Journal of Algal Biomass Utilization
J. Algal Biomass Utln. - Copyright © PHYCOSPECTRUM
ISSN: 2229 – 6905

A study on the geographical variation of nutritive aspects of *Caulerpa*- a marine alga of Visakhapatnam coast, India

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Abstract:

Studies were conducted to estimate the composition of major nutrients and evaluate the effect of geographical variation on the nutritional qualities of *Caulerpa taxifolia*, a marine alga that grows abundantly along the Visakhapatnam(Bay of Bengal) sea coast with a view to its utilization in human nutrition as an edible green sea weed as well as a potential source for the production of secondary metabolites. The composition of carbohydrates, proteins and lipid content showed considerable variation between the two selected regions within the same species. A comparison was made with the nutritional data of the same species growing along the Tamilnadu coast (Gulf of Mannar) and along the Gujarat coast (Dieu & Saurashtra).

Key words: *Caulerpa taxifolia* ,lipid profile.

Introduction

Seaweeds are major coastal resources for a clean environment as well as for human consumption in many countries. Edible seaweeds are widely consumed, especially in Asian countries as fresh or dried forms and also ingredients in prepared foods. Compared to land plants, the chemical composition of seaweeds has been poorly investigated and most of the available information only deals with traditional Japanese seaweeds (Fujiwara-Arasaki *et al.*, 1984; Nisizawa *et al.*, 1987). The chemical composition of seaweeds varies with species, habitat, maturity and environmental conditions (Ito and Hori, 1989). In general, seaweeds are rich in non-starch polysaccharides, minerals and vitamins (Darcy-Vrillon, 1993; Mabeau and Fleurence, 1993). As seaweed polysaccharides cannot be entirely digested by human, they are regarded as a new source of dietary fibre and food ingredient.

Together with their low lipid content, seaweeds only provide a very low amount of energy. Consumption of seaweeds can increase the intake of dietary fibre and lower the occurrence of some chronic diseases (Southgate, 1990). Although several seaweeds are extensively found in Thailand, they are relatively underutilized. Most of them are mainly used as animal feeds and fertilizers by the coastal villagers. The genus *Caulerpa* is common seaweed in tropical and subtropical waters. The nutritional status of this green algae from this coastal region is not yet available and hence an attempt is made in the present study to find out its nutritional status.

Caulerpa is a green marine algal genus having potential uses for mankind. The species of this genus show different percentages of total carbohydrate, protein and lipid content which opens lines for the researchers to explore this particular genus in different ways as in nutrition, secondary metabolites production and for testing the efficacy of various bioactive compounds extracted from the species for therapeutic use.

This paper presents the data on the nutritional and chemical composition of *Caulerpa taxifolia;* i.e. proximate composition, mineral, vitamin, fatty acid, and amino acid contents. This work also reports a comparative evaluation of nutritive values of this seaweed with those of same species of seaweeds growing in other coasts of India. The potential of *Caulerpa* species as sources of food nutrients is also discussed.

Material and methods:

1. *Collection of samples*:

Samples of *Caulerpa taxifolia* were collected from two stations of Visakhapatnam coast,i.e. Tenneti Park and Bheemili at low tidal times by following the tide time table provided by the Office of the Director (G& RB), Survey of India, Dehradun. It was found that the abundance of the sample varied with season and most of the samples were obtained from November to February of every year.

The samples were handpicked and shade dried after washing with sea water and removing the debris and sand. After drying they were powdered using mortar and pestl and the fine powder was used for analysis.

2. *Samples analysis*:

The finely powdered sample was used for analysis of total lipid, protein and carbohydrate content following methods of Bergey's Manual for protein(Lowery et.al; 1951) , carbohydrates(Seifter et.al, 1950) and for lipids(Bligh & Dyer, 1959). The data obtained showed that there are significant differences in the total protein, carbohydrate and lipid content within the species of genus *Caulerpa* due to physiological and geographical reasons.

Results:

By comparing the data obtained from the samples analysed it was found that the samples collected from the Bheemili coast are far better in the nutritive aspect than the samples collected from the Tenneti park as the graphs showed comparatively better values in the total carbohydrates, protein and lipids

Figure 1:

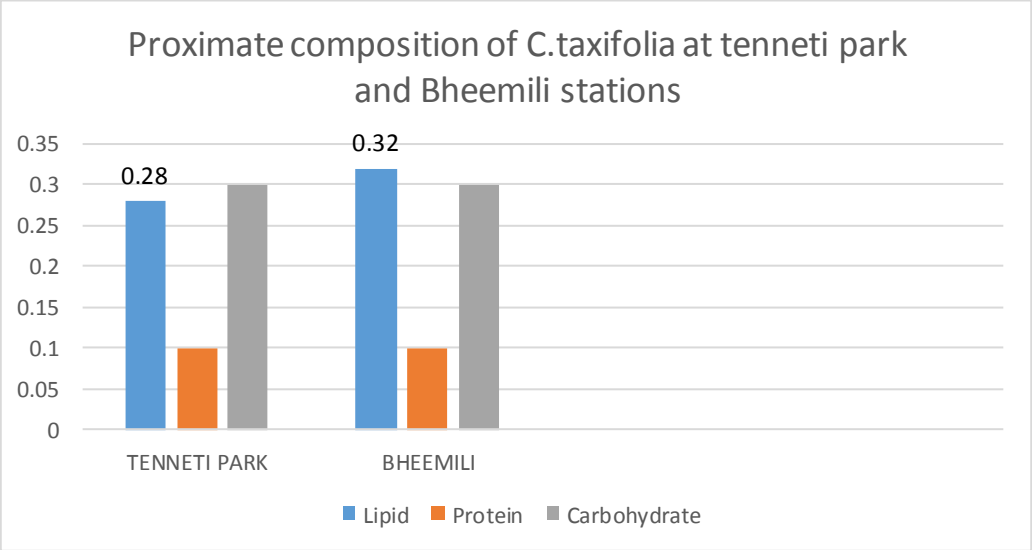

Figure 2: *C.taxifolia* at Tenneti park coast

Figure 3: *C.taxifolia* at Bheemili coast

Table 1: Fatty Acid Composition of Algal Samples at Visakhapatnam coast, Andhra Pradesh (Bay of Bengal)

Sample	Fatty Acid Composition (wt%)												
	14:0	**15:0**	**16:0**	**16:1**	**17:0**	**18:0**	**18:1**	**18:2**	**18:3**	**20:0**	**20:1**	**22:1**	***UK**
Caulerpa taxifolia	2.1	4.4	55.4	4.9	3.2	2.7	4.0	4.8	6.8	0.4	0.4	1.8	9.1

***UK-Unknown**

Table 2: Fatty Acid Composition of Algal Samples at Gulf of Mannar Marine Bioreserve, Tamil Nadu (Bay of Bengal)

Sample	Fatty Acid Composition (wt %)												
	14:0	**15:0**	**16:0**	**16:1**	**17:0**	**18:0**	**18:1**	**18:2**	**18:3**	**20:0**	**20:1**	**22:1**	***UK**
Caulerpa taxifolia	2.6	0.28	27.84	3.2	16.91	3.3	4.1	5.92	9.81	0.56	0.2	0.3	20.56

Table 3: Fatty Acid Composition of Algal Samples at Diu & Saurashtra Coast of Gujarat (Arabian sea)

Sample	Fatty Acid Composition (wt%)												
	14:0	**15:0**	**16:0**	**16:1**	**17:0**	**18:0**	**18:1**	**18:2**	**18:3**	**20:0**	**20:1**	**22:1**	***UK**
Caulerpa taxifolia	**2.2**	**0.4**	**8.9**	**0.8**	**9.2**	**1.4**	**0.03**	**0.5**	**0.3**	**0.15**	**0.17**	**0.10**	**7.3**

Table:4 List of Saturated and Unsaturated fatty acids

S.No	Name of the fatty acid	C:D ratio	SFA'S/UFA'S
1.	**Myristic acid**	**14:0**	**SFA's**
2.	**Pentadecylic acid**	**15:0**	**SFA'S**
3.	**Palmitic acid**	**16:0**	**SFA'S**
4.	**Palmitoleic acid**	**16:1**	**UFA's**
5.	**Margaric acid**	**17:0**	**SFA'S**
6.	**Stearic acid**	**18:0**	**SFA'S**
7.	**Elaidic acid, Vaccenic acid ,Oleic acid**	**18:1**	**UFA's**
8.	**Linolenic acid, Linoelaidic acid**	**18:2**	**UFA's**
9.	**α - linolenic acid**	**18:3**	**UFA's**
10	**Arachidic acid**	**20:0**	**SFA'S**
11.	**Eicosanoate**	**20:1**	**UFA's**
12.	**Erucic acid**	**22:1**	**UFA's**

Discussion

Protein, carbohydrate and lipid are the most important biochemical composition in algae and the results obtained from the seaweed are presented. Carbohydrate is the most important component for metabolism as it supplies the energy needed for respiration and other metabolic processes. Maximum carbohydrate content was observed in *C.taxifolia*. Lipids and carbohydrate contents obviously vary depending upon the nutrition status of the cell (Ricketts TR(1966). The protein content of marine algae forms one for the important constituents for suggesting as supplemental food for human consumption as proteins play crucial functions in all the biological process. Their activity can be described by enzymatic catalysis, transport and storage, growth etc., In comparision to protein and carbohydrate, lipid exhibited very low proportions in *Caulerpa taxifolia.* Lipids provide much more energy in oxidation process than other biological compounds . They constitute as a storage material for living organisms. In macro algae lipids are widely distributed (Miller JPA(1962) .The maximum percentage of lipid was registered in Caulerpa taxifolia at bay of Bengal coast upon comparison with lipid profiling. More studies on fatty acids, vitamins, minerals, toxic elements and other bioactive compounds are necessary to promote the exploitation of marine algae for the production of value added seaweed food products.

Green algae have high concentration of C_{16} and C_{18} polyunsaturated FAs(Jamieson and Reid 1972, Ackman and Ma Lachlan 1977, Aknin et al. 1992, Khotimchenko 1993). This peculiarity of FA composition was observed for the three species of Chlorophyta *collected* from the coast of California. The member of Caulerpales (*Caulerpa taxifolia)* had similar fatty acid patterns, but differed in their FA ratios. They contained hexadecatrienoic(16:3 n-3) acids, and had 18:1n-7/ 18:1 n-9 ratios higher. The algal species was also rich in C18 polyunsaturated fatty acids s- α- linolenic(18;3 n-3) and octadectetraenoic (18:4 n-3).

Green algae from the coast of Visakhapatnam, as well as other members of the Chlorophyta contained long chain PUFAs – arachidonic, eicosapentaenoic and docosapentaenoic(22:5 n-3) acids as minor components; the sum of which did not exceed 4.5% of all the FAs. Polyunsaturate fatty acids are of intrest in cosmetics as components of sun lotions and as regenerating and anti- wrinkle products(Helme 1990).

The FAMEs of dried samples of algae contains saturated fraction (SFA) of 57% followed by polyunsaturated acids (PUFAs) at 39% and monounsaturated fatty acid(MUFA) at 3.8%. Among the saturated portion, palmitic acid(C16:0) was the most abundant with concentration of 34.60%. The other major contribution of the saturated fraction was stearic acid(C18:0) with a concentration of 9.6%. *Ulva lactuca* is also reported to contain a similar stearic acid content (Ortiz et al 2006). This acid is an important ingredient in the production of candles, shampoos, soaps, plastics and other cosmetic products(WHO, 2003). Pentadecanoic acid(c15:0) contributed to a minor extent of 1.3%, and myristoleic acid(C14:0) was present in trace quantities 0.6%, similar to *laminaria* sp.(Fleurence et al., 1994; Takagi et al., 1985). *Caulerpa* species(Kumar et al 2011).The essential proportion of the fatty acids for human nutrition is the polyunsaturated type, such as linoleic acid(15.8%), gamma linolenic acid(15%), cis-eicosadienoic acid(2.4%) and arachidonic acid(3.7%;).

The unsaturated fatty acids play vital role in the prevention of cardio- vascular complications, osteo-arthritis, diabetes, hypertension and autoimmune diseases. Normal human development and growth requires balanced concentration of PUFAs as their increased concentrations can alter physiological functions in the body. High concentration of alpha linolenic acid(C18:3 n-3), gamma linolenic acid (C18:3 n-6) and stearic acid(C18:0) could be a great value in pharmaceutical and food industry.

As the total lipids content of seaweeds was quite low, they were not a conventional source of energy. However, most of them were reported to be rich in polyunsaturated fatty acid regarding to their fatty acid composition (Darcy-Vrillon, 1993). Variations in fatty acid contents are due to both environment and genetic differences mentioned above (Sanchez- Machado et al., 2004). In this work 12 fatty acids were identified. The fatty acid composition of *Caulerpa taxifolia* was shown in Table . It was found that the most abundant fatty acid in seaweed was C16:0(palmitic acid), which accounted for 55.4% of all fatty acids of this species. However, other fatty acids which are essential were also found to be present in lower amounts.

Conclusion

This study gives us information about the proximate composition of carbohydrates, proteins and fatty acid content of marine macro algae *Caulerpa taxifolia* in two different coastal zones of Bay of Bengal near Visakhapatnam. The study is focused on the variation in qualitative as well as quantitative aspects of various fatty acids with reference to geographical

differences. A comparative study between different coasts of India shows that geographical variations cause significant impact in the fatty acid content of the algae. It was found that the most abundant fatty acid in this seaweed was C16:0(palmitic acid), which accounted for 55.4% of all fatty acids of this species.

The unsaturated fatty acids play vital role in the prevention of cardio- vascular complications, osteo-arthritis, diabetes, hypertension and autoimmune diseases. Normal human development and growth requires balanced concentration of PUFAs as their increased concentrations can alter physiological functions in the body. High concentration of alpha linolenic acid(C18:3 n-3), gamma linolenic acid (C18:3 n-6) and stearic acid(C18:0) could be a great value in pharmaceutical and food industry.

In view of all the above positive aspects it is suggested that *Caulerpa taxifolia* might well prove to be one of the potential dietary supplement for human consumption in future. However, further insight into its protein and vitamin contents is needed in order to get a complete picture.

Acknowledgments

The authors are thankful to Dr.G.M.N.Rao, Ass.Professor, Department of Boany, Andhra University, Visakhapatnam for identification of the samples, and the authors show their heartfelt thanks for Dr.V.ChandraSekhar, Principal, Dr.V.S.Krishna Govt.Autonomous College for his encouragement in fulfilling the necessary criteria of this publication.

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