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Research Article

Selected Chemical Constituents and Their Seasonal Variations in *Flabellia petiolata* (Turra) Nizam. and *Halimeda tuna* (Ellis & Sol.) J.V.Lamour. in the Gulf of Antalya (North-eastern Mediterranean)

Şengül BİLGİN, Ö. Osman ERTAN
Süleyman Demirel University, Eğirdir Fisheries Faculty, Isparta - TURKEY

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Abstract: Seasonal changes in selected chemical, ecological and morphological characteristics of *Flabellia petiolata* (Turra) Nizam. and *Halimeda tuna* (Ellis & Sol.) J.V.Lamour., which are commonly found in the Gulf of Antalya, were studied. Crude protein content of *F. petiolata* was found to be higher than that of *H. tuna*, whereas the crude fat contents of the two species were similar. On the other hand, compared to *F. petiolata*, *H. tuna* was rich in inorganic material. Both species were observed to be dense on a seasonal basis in the sampling area and they reached their maximum length during summer.

Key Words: *Flabellia petiolata*, *Halimeda tuna*, Chemical composition, Seasonal.

Antalya Körfezi'ndeki (Kuzeydoğu Akdeniz) *Flabellia petiolata* (Turra) Nizam. ve *Halimeda tuna* (Ellis & Sol.) J.V.Lamour.'nın Bazı Kimyasal Bileşenlerinin Mevsimsel Değişimi

Özet: Bu çalışmada, Antalya Körfezi'nde dağılım gösteren *Flabellia petiolata* (Turra) Nizam. ve *Halimeda tuna* (Ellis & Sol.) J.V.Lamour. türlerinin bazı kimyasal bileşenleri, ekolojik ve morfolojik özellikleri mevsimsel olarak incelenmiştir. *F. petiolata*'nın ham protein içeriği *H. tuna*'ya göre yüksek, oysa ham yağ içeriğinin her iki türde benzer olduğu görülmüştür. Diğer taraftan, *F. petiolata* ile karşılaştırıldığında *H. tuna*'nın inorganik madde ve bileşenlerince zengin olduğu saptanmıştır. Her iki türün yaz mevsiminde yoğun olduğu ve maksimum boya ulaştıkları görülmüştür.

Anahtar Sözcükler: *Flabellia petiolata*, *Halimeda tuna*, Kimyasal Bileşim, Mevsimsel.

Introduction

Since ancient times, seaweed and its products (agar, alginic acid, carragen, etc.) have been used in medicine, agriculture, cosmetics and the food industry. Japan is where the algal industry originated and the industry has developed rapidly in many countries in the Far East, where algae are used intensively (Güner & Aysel, 1991).

Investigations related to the determination of the chemical compositions of algae in Turkey started in 1961 and mostly concentrated on their pharmacological and microbiological importance as well as the isolation of chemical by products of these algae (Ertan & Ateş, 1996-1997).

The chemical composition of macroalgae shows variation according to species, seasons and habitats. Green algae (*Chlorophyta*) contain more proteins than other algae (*Phaeophyta, Rhodophyta*) and this makes green algae more tempting to study, especially for food additives as a protein source (Parekh *et al.*, 1977). It has been reported that green algae contains 68-88% water, 3-18% protein (Burkholder *et al.*, 1971; Levring *et al.*, 1969; Munda, 1972), 0.6-4.3% fat (Munda, 1972), 1-47% carbohydrate (Burkholder *et al.*, 1971; Imbamba, 1972), 2.5-41.6% calcium and 0.51-4.9% magnesium (Imbamba, 1972).

Complete assessment of the chemical composition of algae will undoubtedly provide further information for finding and evaluating new possibilities for using them. Considering the limited data available on the distribution, chemical composition and several other characteristics of the algae commonly found in the three seas surrounding our region (the Black Sea, the Aegean Sea and the North-eastern Mediterranean Sea), it is essential to collect and identify every group of algae to evaluate and determine new possibilities for their use. The purpose of this study was to analyse selected chemical constituents and seasonal changes associated with these constituents in some marine algae, such as *Flabellia petiolata* (Turra) Nizam. [= *Udotea petiolata* (Turra) Borg)] (Gallardo *et al.*, 1993) and *Halimeda tuna* (Ellis & Sol.) J.V.Lamour. (*Chlorophyta*), collected from the Gulf of Antalya over a one-year period. We also studied some ecological and morphological characteristics of these species and related any changes in these characteristics to the seasonal variations in the environment.

Materials and Methods

F. petiolata and *H. tuna* samples, ten each, were collected from the Gulf of Antalya, specifically from the sub-littoral zones of the coast at Side and Lara, between July 1995 and July 1996. The samples were separated from other contaminating species, weighed, dried in open air and packaged in polyethylene bags. The dried samples were ground with a mortar and again placed in small polyethylene bags for further use.

Two samples for each analysis were used and, for each sample, the water content was determined by the heating drying method. The ash content was determined by combustion at 600°C. The crude protein content was determined by Kjeldahl combustion, the total fat by soxhlet extraction, and the Ca^{+2} and Mg^{+2} contents in the ash according to EDTA-complexion methods. The dry matter, total carbohydrate and organic matter contents of samples were calculated mathematically. Total water content was calculated on the basis of wet weight, crude fat and crude cellulose; inorganic matter content was calculated on the basis of dry matter, and Ca^{+2} and Mg^{+2} content was calculated on the basis of total inorganic matter (Kacar, 1972; Keskin, 1975). Yearly seasonal values for each species are the average of the two samples. Average values and standard errors for each species were calculated according to known statistical methods (Düzgüneş *et al.*, 1983).

Results

F. petiolata species were found at a depth of 1-2 m on rock and stones during every season. It formed large populations and grew on the stems of *Posidonia oceanica* L. Del. (*Posidoniaceae*). This alga grew in shaded places such as caves and in shallow areas in spring and summer. The thalli reached their maximum length during summer (Table 1) and a partial reduction in thallus size was observed during winter.

H. tuna, collected from the coast at Lara, formed dense populations at inhabited areas at a 1m depth sheltered from waves. *Jania* sp. and other red algae species were quite common epiphytes on these plants. This alga was much more abundant in summer than in winter.

The total water content of *F. petiolata* ranged from 63.15% to 82.39%, the lower value being measured during spring. The total water content of *H. tuna* ranged from 77.27% to 82.70%, the lower value being observed during autumn. The average dry matter content of *F. petiolata* and *H. tuna* was 26.98±0.95% and 20.77±0.52% respectively, but there was a marked difference in the dry matter values of the two species during summer (Table 2). Crude fat content was highest during winter in *F. petiolata* (1.83 as % dry matter), whereas this value was lowest in *H. tuna* during the same season (0.68 as % dry matter). The average crude protein content of *F. petiolata* was higher than that of *H. tuna* (Table 2). The crude fat content of *F. petiolata* was lowest during spring and increased throughout the year. However, the crude fat content of *H. tuna* was highest during spring and decreased throughout the year. Crude cellulose, total carbohydrate and organic matter values of *H. tuna* were shown to be approximately twice as great as those of *F. petiolata*. On the other hand, the inorganic matter values of *F. petiolata* were half those of *H. tuna*.

Discussion

Ecological and morphological observations on *F. petiolata* collected from the coast at Side are supported

Table 1. The average maximum thallus length of samples.

	N Number	Spring cm. ± SE.	Summer cm. ± SE	Autumn cm. ± SE	Winter cm. ± SE
F. petiolata	10	7±0.07	10±0.10	9±0.04	8±0.08
H. tuna	10	6.5±0.08	9.5±0.11	6.8±0.09	6±0.04

Table 2. The chemical constituents of *F. petiolata* and *H. tuna* in different seasons.
(*):% wet weight, (◆): % dry matter, (■): % inorganic matter (N=2)

Seasons	Spring		Summer		Autumn		Winter		Average±SE	
Species	*F. petiolata*	*H. tuna*	*F. petiolata*	*H. tuna*	*F. petiolata*	*H. tuna*	*F. petiolata*	*H. tuna*	*F. petiolata*	*H. tuna*
Total water*	63.15	82.70	82.39	78.54	74.19	77.27	72.31	78.27	73.04±0.95	79.16±0.52
Dry matter	36.85	17.30	17.61	21.46	25.81	22.73	27.69	21.73	26.98±0.95	20.77±0.52
Crude protein◆	24.72	13.53	23.43	12.79	24.51	13.69	17.50	15.38	22.45±0.62	13.78±0.35
Crude fat◆	0.61	2.10	0.80	0.99	1.22	1.18	1.83	0.68	1.08±0.24	1.17±0.27
Crude cellulose◆	16.46	8.75	14.65	7.30	20.66	8.81	23.86	9.32	18.86±0.69	8.54±0.32
Total carbohydrate◆	29.63	11.90	54.20	23.82	40.34	21.33	33.67	10.04	39.45±1.11	16.77±0.88
Organic matter◆	45.96	27.53	78.43	37.60	66.07	36.20	53.00	26.10	60.80±1.28	31.84±0.82
Inorganic matter	45.04	72.47	21.57	62.40	33.93	63.80	47.00	73.90	36.87±1.16	68.10±0.82
Calcium■	19.76	22.42	14.00	19.30	17.68	19.30	17.08	22.08	17.16±0.51	20.76±0.44
Magnesium■	2.53	3.25	1.07	3.17	3.30	2.91	2.73	3.34	2.45±0.32	3.14±0.17

by information given by various investigators (Turna *et al.*, 2000). In both species, increases in the total water content observed during spring and summer could be explained by the fact that the maximum growth is attained during these seasons because of the optimum temperature and relevant changes in the ecological factors such as depth and location. It is obvious that the average crude protein content of *F. petiolata* is higher than that of *H. tuna*. The reason for this difference may come from the fact that the higher inorganic matter content of *H. tuna* resulted in a proportional decrease in the protein content of this species.

Previous reports showed that the crude fat content of green algae is low (Munda, 1972). Our calculations on the crude fat content of *F. petiolata* confirm these findings. The crude fat content of *H. tuna* reached its maximum levels in spring and decreased towards winter, as indicated in earlier reports (Burkholder *et al.*, 1971). The calculated crude fat content value agrees with that of green algae (Munda, 1972). Especially the observed crude fat value obtained from winter samples was very similar to that of *Halimeda opuntia* (L.) J.V.Lamour. (Munda, 1972; Burkholder *et al.*, 1971)

The average cellulose content of *F. petiolata* was 18.86±0.69%, which agrees with the total carbohydrate content of green algae. The total cellulose content of *F. petiolata* showed an increase from summer to winter and began to decrease in spring. This could be rationalised as a series of metabolic changes in this species taking place during these periods. The crude cellulose content of *H. tuna* and *F. petiolata* showed a marked difference. This could be related to species difference and to differences in their habitat, metabolic preferences etc. Burkholder *et al.* (1971) and Munda (1972) showed that the crude cellulose contents of *H. tuna* and *H. opuntia* were similar.

The highest inorganic matter content in *F. petiolata* was found in winter samples. Growth of this species slowed during this period and, as a result, there was a decrease in the production of organic matter. This may cause a mechanical weakness at the apices of the thalli. The inorganic matter content of *H. tuna* was almost twice that of *F. petiolata*. Similar to that of *F. petiolata*, the inorganic matter for *H. tuna* reached maximum levels during winter. This coincides with the period when the growth of the plant is at its slowest (Table 1), with a decreased rate of production of organic matter. Previously it was shown that *H. tuna* and *H. opuntia* had similar inorganic matter contents (Burkholder *et al.*, 1971). Parekh *et al.* (1977) determined that the crude ash contents of *Codium dwarkense* Boergesen, *Codium taylori* P.C.Silva, and *Codium decorticatum* (Woodw.) M. Howe showed seasonal differences. Parekh *et al.* (1977) showed that the crude ash content of *Udotea indica* (average value 49.37%) falls within the range of our findings for *F. petiolata*.

F. petiolata is found to contain on average 17.16±0.51% calcium and 2.45±0.32% magnesium.

These values are regarded as normal, and in our study the highest calcium level was found in spring samples and the highest magnesium level in autumn samples. Calcium and magnesium levels of this species are consistent with the values obtained from *U. indica* (Parekh *et al.*, 1977).

There is a parallelism between the observations related to *H. tuna* obtained from the coast at Lara and published information on this matter (Aydın, 1991; Delepine *et al.*, 1977; Turna *et al.*, 2000). The water content of *H. tuna* varies according to seasons and the highest value was found in spring samples (Table 2). The water content of this species agrees with the water contents for the marine macroalgal *Chlorophyta* (Levring *et al.*, 1969).

It was found that the crude protein content of *H. tuna* (average value 13.78±0.35%) agrees with the protein contents of other green algae and was higher than the protein content of *Halimeda macroloba* Dec., another species of the genus.

The calcium and magnesium value of *H. tuna* was found to be quite high (Table 2). It is known that the members of *Halimeda* Lam,1816 genus, which are significant carbonate producers in shallow warm seas (Delgado & Lapointe, 1994), accumulated large amounts of lime and were very effective in producing carbonate sand in these seas (Imbamba, 1972; Nybakken, 1988; Turna *et al.*, 2000). The high calcium content of *H. tuna* is to be expected; calcium and magnesium contents increase in parallel with the increase in inorganic matter in winter and spring (Table 2). In research related to the mineral matter content, *H. macroloba* was shown to contain 20.8% calcium (Imbamba, 1972). This value agrees with the calcium contents of *H. tuna*. In other work, it has been stated that *H. tuna* can be used in commercial animal feed preparations because of its high mineral matter contents and because it contains antimicrobial matter (Delepine *et al.*, 1987). These two species, which are different in terms of their chemical composition, are both very common during summer. Based on our results, *H. tuna* is rich in inorganic matter, and *F. petiolata* is rich in protein.

Finally, owing to the high protein content of *F. petiolata*, it would be suitable to use it as a source of protein in animal feeding and feed additive matter in animal feed, especially as a source of mineral matter containing a high level of inorganic matter of *H. tuna*. These algae can benefit our natural wealth especially since we are surrounded by seas on three sides.

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