Variations in energy values and lipid content in *Enteromorpha* spp. from the Gulf of Gdańsk*

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Energy values
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Enteromorpha spp.
Gulf of Gdańsk

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Abstract

The variations in energy values and lipid content in *Enteromorpha* spp. collected from Jurata at monthly intervals during the period from November 1992 to October 1993 and from 7 stations situated on the coast of the Gulf of Gdańsk during September 1993 in relation to season and place are presented.

As far as the samples from Jurata are concerned, seasonal variations in energy values and lipid content are observed when the highest total energy values and lipid content were recorded at the beginning of the growing season during April and May – between 14.0 and 10.8 J mg^{-1} DW – for total energy and between 6.0 and 5.0% of DW for lipid content. After this time, these values started to decrease and fluctuated between 8.2 and 10.5 J mg^{-1} DW for total energy and between 2.5 and 3.7% of DW for lipid content. The values of ash fluctuated within a wide range between 12.2 and 27.5% of DW; here, the highest values were recorded at the end of the growing season and the lowest values at its beginning.

Moreover different values were recorded for energy, organic matter, ash and lipid content in samples collected from different stations on the coast of the Gulf of Gdańsk during September, where the highest total energy values and lipid content

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were recorded in the samples from Chałupy followed by those from Jurata – 9.9 and 9.5 J mg^{-1} DW for total energy and 3.4 and 3.5% of DW for lipid content respectively.

1. Introduction

Enteromorpha spp., a green alga in the family Ulvaceae, is common in the intertidal zone of certain bays, and is an important alga from several economic points of view. Previous studies (Tsuda and Bryan, 1973; Bryan, 1975; Lundberg and Lipkin, 1979) reveal that the genus *Enteromorpha* is the preferred food of the herbivorous rabbitfishes *Siganus spinus* and *Siganus argenteus*. It is also used as a food source by people in some Asian countries, such as the Philippines and Japan (Hoppe, 1966; Tamura, 1970; Velasquez, 1972). In recent years, increasing interest has been shown in edible seaweeds in Europe; in particular, several algae, including species of *Ulva* and *Enteromorpha*, have been authorised for human consumption by the French authorities. Sea-vegetables are of nutritional interest as they are low-calorie food, rich in vitamins, trace elements, minerals and dietary fibres (Ito and Hori, 1989; Lahaye, 1991). Consumption of sea-vegetables could in particular increase the intake of dietary fibres and limit the occurrence of diseases (obesity, diabetes, heart disease, cancer) associated with the roughage-poor diets of the western countries (Southgate, 1990).

Although *Enteromorpha* spp. are widely distributed in the Gulf of Gdańsk, there are only a few papers on it: its distribution in the Gulf of Gdańsk (Pliński *et al.*, 1982; Pliński and Florczyk, 1984), its taxonomy (Pliński *et al.*, 1988), effect of particular hydrocarbons on the photosynthesis and respiration (Latała and Wójcik, 1979), and the concentration of some elements (Szefer and Skwarzec, 1988; Bojanowski, 1973). Nothing was found in the literature about the energy value of *Enteromorpha* spp.

The aim of this work was to determine the variations in energy value and lipid content of *Enteromorpha* spp. from the Gulf of Gdańsk with respect to season and place.

2. Materials and methods

The materials used in the present investigations were collected from Jurata at monthly intervals from November 1992 to October 1993 and also from 7 stations located on the coast of the Gulf of Gdańsk (Fig. 1.) during September 1993. Samples were collected by hand from the shallow littoral, then kept in seawater during transport to the laboratory, where they were washed with distilled water. After that, the materials were dried at 60°C to constant weight and homogenised. The energy values were measured directly

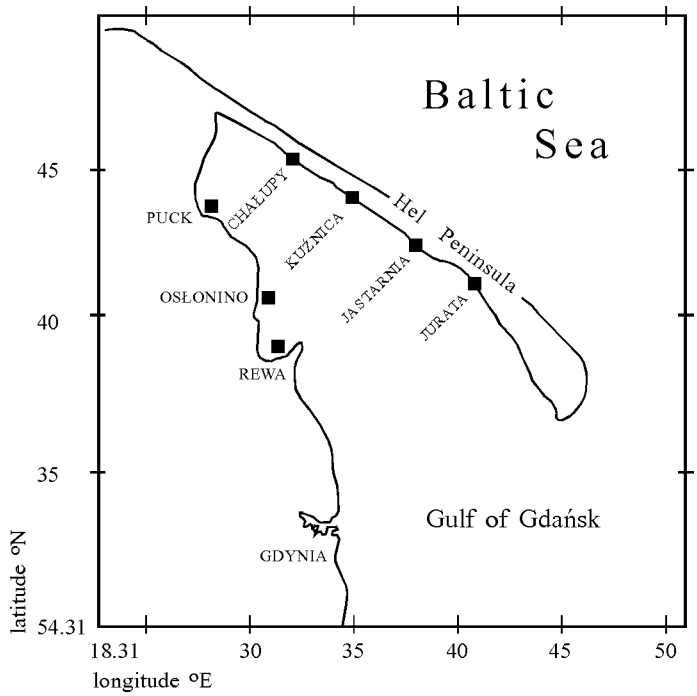

Fig. 1. Location of stations

using a Phillipson-type microcalorimetric bomb (Phillipson, 1964), the operating principles of which were described by Klekowski and Bączkowski (1973). The remaining ash was used to determine the organic compound content in the dry matter. For each sample 3 combustions were carried out; these were followed by the calculation of average values. The results of total energy values are expressed in [J mg^{-1} DW], and the energy value of organic matter in [J mg^{-1} AFDW]
where
DW – dry weight,
AFDW – ash free dry weight.

For lipid separation a mixture of chloroform – methanol – water was used, utilising the method of Blight and Dyer (1959). When determining lipids, the method of Marsch and Weinstein (1966) was used, which involves the measurement of extinction and reading off the lipid level from the model curve plotted on the basis of glyceral tripalmitin. Extinctions were read off using a SPEKOL II Carl Zeiss Jena Spectrophotometer at wavelength of 360 nm. For each sample three results were calculated and the average found; the results are expressed in % of DW.

3. Results and discussion

Seasonal variations in energy values of *Enteromorpha* spp. from Jurata were recorded (Tab. 1 and Fig. 2): the highest values were found in samples collected during April and May – between 14.0 and 10.8 J mg^{-1} DW and between 16.8 and 14.5 J mg^{-1} AFDW. At other times the respective values varied between 8.2 and 10.5 J mg^{-1} DW and from 9.5 to 13.5 J mg^{-1} AFDW. The average values of total energy and energy value of organic matter during the year were 10.1 J mg^{-1} DW and 12.8 J mg^{-1} AFDW respectively; they do not differ much from the results recorded by Best and Dassen (1987) for three species of aquatic macrophytes growing in meso- to eutrophic Lake Vechten, the Netherlands. At the same time these values are very low when compared with the average energy values of animals, so this increases the importance of *Enteromorpha* as a source of food for people who need special food rich in vitamins, minerals and dietary fibres, but low in energy content.

Table 1. Seasonal variations in energy value, organic matter, ash and lipid content in *Enteromorpha* spp. from Jurata

Date	Energy values		Organic matter	Ash	Lipid
	total	organic matter			
	[J mg^{-1} DW]	[J mg^{-1} AFDW]	[% of DW]		
1992					
Nov.	9.0	12.0	77.8	22.2	4.0
1993					
Apr.	14.0	16.8	83.6	16.4	6.0
May	10.8	14.5	80.0	20.0	5.0
June	8.2	10.6	78.1	21.9	3.7
July	10.1	13.0	77.9	22.1	3.7
Aug.	8.3	9.5	87.8	12.2	3.0
Sept.	9.5	12.4	77.6	22.4	3.5
Oct.	10.5	13.5	72.5	27.5	2.5
Mean ± SD	10.1 ± 1.9	12.8 ± 2.3	79.4 ± 4.6	20.6 ± 4.6	3.9 ± 1.1
Minimum	8.2	9.5	72.5	12.2	2.5
Maximum	14.0	16.8	87.8	27.5	6.0

Enteromorpha spp. from Jurata also exhibited distinct seasonal variations in their lipid content (Fig. 2), with a maximum in April and May between 6.0 and 5.0% of DW; from June to October these values started to decrease and fluctuated between 2.5 and 3.7% of DW. A similar lipid

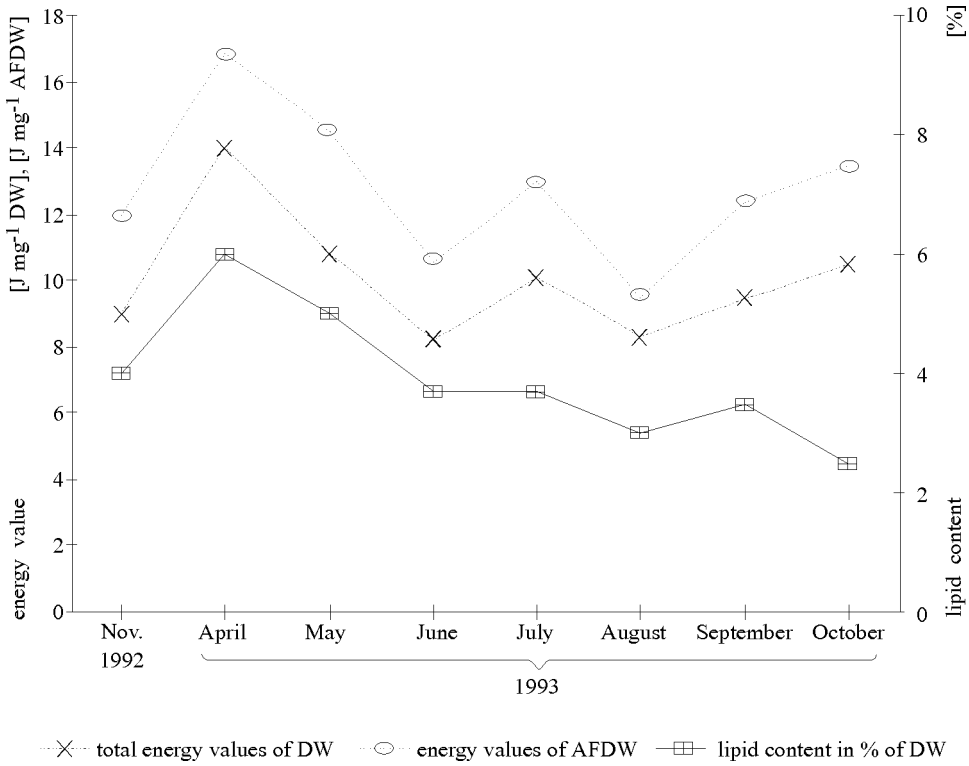

Fig. 2. Seasonal variations in energy values and lipid content of *Enteromorpha* spp. from Jurata

level (4.6% of DW) was found by Banaimoon (1992) for *Enteromorpha flexuosa* from the Hadramout coast (Yemen).

The lowest organic matter value (72.5% of DW) and the highest ash value (27.5% of DW) were recorded in samples collected during October 1993 (Fig. 3).

As shown in Tab. 2 and Figs. 4 and 5, different values were recorded for the energy content, organic matter, ash and lipid content of *Enteromorpha* spp. from different stations in the Gulf of Gdańsk. The highest energy and lipid content were recorded in samples from Chałupy and Jurata – 9.9 and 9.5 J mg^{-1} DW for total energy, 12.1 and 12.4 J mg^{-1} AFDW for organic matter, and 3.4 and 3.5% of DW for lipid content respectively.

The values of ash (Fig. 5) ranged between 8.8 and 32.2% of DW; and lie within the range of values recorded by Bojanowski (1973), Munda and Gubensek (1976, 1986), and Szefer and Skwarzec (1988).

From the above results it is clear that the variations in all the parameters are very significant during the year and in different places. To discover

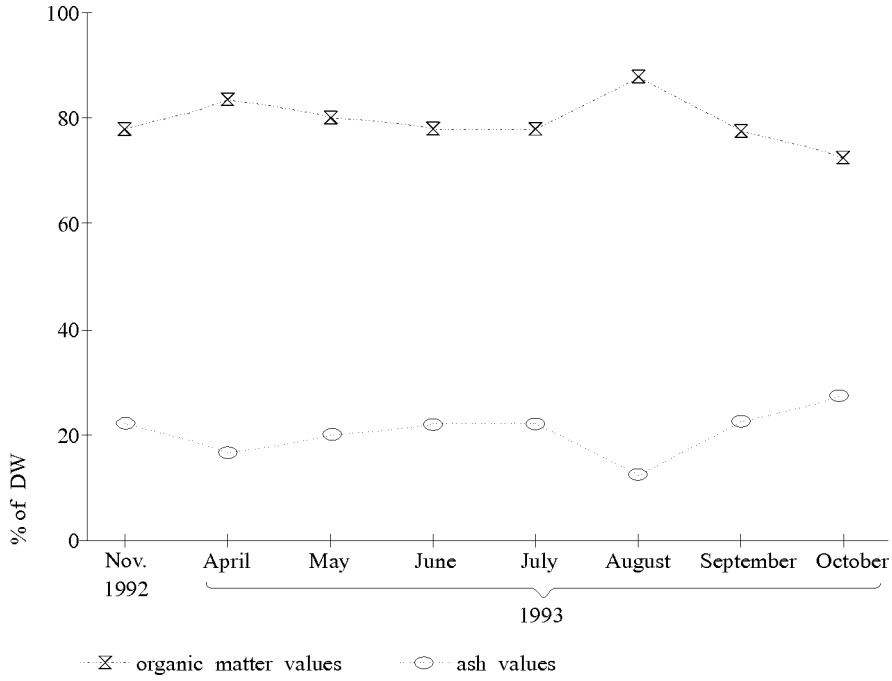

Fig. 3. Seasonal variations in organic matter and ash content of *Enteromorpha* spp. from Jurata

Table 2. Variations in energy value, organic matter, ash and lipid content in *Enteromorpha* spp. from seven stations in the Gulf of Gdańsk

Station	Energy values		Organic matter	Ash	Lipid
	total	organic matter			
	[J mg^{-1} DW]	[J mg^{-1} AFDW]	[% of DW]		
Rewa	6.3	7.9	80.1	19.9	2.8
Osłonino	8.4	10.2	82.3	17.7	2.7
Puck	6.4	9.5	67.8	32.2	2.1
Chałupy	9.9	12.1	82.0	18.0	3.4
Kuźnica	8.4	9.2	91.2	8.8	2.9
Jastarnia	5.5	6.5	85.2	14.8	2.7
Jurata	9.5	12.4	77.6	22.4	3.5
Mean ± SD	7.8 ± 1.7	9.7 ± 2.1	80.9 ± 7.2	19.1 ± 7.2	2.9 ± 0.5
Minimum	5.5	6.5	67.8	8.8	2.1
Maximum	9.9	12.4	91.2	32.2	3.5

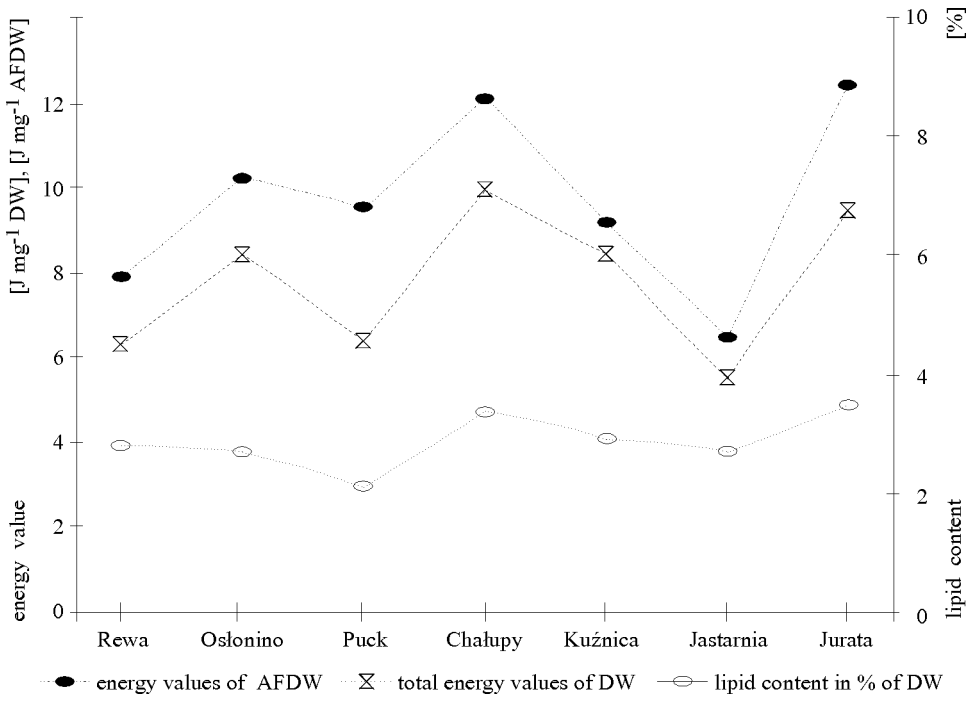

Fig. 4. Variations in energy values and lipid content of *Enteromorpha* spp. from various regions of the Gulf of Gdańsk

Table 3. Linear correlation coefficients between the parameters studied in *Enteromorpha* spp. from Jurata

	A	B	C	D	E
A	1.00				
B	0.96	1.00			
C	0.08	–0.14	1.00		
D	–0.08	0.14	–1.00	1.00	
E	0.75	0.74	0.34	–0.34	1.00

Legend:
A – total energy value,
B – energy value of organic matter,
C – organic matter content,
D – ash content,
E – lipid content.

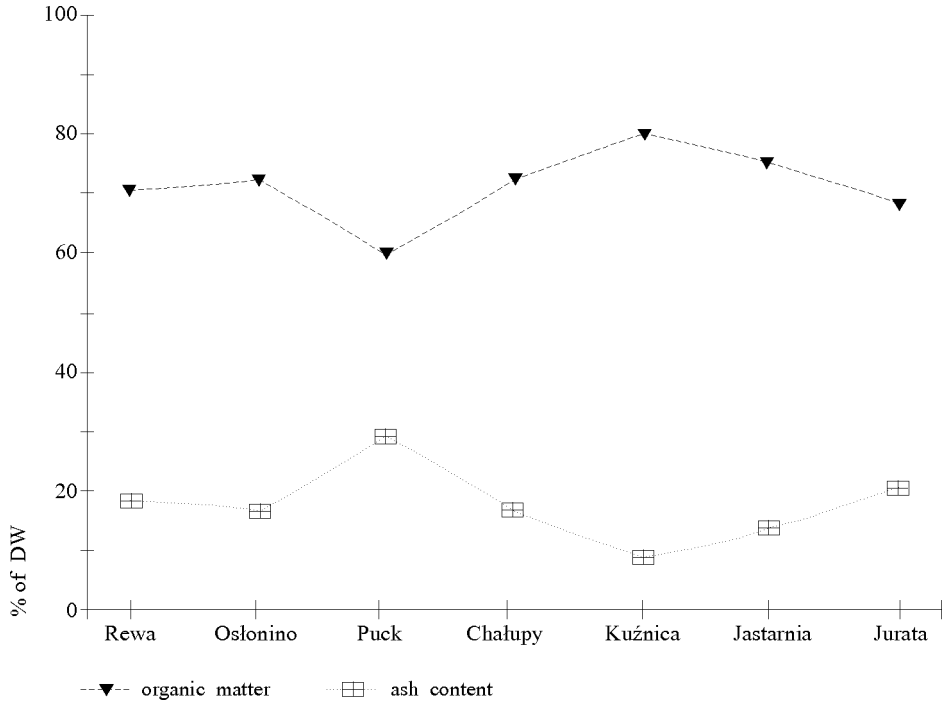

Fig. 5. Variations in organic matter and ash content of *Enteromorpha* spp. from various regions of the Gulf of Gdańsk

Table 4. Linear correlation coefficients between the parameters studied in *Enteromorpha* spp. from the Gulf of Gdańsk

	A	B	C	D	E
A	1.00				
B	0.92	1.00			
C	0.17	–0.22	1.00		
D	–0.17	0.22	–1.00	1.00	
E	0.76	0.59	0.45	–0.45	1.00

Symbols as in Tab. 3.

the relations between the parameters, linear correlation coefficients were calculated (Tabs. 3 and 4). Significant correlations were found between the lipid content of *Enteromorpha* spp. and all the parameters except between lipid and ash content (–0.34 and –0.45). There was also a strong relation between total energy value and the energy value of the organic matter.

Weaker correlations were found for the total energy and the organic matter content, and between the energy value of the organic matter and the ash content.

4. Conclusions

During the period from November 1992 to October 1993, samples of *Enteromorpha* spp. were collected from Jurata at monthly intervals, and from seven stations situated on the coast of the Gulf of Gdańsk during September 1993. There were evident seasonal variations in energy value, organic matter, ash and lipid content, where the maximum energy value (14.0 J mg^{-1} DW – total, 16.8 J mg^{-1} AFDW – organic matter, 6.0% of DW – lipid content) were recorded in samples collected during April and the lowest ones in samples collected during June and August (8.2 and 8.3 J mg^{-1} DW – for total energy, 10.6 and 9.5 J mg^{-1} AFDW – for organic matter respectively).

Different values were recorded for energy value, organic matter, ash and lipid content in samples from the Gulf of Gdańsk, where energy values ranged between 5.5 and 9.9 J mg^{-1} DW – total, 6.5 and 12.4 J mg^{-1} AFDW – for organic matter; organic matter content between 67.8 and 91.2% of DW, the ash content between 8.8 and 32.2% of DW, and the lipid content between 2.1 and 3.5% of DW. From the results obtained we regard the variations in energy values as being related not only to the variations in lipid content, but also to a number of factors directly affecting the biochemical composition and the energy value such as the environmental conditions, and the age and maturity of the algae at the time of collection.

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