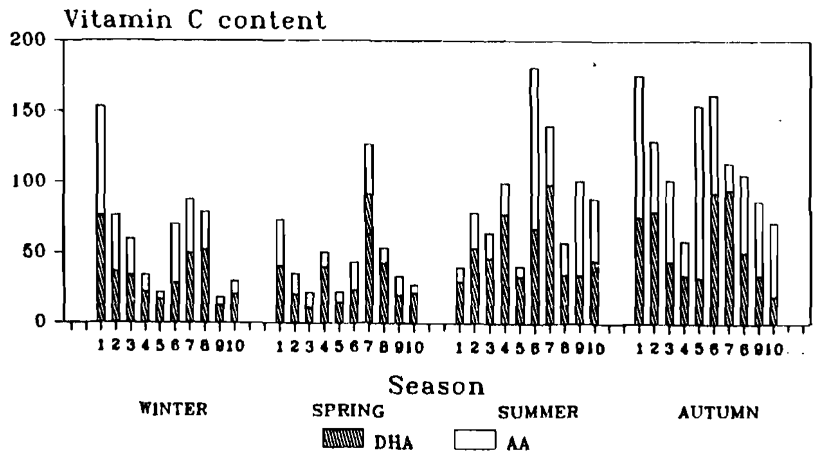
Monthly and seasonal variations of total (AA+DHA) vitamin C contents (T) ug g^{-1} f.w. and AA/DHA ratio (R) in some Rhodophycophyta species.

		Nemalion helminthoides	Pterocladia capillacea	Jania rubens	Corallina mediterranea	Hypnea musciformis	Ceramium ciliatum	Polysiphonia opaca	Laurencia papillosa	Laurencia pinnatifida
Jan.	T	---	59.0	120.9	112.2	46.9	36.0	171.7	115.0	16.5
	R	---	0.44	0.42	0.80	2.40	0.61	2.33	1.61	0.23
Feb.	T	---	54.3	91.3	77.8	40.3	35.1	132.2	88.5	20.0
	R	---	0.39	0.72	0.63	1.00	0.5	0.67	1.32	0.43
Mar.	T	49.6	44.3	82.5	52.8	57.2	32.8	106.9	71.1	21.4
	R	0.10	0.24	3.08	10.48	0.32	0.45	0.60	0.87	0.27
Winter mean	T	16.5	52.5	98.2	80.9	48.1	34.7	136.9	91.3	91.3
	R	0.10	0.36	0.86	1.12	0.78	0.53	1.16	1.28	0.34
Apr.	T	53.6	37.5	207.2	62.1	23.5	26.0	81.0	48.2	117.5
	R	0.32	0.60	5.24	0.19	0.18	0.24	0.56	0.41	0.07
May.	T	47.4	27.4	65.9	141.0	20.6	26.1	26.5	1.4	18.5
	R	0.44	0.29	1.25	1.62	0.26	0.28	0.31	0.31	0.31
Jun.	T	50.7	30.4	60.0	442.9	12.4	25.0	24.3	59.0	22.9
	R	0.25	0.35	0.17	0.35	0.33	0.62	0.27	0.15	0.28

Spring mean	T	50.6	31.8	111.1	215.4	21.9	25.7	43.7	27.1	52.9
	R	0.33	0.42	1.93	0.49	0.25	0.28	0.45	0.55	0.13
Jul.	T	---	64.2	181.5	320.0	44.5	22.8	26.5	55.0	63.0
	R	---	0.60	0.05	0.33	0.41	0.37	0.46	0.26	0.25
Aug.	T	---	73.0	89.5	264.8	64.0	52.0	40.0	223.5	44.9
	R	---	0.11	0.40	0.37	0.44	0.24	0.63	0.34	0.43
Sep.	T	---	82.5	87.5	247.9	54.7	120.3	593.0	91.9	25.9
	R	---	0.13	0.26	0.70	0.65	0.41	12.09	0.67	0.75
Summer mean	T	---	73.2	116.2	277.5	48.4	65.0	220.0	123.5	44.6
	R	---	0.23	0.17	0.44	0.50	0.36	6.48	0.41	0.39
Oct.	T	---	167.7	150.0	226.5	140.7	417.4	105.4	90.5	25.0
	R	---	4.70	0.2	2.30	11.13	26.64	0.57	1.09	0.32
Nov.	T	---	88.1	93.7	199.8	67.7	86.1	132.4	90.1	21.8
	R	---	0.66	0.67	0.80	4.2	1.7	0.50	1.25	0.42
Dec.	T	---	60.3	46.8	157.0	64.7	38.2	200.9	125.3	17.3
	R	---	0.72	0.79	0.57	2.2	0.3	8.01	3.23	0.7
Autumn mean	T	---	105.3	97.0	194.4	91.0	180.6	145.2	101.9	21.3
	R	---	1.69	0.41	1.08	5.07	6.14	1.47	1.71	0.44

Fig. 1

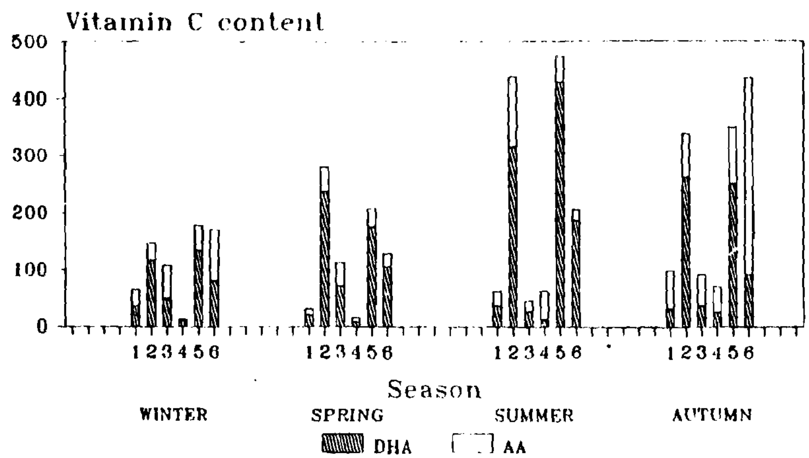
Seasonal variation of vitamin C content (ug/g f.w.) in some chlorophycophyta species.



1- *Ulva lactuca*
2- *Ulva fasciata*
3- *Caulerpa racemosa*
4- *Caulerpa prolifera*
5- *Enteromorpha intestinalis*
6- *Enteromorpha linza*
7- *Halimeda tuna*
8- *Cladophora pellucida*
9- *Codium tomentosum*
10- *Codium elongatum*

Fig. 2

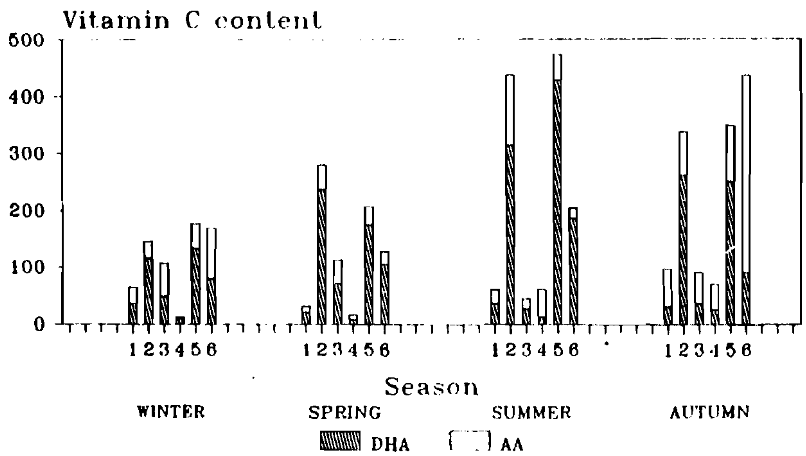
Seasonal variation of vitamin C content (ug/g f.w.) in some phaeophycophyta species.



1 - *Ectocarpus siliculosus*
2 - *Dictyota dichotoma*
3 - *Padina pavonica*
4 - *Colpomenia sinosa*
5 - *Cystoseira foeniculacea*
6 - *Sargassum salicifolium*

Fig. 2

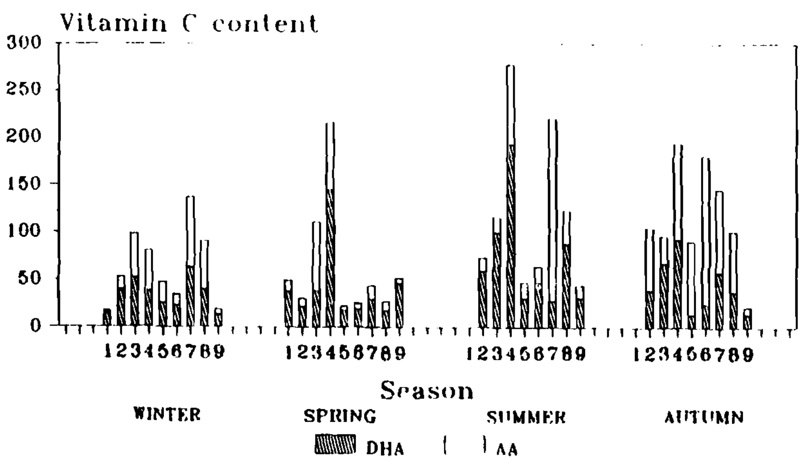
Seasonal variation of vitamin C content (ug/g f.w.)
in some phaeophycophyta species.



1 *Ectocarpus siliculosus*
2 - *Dictyota dichotoma*
3 *Padina pavonica*
4 *Colpomenia sinosa*
5 - *Cystoseira foeniculacea*
6 - *Sargassum salicifolium*

Fig. 3

Seasonal variation of vitamin C content (ug/g f.w.) in some Rhodophycophyta species.



1 *Nemalion helminthoides*
2 *Pterocladia capillacea*
3 *Jania rubens*
4 *Corallina mediterranea*
5 *Hypnea musciformis*
6 *Ceramium ciliatum*
7 *Polysiphonia opaca*
8 *Laurencia papillosa*
9 *Laurencia pinnatifida*

Working on 59 species of marine algae from Karachi, Northern Arabian Sea, Qasim and Barkati, (1985) showed that with few exceptions, DHA was greater than AA in the studied algae. Liso and Calabrese (1974) suggested that only a fraction of total DHA present in the cell is subjected to oxidation-reduction process, while most of it stays out of such metabolic process. The non-reduction of certain amount of DHA in vivo is probably related to the fact that a fraction of DHA is located in a compartment (possibly the vacuole) which is inaccessible to the DHA reductase. In other words, when the AA/DHA ratio is lower, more DHA is compartmented.

In conclusion, it could be regarded that many species of algae growing along the Mediterranean Sea shore of Alexandria are rich in vitamin C, especially those belonging to phaeophyceae. With some exceptions, there is a direct relationship between both growth and vitamin C content as well as AA/DHA ratio of the investigated algae.

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