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Seasonal evaluation of chemical composition of *Codium fragile* (Suringar) Hariot distributed in Canakkale Strait (Dardanelles), Turkey.

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ABSTRACT

The significant increase of the World population in recent years has linked researchers to focus on the utilization of marine food resources additional to the terrestrial ones for human consumption. Being an important source of protein and an effective source used not only as fertilizer but also in the industry with its useful chemical content makes them a target topic for research. In the present study, temporal and spatial changes of the chemical compositions of *Codium fragile* were investigated. The analyses were carried out seasonally (fall, winter, spring and summer). Significant differences were recorded in the findings obtained for the species collected in relation to the seasons and stations.

Introduction

The food industry in the world is facing new challenges in food supply for human consumption, seeking new resources as alternatives to terrestrial food. Marine based food resources are promising candidates for this new challenge. As an important source of protein marine algae are not only used as a food for human but also effectively used in a variety of fields from fertilizers to industrial products.

Chemical composition of algae has been of interest to researchers since 1900s. The possibility of using algae as a food for human consumption has been widely investigated. It has been reported that marine algae may have high levels of nutritional value even more than some terrestrial plant sources. In Turkey, studies on marine algae concentrated mostly on their taxonomy. Recent studies however, are focused on their chemical composition and possible utilization in the medical issues. Utilization of algae in the pharmaceutical industry has begun with their use in soda and iodine production and continued with the production of organic materials such as alginate, carrageen and agar (Santelices 1989). Furthermore, algae with its high levels of protein, vitamins, amino acids and minerals and low levels of lipid have put this marine source in a high ranking for human food right after fish, in terms of healthy food products (Southgate 1990).

Almost 50% of the nature collected or cultured algae in the world are being used in the food industry, while 40% of the total production is used in the pharmaceutical and cosmetic industry and 10% in other fields of production (Chapman and Chapman 1980; Güner and Aysel 1999).

Even though there is an increase of research on marine algae in Turkey with its long coastline share to the Black Sea, Sea of Marmara, the Aegean and the Mediterranean Sea has, the utilization of marine algae as a food for human consumption is still relatively rare compared to other countries. It is essential to encourage and improve the utilization of marine algae, well known healthy food for human consumption.

Green algae, Chlorophyta, comprise single cell, colony forming, or multicellular species, where more than 9000 species are known. About 90% of green algae are distributed

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in fresh waters, while 10% are available in the sea. They contain Chlorophyll a, b and various carotenoids (carotene, lutein, xanthophylls, and pirenoids). They store photosynthesis products carbohydrates in the form of starch and fats.

Material and methods

In the study conducted in Çanakkale Strait (formerly the Dardanelles) (40º 02'-40º 30' North and 26º 10'-26º 45' East), seasonal samples of *C. fragile* from Chlorophyta division have been collected from eight different locations from September 2007 to June 2008. The experimental stations were chosen as Gelibolu, Eceabat, Havuzlar and Soğandere, Lapseki, Yapıldak, Çanakkale and İntepe (Figure 1).

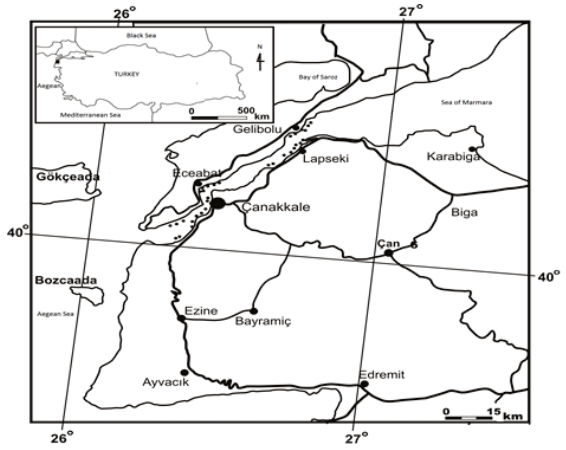

Figure 1. Dardanelles (Experimental location; 40º 02'-40º 30' N; 26º 10'-26º 45' E).

Illustration of *Codium fragile* (Suringar) Hariot used in the study is shown in Figure 2. The samples were separated from epiphytes and carefully washed with tap water immediately after collection. After drying in an oven at 70°C until constant weight, the samples were then grinded into flour using a rotatory grinder and prepared for laboratory analyses, such as crude protein, crude lipid and crude ash contents. Lipid analyses were conducted according to Folch et al. (1957), protein and ash were analyzed in duplicates according to AOAC (2000) methods. Nitrogen free extracts were calculated with deduction of nutritional fractions from hundred.

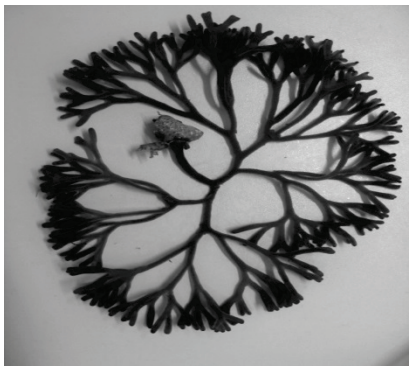

Figure 2. *Codium fragile* (Suringar) Hariot used in the study.

Results

In the present study, *C. fragile* taxa belonging to *Chlorophyta* division has been used due to its abundance and availability in almost all locations and all season round in the Strait of Çanakkale.

Studies on the utilization of marine algae, important resources of the ocean environment, can be developed by consideration of seasonal effects or location based distribution of these resources. Results of the present study conducted at different locations for a period of one year were given in Table 1. From findings demonstrated in Table 1, it can be concluded that the chemical composition of *C. fragile* showed significant differences in various locations and seasons.

The highest protein content of 12.5% was recorded in autumn from the samples collected at Eceabat location. The highest lipid level 9.3% in *C. fragile* was observed again in autumn samples at Yapıldak location, while the highest ash content of 54.31% was recorded in Çanakkale during the summer period. Protein (3.03-4.01%) and lipid (1.02-1.05%) levels were lowest during the spring and the summer periods, respectively in the sampling location of Çanakkale. Ash level in *C. fragile* was lowest (27.45%) in the samples collected in Lapseki station during the autumn period.

The protein levels recorded in the winter period was highest (15.7%) in the samples collected at Çanakkale station, while the lowest level of protein (4.11%) was found in the Intepe station. For the lipid levels of *C. fragile* in the winter season, the highest content of 9.02% was found in the Eceabat location and the lowest level of lipid (2.07%) was observed in samples collected in Gelibolu. Ash contents of *C. fragile* again in the winter period were found as the highest (67.3%) in İntepe, and the lowest (22.6%) in Çanakkale stations.

During the evaluations for chemical composition of *C. fragile* collected during the spring season, protein levels were found as the highest (10.1%) in Lapseki, and the lowest (3.03%) in Gelibolu station. In the same season lipid contents showed the highest value of 5.73% which were seen in the samples collected at İntepe, while the lowest level of lipid (1.05%) was found in Gelibolu station. In contrast to the lowest protein and lipid levels found in Gelibolu, ash content (66.9%) in the same location was found to be the highest among other locations. The lowest ash content (30.2%), however was found in Havuzlar location.

Changes in the percentage of protein levels were also recorded for *C. fragile* during the summer period in different experimental stations in Çanakkale Strait. The highest level of 10.9% ± 0.81 was found in Lapseki, while the lowest protein content (4.01%) was seen in samples from Gelibolu. In regards to differences in lipid levels collected during the summer period, the highest level of 5.02% ± 0.29 was recorded in samples from Lapseki station, while the lowest lipid content of 1.02% ± 0.69 was seen in the Gelibolu location. Comparison of ash levels in *C. fragile* collected during the summer period from different experimental stations in Çanakkale Strait, showed the highest content (54.4% ± 0.64) of ash in samples from

Table 1. Seasonal changes in the chemical composition of *C. fragile* in different locations

		Stations							
		Gelibolu	Eceabat	Havuzlar	Soğandere	İntepe	Çanakkale	Yapıldak	Lapseki
Autumn	Protein	-	12.50	11.36	-	12.23	11.71	7.62	11.09
	Lipid	-	8.43	6.84	-	6.17	9.19	9.63	6.46
	Ash	-	41.9	48.9	-	49.7	54.3	46.0	27.5
	NFE	-	37.1	33.0	-	31.9	24.8	36.7	55.0
Winter	Protein	12.61	12.15	10.58	10.45	4.11	15.70	5.75	9.24
	Lipid	2.07	9.02	4.28	4.08	3.45	2.81	4.92	7.17
	Ash	31.2	32.5	37.0	38.3	67.3	22.6	54.6	58.7
	NFE	54.1	46.3	48.1	47.2	25.1	58.9	34.7	24.9
Spring	Protein	3.03	8.08	8.51	8.18	9.24	7.18	8.92	10.1
	Lipid	1.05	3.37	5.56	3.55	5.73	5.19	5.51	5.04
	Ash	66.9	32.6	30.2	36.9	35.8	40.7	31.6	51.1
	NFE	29.0	56.0	55.8	51.3	49.3	47.0	54.0	33.8
Summer	Protein	4.01	8.06	9.92	9.86	10.0	8.81	9.72	10.9
	Lipid	1.02	2.88	4.09	3.56	2.98	3.06	4.65	5.02
	Ash	54.4	35.9	29.0	39.1	28.8	25.1	30.2	49.1
	NFE	40.6	53.2	57.0	47.5	58.2	63.1	55.5	35.0

Gelibolu, and the lowest levels (25.08% ± 0.85) of ash in samples from Çanakkale Station.

Significant changes were found in Nitrogen free extracts (NFE) of *C. fragile* in terms of seasonal samplings from different experimental stations. The highest level of NFE (55%) in autumn period was found as the highest in samples from Lapseki, while the lowest level (24.8%) was reported in Çanakkale location. During the winter season however, the highest level of NFE (58.9%) was observed in samples from Çanakkale, while the lowest level (24.9%) was found in those collected at Lapseki location. Analyses results of samples during the spring season, showed the highest level of NFE (75.6%) in İntepe, and lowest (29.0%) in those from Gelibolu station. For the summer period, the highest level of NFE (79.2%) was recorded in samples collected at İntepe station, while the lowest value of 35.0% was observed in those from Lapseki.

Discussion

In the present study, seasonal evaluations of chemical compositions of *C. fragile* taxa distributed in the Strait of Çanakkale were conducted at eight different stations. At the end of the one year field study, it has been recorded that protein contents varied according to seasons and experimental locations.

Protein contents of green algae were reported to be between 10-26% (Arasaki and Arasaki 1983; Darcy-Vrillon 1993) and the protein level of *Ulva* species were reported between 15-20% on dry matter basis (Burtin 2003). The findings in the present study showed similar results with previous studies. Lipid contents of algae are relatively low compared to those of other marine products, and differ between 1-5% in almost all algae species (Morales et al. 2005). In green algae however, lipid levels are reported between 0.6 and 4.3% (Parekh et al. 1977). These values also showed similarities with the findings in the present study. Ruperez et al. (2002) reported that the ash contents of algae are considerably lower than those of terrestrial plants. Ash contents of *C. fragile* in the present study were between 25-67% of level. Nitrogen free extracts (NFE), known as cellulose and carbohydrates contents, were calculated with deduction of nutritional fractions from hundred. NFE levels in the present study were found over 50% of the total compound for all samples collected during the year around.

The utilization of algae has been in an increasing period due to new outcomes from researches on their nutritional composition or benefits on human health. Production, market or the consumption of algae in China, Japan, Korea, Canada and France has become prominent (McHugh 2003).

The nutritional benefits of algae are considered as sufficient nutrients in terms of their rich protein, energy, vitamin or mineral contents when compared to animal or plant based food sources. Algae are capable to provide most of the necessary proportion for daily intake levels of vitamins A, C, B_2 and B_{12} (Chapman and Chapman 1980).

The potential of fisheries and aquatic resources of Turkey due to its geographical and ecological location can be considered as more profitable compared to many other countries, however, the utilization of algae in Turkey is much lower than Asian countries. As an important component of the food chain, algae is not only an important food source for human consumption, but also an important ingredient for animal food production as well as an important raw material for the fertilizer, pharmaceutical, cosmetics, and the textile industry. Algae are also used in medicine and contain compounds with antifungal, antiviral and antibacterial characteristics (Trono 1999).

As an important protein source with a wide range of utilization, algae have attracted researchers more and more in recent years. However, knowledge on the seasonal variations in their chemical composition and their

availability in different locations depending on the seasons are important information for sustainable utilization of algae as high value protein supply for human consumption in the future. Further studies are encouraged on the utilization and production of algaa as food ingredients or raw materials in various fields.

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