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RESEARCH ARTICLE

Chemical composition of *Ulva rigida* C. Agardh from the Çanakkale Strait (Dardanelles), Turkey

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Abstract

The significant increase of the world population in recent years has encouraged researches to focus on the utilization of marine food resources together with 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 *Ulva rigida* C.Agardh a target topic for research. In present study, seasonal and locational changes of the chemical compositions of *U. rigida* were investigated. The analyses were carried out in duplicate and seasonally (fall, winter, spring and summer). Significant differences were recorded in the findings obtained for the species collected in terms of seasons and stations.

Keywords: Macroalgae, *Ulva rigida*, chemical composition, Çanakkale Strait (Dardanelles)

Introduction

The utilization of marine resources has become more important nowadays due to the rapid increase of world's population. Especially countries with insufficient agricultural production are facing new challenges in terms of food resources alternative to agricultural and industrial resources. Marine based food resources are considered as important alternatives for the food supply of the increasing world population for the future (Drum 2014).

Green algae (Chlorophyta) are comprised of single cell, colony forming, or multicellular species. About 9,000 species are known, among which 90% are available in freshwater, while 10% are distributed in the seas. They contain chlorophyll a, b and a various carotenoids (carotene, lutein, xanthophylls, and

pirenoids). They store photosynthesis products, carbohydrates, in the form of starch and fats.

Marine algae are considered as important resources in marine environment; hence various studies in terms of their utilization have been conducted for many years. The industrial utilization of algae began with soda and iodine production and continued with the production of organic materials such as alginate, carrageen or carrageenan (Santelices 1989).

Studies on chemical composition of algae began in the 1900's and there are numerous studies in this field today. In earlier studies the possible utilization of algae as a food source has been reported with special reference to their high protein contents comparable to the terrestrial product (Haug 1964; Lee 1977; Jeon *et al.* 1980; Aguilera-Morales *et al.* 2005). Furthermore, the high levels of protein, vitamins, amino acids, minerals and the low level of fat in algae has brought this food source to a higher rank after fish as an health food product for human consumption (Southgate 1990).In many countries the utilization of algae is increasing with the outcomes of new studies and reports on their nutritional composition and advantages as a functional food source. The production, marketing and consumption of algae have shown a significant increase in countries such as China, Japan, Korea and France (McHugh 2003).

Ulva species are rich in vitamins and well-consumed as an alternative for vegetables and salads. Additionally they can also be utilized as fertilizer due to their high level of nitrogen content. For example in India or eastern Asian countries, algae are used as feed or fertilizer. It has been reported that *Ulva* constitutes around 25% of the world's total green algae production (Padua *et al.* 2004).

Ulva rigida C. Agardh used in the present study can easily adapt to different environmental conditions and is tolerant to salinity. It is a cosmopolite species, distributing shallow and rocky areas. Being tolerant to different environmental conditions, however, makes it possible to widely distribute in waters rich with nutrients such as nitrogen and phosphorous (Cirik *et al.* 2001).

There are some studies related with *U. rigida* in Izmir Bay, Turkey, by Çetingul *et al*. (1994, 1995), but researches on the distribution and seasonal changes of chemical composition of *U. rigida* in the Çanakkale Strait (Dardanelles) are rare. Hence, the aim of the present study is to evaluate the chemical composition of *U. rigida* distributed in the Çanakkale Strait (Dardanelles) in terms seasonal variation at different locations in the Strait.

Materials and Methods

Samplings were made seasonally at eight localities (Gelibolu, Eceabat, Havuzlar and Soğandere, Lapseki, Yapıldak, Çanakkale and İntepe) of Çanakkale Strait (40º02'-40º30' N, 26º10'-26º45'E) between September 2007 and June 2008 (Figure 1).

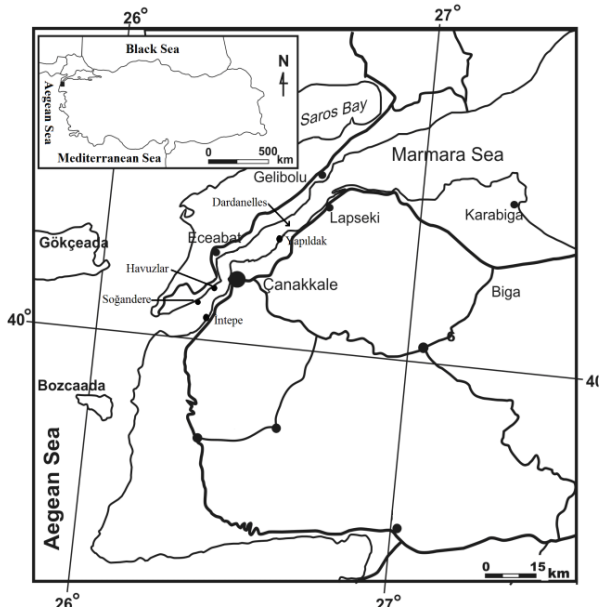

Figure 1. Location of sampling sites in the Çanakkale Strait (Dardanelles)

Collected samples were separated from epiphytes and carefully washed with tap water. Afterwards the samples were dried in a fume hood. The dried samples were then grinded into powder using a rotatory grinder. These samples were then used for nutritional analyses such as crude protein, crude lipid and crude as contents. Lipid analyses were conducted according to Folch *et al*. (1957), protein and ash were analyzed in duplicates according to AOAC (2000).

Analysis of variance and the Duncan multiple-range test were used to detect significant differences ($p < 0.05$) in protein, fat, ash and nitrogen free extracts of *U. rigida*. All statistical analyses were performed using the SPSS Statistical Analysis Software Program for Windows, Version 10.0.1, 1999.

Results and Discussion

The protein content of *U. rigida* has been recorded between 4.81% and 21.21%; with the highest level in the summer period at Lapseki (21.21%) and lowest in

Table 1. Seasonal changes of chemical composition of *Ulva rigida* in various locations of the Çanakkale Strait (NFE: Nitrogen free extracts; n.t.: not tested) Values (means ± standard deviation of data for duplicated groups) with different superscript letters for each season in the same column are significantly different at 5% level.

Autumn (%)				
Stations	**Protein**	**Fat**	**Ash**	**NFE**
Gelibolu	14.04±0.68^{c}	3.31±0.73^{a}	29.66±0.81^{d}	52.99±0.91^{a}
Havuzlar	7.89±0.37^{a}	5.94±0.47^{b}	27.64±0.59^{c}	58.53±0.61^{b}
Soğandere	n.t	n.t	n.t	n.t
İntepe	n.t	n.t	n.t	n.t
Çanakkale	n.t	n.t	n.t	n.t
Yapıldak	7.98±0.63^{a}	3.40±0.40^{a}	24.11±0.50^{b}	64.51±0.69^{c}
Lapseki	9.99±0.33^{b}	3.89±0.42^{a}	16.24±0.35^{a}	69.88±0.83^{d}
Winter (%)				
Stations	**Protein**	**Fat**	**Ash**	**NFE**
Gelibolu	13.27±0.68^{d}	0.95±0.23^{a}	14.55±0.76^{a}	71.23±0.72^{d}
Havuzlar	11.56±0.57^{c}	5.94±0.92^{c}	16.26±0.68^{b}	66.24±0.84^{c}
Soğandere	11.41±0.40^{c}	0.11±0.04^{a}	16.87±0.59^{b}	71.71±0.78^{d}
İntepe	5.12±0.29^{a}	0.31±0.12^{a}	33.19±0.63^{f}	61.38±0.54^{b}
Çanakkale	10.49±0.44^{c}	2.04±0.14^{b}	24.80±0.52^{d}	62.67±0.69^{b}
Yapıldak	7.28±0.23^{b}	2.40±0.30^{b}	23.22±0.47^{c}	67.10±0.71^{c}
Lapseki	15.10±0.67^{e}	2.31±0.19^{b}	30.82±0.41^{e}	51.77±0.54^{a}
Spring (%)				
Stations	**Protein**	**Fat**	**Ash**	**NFE**
Gelibolu	10.73±0.53^{c}	4.02±0.44^{d}	15.83±0.85^{ab}	69.42±1.05^{a}
Havuzlar	13.30±0.62^{d}	0.85±0.13^{b}	16.95±0.34^{bc}	68.90±0.85^{a}
Soğandere	7.25±0.25^{a}	0.21±0.02^{a}	18.75±0.41^{de}	73.79±0.79^{bc}
İntepe	7.13±0.25^{a}	1.01±0.08^{b}	17.39±0.24^{cd}	74.47±0.89^{bc}
Çanakkale	9.54±0.42^{b}	1.43±0.16^{bc}	19.75±0.81^{e}	69.28±0.77^{a}
Yapıldak	9.89±0.47^{bc}	1.36±0.31^{b}	16.10±0.44^{abc}	72.65±0.65^{b}
Lapseki	7.64±0.35^{a}	1.96±0.18^{c}	15.31±0.74^{a}	75.09±0.58^{c}
Summer (%)				
Stations	**Protein**	**Fat**	**Ash**	**NFE**
Gelibolu	10.04±0.71^{c}	1.15±0.20^{ab}	19.74±0.40^{c}	69.07±0.92^{b}
Havuzlar	4.81±0.30^{a}	2.49±0.17^{cd}	21.45±0.76^{d}	71.25±0.82^{c}
Soğandere	6.60±0.42^{b}	3.16±0.92^{d}	19.80±0.57^{c}	70.28±0.78^{bc}
İntepe	n.t	n.t	n.t	n.t
Çanakkale	5.41±0.26^{ab}	0.76±0.07^{ab}	15.99±0.38^{b}	77.84±0.83^{e}
Yapıldak	8.71±0.57^{c}	0.39±0.33^{a}	16.20±0.49^{b}	74.70±0.86^{d}
Lapseki	21.21±0.87^{d}	1.79±0.28^{bc}	11.29±0.78^{a}	65.71±0.83^{a}

the summer period at Havuzlar (4.81%) with a significant difference ($p<0.05$). In earlier studies, protein contents of green algae have been reported as 10–26% (Arasaki and Arasaki 1983; Darcy-Vrillon 1993) and the dry based protein level

of *Ulva* species is given as 15–20% by Burtin (2003). Our findings in the present study showed similarities and our values fall in the same range with previous studies in terms of the protein content of *Ulva* species (Table 1).

Seasonal changes of fat contents of *U. rigida* taxa collected from different locations in the Çanakkale Strait varied between 0.1-5.9% and differed significantly among sampling locations ($p<0.05$). Fat contents of algae are relatively lower than those of other marine products, being around 1-5% in most algae species (Morales *et al.* 2005). In green algae, the fat content is reported to vary between 0.6% and 4.3% (Parekh *et al.* 1977). Results of the present study showed highest and lowest fat levels during autumn and winter seasons at Havuzlar and Soğandere (0.11% and 5.94%, respectively). Padua *et al.* (2004) reported protein levels of 6-16%, ash levels of 17-31%, fat levels of 0.5-3.2%, cellulose level of 3-12% and carbohydrates of 46-72% in *Ulva lactuca* L., *Ulva fasciata* Delile and *Ulvaria oxysperma* (Kützing) Bliding. These values are in agreement with the findings of protein and fat contents of the present study.

Higher levels of ash contents have been reported for algae compared to terrestrial plants (Ruperez *et al.* 2002). In the present study, ash level was found between 11–33% and showed significant differences among sampling locations ($p<0.05$). Padua *et al.* (2004) reported ash level for *U. oxysperma* was between 18.91% and 22.14%, for *U. lactuca* between 12.54% and 13.23%, and for *U. fasciata* between 17.75% and 20.61% during the winter season. Our findings in terms of ash content in *U. rigida* were comparable with those of previous studies.

Based on the results of the laboratory analyses for nutritional fractions, nitrogen free extracts were calculated with deduction from hundred. Nitrogen free extracts (NFE) are known as cellulose and carbohydrates contents. The amount of NFE was found more than 50% of the total compound. Highest level of NFE (77.84%) was found in Çanakkale during the summer period, while the lowest level (51.77%) was recorded in Lapseki during the winter period. Seasonal changes in NFE levels of *U. rigida* collected from different locations in the Çanakkale Strait showed significant differences among sampling locations ($p<0.05$).

An increase in protein and lipid content was recorded with the decline in seawater temperature. The high level of protein at Gelibolu and Lapseki can be attributed to the pollution in these locations.

Even though Çanakkale, with its rich marine resources, has an important potential in terms of fisheries and aquaculture production there has been no utilization of marine algae or algae products in the area. Algae, an important link in food chain, are valuable source not only as food for human consumption,

but also as a valuable ingredient for animal feed industry, pharmaceutical and cosmetics industry, and textile industry.

Chemical compositions of *U. rigida* distributed in the Çanakkale Strait were investigated for eight experimental stations in the area. According to the results from the study, it has been found that the protein content of the studied taxon showed seasonal variations and differed among experimental stations depending on seasons. *U. rigida*, with its high level of protein content and abundance in the Turkish coasts, is a marine based protein source and its sustainable utilization should be encouraged for the future of high value protein supply for human consumption as well as for various industries.

Çanakkale Boğazı'ndan *Ulva rigida* C. Agardh'nın kimyasal kompozisyonu

Özet

Dünya nüfusundaki hızlı artışa bağlı olarak, gıda ve hammadde gereksiniminin karşılanmasında karasal canlıların yanı sıra deniz canlılarından yararlanma ihtiyacı da ortaya çıkmıştır. Deniz algleri protein içerikleriyle önemli bir besin kaynağıdır. Ayrıca gübreden endüstriye kadar her alanda kullanılan önemli bir hammadde kaynadır. Bu nedenle alglerle ilgili çalışmalar hızla artarak günümüze gelinmiştir. Bu çalışmada, Çanakkale Boğazı'nın sekiz farklı noktasından alınan *Ulva rigida* C. Agardh taksonunda mevsimsel olarak kimyasal kompozisyon değişimi incelenmiştir. Analizler mevsimsel olarak (sonbahar, kış, ilkbahar ve yaz) ve iki tekrarlı olarak yürütülmüştür. Araştırma sonucuna gerek mevsimsel gerekse istasyonlar bakımından önemli farklılıklar belirlenmiştir.

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