EC NUTRITION
Research Article

Evaluation of the Proximate Composition of *Halimeda opuntia* from the Bay of Bengal, Bangladesh, as Potential Food and Feed Resources

Sheikh Shohag[1], Shomaya Akhter[1], Md. Tamim Hossain[1], Ethneen Mostafa Audri[1], Md. Moinul Hasan[2] and Mohammad Nazir Hossain[3]*

[1]Student, Department of Genetic Engineering and Marine Biotechnology, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka, Bangladesh

[2]Student, Department of Oceanography and Hydrography, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka, Bangladesh

[3]Professor and Head of the Department of Genetic Engineering and Marine Biotechnology, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka, Bangladesh

***Corresponding Author:** Mohammad Nazir Hossain, Professor and Head of the Department of Genetic Engineering and Marine Biotechnology, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka, Bangladesh.

Received: April 14, 2024; **Published:** April 24, 2024

DOI: 10.31080/ECNU.2024.19.01167

Abstract

Seaweed, particularly *Halimeda opuntia*, represents a valuable marine resource with diverse food, pharmaceuticals, and agriculture applications. *Halimeda opuntia* is a segmented green alga that grows abundantly in the shallow sub-tidal and lower intertidal zones. This study aimed to conduct a nutritional evaluation of *Halimeda opuntia* collected from St. Martin Island, Bangladesh, utilizing proximate analysis techniques. The proximate composition, including moisture content, ash content, protein content, fat content, crude fiber, and carbohydrate content, was determined following standard analytical procedures. Seaweeds can differ in terms of their nutritional value and bioactive components based on the species, season, environmental factors, and geographic location. Understanding the nutritional profile of *Halimeda opuntia* is crucial for its sustainable utilization and potential food and feed resources. The results revealed that Halimeda opuntia has a low moisture content, high ash content, low fiber content, moderate protein content, low-fat content, and low carbohydrate content. These findings suggest that *Halimeda opuntia* could be a valuable resource for human consumption and animal feed. Further investigation is needed to determine its nutritional value, bioactivity, and possible applications in the food and feed industries.

Keywords: *Halimeda opuntia; St. Martin Island; Proximate Composition; Minerals*

Introduction

The growing global population raises demand for food, chemicals and energy. Now that terrestrial resources cannot be fully utilized for agriculture, effort is being shifted toward the ocean's potential to satisfy these needs [1]. Seaweeds, or macroalgae, are gaining popularity due to their unique properties, which include their widespread occurrence, abundance, rapid rate of production, and lack of reliance on agricultural inputs when grown using cutting-edge technologies. Seaweeds are generally classified as Rhodophyta, Phaeophyta, and Chlorophyta based on their color [2,3]. Seaweeds are gaining increasing recognition as valuable sources of nutrients, possessing various bioactive compounds that offer potential health benefits. The nutritional composition of seaweeds is of significant interest due to their potential applications in various industries, including food, pharmaceuticals, and agriculture [4]. Seaweeds are available along the whole Bangladeshi coast, mostly in St. Martin Island, Cox's Bazar and Sundarbans Mangrove forest. There are about 193 seaweed species under 94 genera or 215 seaweed species under 102 genera in Bangladesh's coastal regions [5]. Among the numerous species of seaweed, *Halimeda opuntia* stands out due to its prevalence in coastal areas, including the shores of St. Martin Island, Bangladesh. It is situated in the northeastern part of the Bay of Bengal is renowned for its diverse marine ecosystem, harboring a rich variety of seaweed species, including *Halimeda opuntia* [6,7]. *Halimeda opuntia*, a green macroalgae often found in tropical and subtropical marine habitats, has a remarkable nutritional profile [8]. This seaweed is renowned for its high calcium content, making it a valuable dietary source for bone health and overall mineral balance [9,10]. The nutritional qualities and bioactive substances of seaweeds may vary from species to species, primarily depending on the season, environmental variables, and geographical location. Halimeda opuntia is an important source of bioactive compounds, such as carotenoids, fats, proteins, dietary fibers, fatty acids, vitamins, and minerals [11,12].

Proximate analysis is a widely used method for determining the basic nutritional components of food and biological samples. It involves evaluating moisture content, ash content, crude protein, crude lipid, crude fiber, and carbohydrates, providing essential information about the sample's nutritional profile.

This study aims to evaluate the nutritional value of *Halimeda opuntia* collected from different locations around St. Martin Island using proximate analysis. By analyzing the proximate composition of *Halimeda opuntia* samples, we seek to assess their potential as a sustainable source of nutrition. Understanding the nutritional composition of *Halimeda opuntia* is crucial for unlocking its potential as a functional food ingredient, dietary supplement, or bioactive compound source. This study was primarily done with six seaweeds, where the result of the proximate analysis of *Hypnea sp., Sargassum sp., Hydroclathratus sp., Padina pavonica and Asparagopsis taxiformis* validate the previous study done by Chowdhury., *et al*. 2022 and Mehedi., *et al*. 1999 [13,14].

The findings of this study could contribute to the development of value-added products from *Halimeda opuntia*, thereby promoting sustainable utilization of marine resources and enhancing the economic prospects of coastal communities in Bangladesh. Furthermore, insights gained from this research may inspire further investigations into the bioactive compounds present in *Halimeda opuntia* and their potential health benefits. This study underscores the importance of evaluating the nutritional composition of *Halimeda opuntia* through proximate analysis and highlights its potential as a valuable resource for food and feed. By shedding light on the nutritional profile of this seaweed species, we aim to stimulate further research and innovation in utilizing the benefits of marine algae for human consumption and industrial applications.

Materials and Methods

Sample collection, validation and processing

Samples of seaweed were gathered at Chera Dwip, the southernmost point of St. Martin's Island in Bangladesh. To get rid of sand particles, epiphytes, and other impurities, the sample were first cleansed with seawater. Distilled water was used to wash the samples in order to get rid of any remaining salt. The samples' visual appearance, collection location, and information on seasonal availability were used to validate them [15]. Following collection, samples were sun-dried and stored in airtight receptacles for later analysis. Using a dryer (Model: JSON 030S JSR, Korea), the sun-dried samples were then further dried at 45°C to obtain a crisp texture. Afterwards, a mortar and pestle were used to grind the crisped samples into a fine powder. Then, all powdered seaweed samples were kept in airtight containers at room temperature until the chemical analysis was completed.

Estimation of proximate composition

Biochemical analysis was carried out using established protocols to assess the proximate composition of marine seaweed, such as ash, moisture, crude fiber, carbohydrates, fat, and protein. All of the experiments were reproduced to validate the results.

Determination of ash content

The following was the process for determining the ash content [16]: 1) pre-conditioning porcelain crucibles for at least 30 minutes at an ashing temperature of 600°C in a muffle furnace with a vent cover to get rid of any combustible contaminants; 2) taking the crucibles out of the furnace and letting them cool in a desiccator till room temperature (approximately one hour); 3) utilizing gloves, tweezers, or tongs to weigh each crucible to the closest 0.1 mg in order to avoid gaining weight from impurities and hand moisture; 4) loading 1 - 4g of each powdered sample (sufficient to provide 20 mg or more of ash) into the tared crucibles; 5) inserting the crucibles containing the samples into the muffle furnace, which was beneath a vent hood and had been preheated to 600°C; 6) pre-igniting the samples using a lighter or match, or by allowing the door to open slightly to allow smoke to leave, then shutting it until no more smoke or fumes were visible; 7) ashing the samples in the furnace for around six hours; 8) taking the crucibles containing the ash out of the muffle furnace and allowing them to cool in a desiccator to room temperature; 9) weighing each crucible containing ash and 10) computing the total ash content as a percentage of sample mass (as is basis). The proportion of ash content was approximated using the following formula:

$$\%\ \text{Ash} = \frac{\text{Weight of ash (g)}}{\text{Weight of the sample (g)}} \times 100$$

Where:

Weight of ash = Total weight of sample and crucible after heating - Weight of crucible.

Weight of the sample = Total weight of sample and crucible before heating - Weight of crucible.

Determination of moisture content

Two hours were spent drying the approximately two-gram sample in a drier (Model: JSON 030S JSR, Korea) at 135 ± 2°C. The dish was covered before being removed from the dryer and placed in a desiccator. It was then allowed to cool before the final mass was taken out [17]. The following formula was used to approximate the proportion of moisture content:

$$\%\ \text{Moisture} = \frac{\text{Ws} - (\text{W2} - \text{W1})}{\text{Ws}} \times 100$$

Where:

Ws = Weight of sample; W1 = Weight of dish; W2 = Weight of dish after drying.

Determination of crude fiber content

Gravimetric analysis was used to quantify the crude fiber (AOAC 978.10) [13]. The sample was chronologically extracted using 0.128M of H_2SO_4 (30 minutes) and 0.313M of NaOH (30 minutes) to determine the amount of crude fiber. This process primarily removes protein, sugar, starch, lipids, and parts of structural polysaccharides and lignin through a series of acid and alkali extractions. Filtration was used to collect the insoluble filtrate, which was then dried (remove excess water by placing on hot plate by evaporating, then place it on dryer at 135 degree centigrade for 2 hour, cooling it on desiccator then and weighed) and finally making ash at 550 degree for 2 hour and weighed. The crude fiber content of seaweeds was calculated using the following formula:

$$\%\ \text{Crude Fiber} = \frac{\text{W1} - \text{W2}}{\text{Ws}} \times 100$$

Where:

Ws = Weight of sample; W1 = Weight of crucible with fiber; W2 = Weight of crucible with ash.

Determination of protein and fat content

Halimeda opuntia's protein and fat percentages were determined from dried samples using commercial support from Waffen Research Lab (www.waffenbd.com) using the AOAC 2001.11 and GB 5009.6-2016 Method I and II methods.

Determination of carbohydrate content

The carbohydrate percentage of *Halimeda opuntia* was calculated by deducting the total amount of ash, fat, fiber, and protein from 100 on a dry weight basis. Carbohydrate content was estimated using the approach of James (1995):

$$\% \text{ Carbohydrate} = 100 - (\text{crude fiber} + \text{protein} + \text{ash} + \text{lipid})$$

Statistical analysis

The examined data were statistically analyzed using Microsoft Excel 2013. Every experiment was conducted three times to verify results and lower errors. The data were presented in tabular form, and descriptive statistics like mean ± standard deviation (SD) were employed.

Result and Discussion

The nutrient makeup of seaweeds varies depending on geographical area, species, and environmental growing conditions. The primary metabolic activity of seaweeds is governed by temperature and the concentration of critical nutrients in the surrounding waters [18]. Table 1 shows the moisture, protein, ash, lipid, carbohydrate, and fiber content of *Halimeda opuntia* taken from St. Martin Island in Bangladesh.

Composition	DW %
Moisture	1.912 ± 0.006
Ash	86.976 ± 1.721
Crude Fiber	4.25 ± 0.25
Protein	3.10 ± 0.11
Fat	2.08 ± 0.08
Carbohydrate	1.682 ± 1.25

Table 1: *Proximate composition of dried ground Halimeda opuntia.*

N.B.: DW = Dry Weight.

The amount of moisture in food impacts its quality and shelf life. The product's shelf life increases as the moisture content decreases [19]. This study indicated that *Halimeda opuntia* has a moisture value of 1.912 ± 0.006%. Seaweeds must be dried before bioprocessing because they are easily deteriorated. Indeed, reduced water activity inhibits microbial development, preserving the nutritional and functional integrity of seaweeds while reducing storage space [20].

Ash is a food component that helps determine mineral content. In this investigation, *Halimeda opuntia* had an ash concentration of 87.976%. Ash content is related to an ingredient's mineral level. A material's high or low ash content can be related to the amount of mineral elements, although the mineral content of seaweed can be altered by the processes used. *Halimeda opuntia* contains more ash (minerals). This is assumed to be connected to the mode of absorption of mineral nutrients. Aside from being a kind of adaptation to the environmental circumstances of marine waters, which contain several minerals in high concentrations. Absorption of mineral nutrients in seaweed occurs across the full surface of the talus rather than through the roots, making mineral nutrient absorption more efficient. The amount of mineral nutrients ingested impacts the ash concentration in the seaweed tissue, resulting in high seaweed ash content [19].

Although dietary fibers are non-nutritional molecules, they have been identified as a significant dietary component with a variety of beneficial qualities. Dietary fiber has been linked to a variety of physiological consequences, depending on the specific source. High fiber diets contribute to a lower risk of colon cancer, ischemic heart disease, diabetes mellitus, gallstones, hemorrhoids, and hiatus hernia, as well as improved large intestine function, increased fecal bulk, and other health benefits [21]. The result of proximate analysis of *Halimeda opuntia* revealed 4.25 ± 0.25% fiber content.

Protein content in food items determines their quality. In this study, the protein level of *Halimeda opuntia* was 3.10 ± 0.11%. Protein content in seaweed is affected by seaweed type and season; the highest protein content is achieved in winter and spring, while the lowest protein content is reported in summer [22]. Protein is beneficial since it can assist regenerate body cells during both cell repair and growth, hence it is strongly advised that youngsters consume protein.

In this study, the fat content of *Halimeda opuntia* was found to be 0.617% of dry weight. Seaweed contains extremely little fat because it maintains its nutritional reserves mostly in the form of carbohydrates, particularly polysaccharides. Seaweed's fat content ranges from 1 - 3%. While fat offers energy benefits, over consumption can lead to fat storage in the body and blood vessels [19].

Many seaweed carbohydrates serve as either a structural component of the cell wall or as plastidic storage molecules. Carbohydrates generated from seaweed are categorized into several types based on their chemical diversity: fucoidan, alginate, carrageenan, ulvan, laminarin, and cellulose/hemicellulose [23]. The result of this study revealed that *Halimeda opuntia* has a very low amount of carbohydrate which was 1.682 ± 1.25%.

Conclusion

Seaweed is a highly prolific sea organism that can grow on non-arable land and use waste products as a source of nutrients. As a result, seaweed differs from terrestrial plants in terms of physical and physiological properties and chemical content, as evidenced by their appearance. According to the above description, *Halimeda opuntia* is a rich source of minerals with relatively little protein, fat, fiber, and carbohydrate. However, further research is required before introducing *Halimeda opuntia* on an industrial scale. St. Martin Island is rich in marine algae, which can be used as a source of food, feed, and renewable energy. So, it is critical to use this vast resource for the benefit of the country as a whole.

Acknowledgements

The authors would like to express their gratitude to the Marine Biotechnology Laboratory, Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh, for providing all technical and laboratory support for conducting this research.

Funding Support

This work was supported by the University Grants Commission (UGC) research grant, Bangabandhu Sheikh Mujibur Rahman Maritime University (BSMRMU), Dhaka, Bangladesh (2021- 2022-2023).

Bibliography

1. Baghel RS. "Developments in seaweed biorefinery research: A comprehensive review". *Chemical Engineering Journal* 454.2 (2023): 140177.
2. Samiee S., *et al*. "Algae as a source of microcrystalline cellulose". Advanced bioprocessing for alternative fuels, biobased chemicals, and bioproducts: technologies and approaches for scale-up and commercialization". (2019): 331-350.
3. Kraan S. "Pigments and minor compounds in algae". Functional Ingredients from Algae for Foods and Nutraceuticals (2013): 205-251.
4. Pradhan B., *et al*. "Beneficial effects of seaweeds and seaweed-derived bioactive compounds: Current evidence and future prospective". *Biocatalysis and Agricultural Biotechnology* 39 (2022): 102242.
5. Sarkar MSI., *et al*. "Present status of naturally occurring seaweed flora and their utilization in Bangladesh". *Research in Agriculture Livestock and Fisheries* 3 (2016): 203-216.
6. Abdullah Al M., *et al*. "Habitat structure and diversity patterns of seaweeds in the coastal waters of Saint Martin's Island, Bay of Bengal, Bangladesh". *Regional Studies in Marine Science* 33 (2020): 100959.
7. Ferrara L. "Seaweeds: A food for our future". *Journal of Food Chemistry and Nanotechnology* 6 (2020): 56-64.
8. "Protective role of the seaweed *Halimeda opuntia* extract on cadmium-stressed *Eruca sativa* (Mill.)". *Egyptian Journal of Botany* 56.3 (2016): 863-881.
9. Lozano Muñoz I and Díaz NF. "Minerals in edible seaweed: health benefits and food safety issues". *Critical Reviews in Food Science and Nutrition* 62.6 (2020): 1592-1607.
10. Circuncisão AR., *et al*. "Minerals from macroalgae origin: Health benefits and risks for consumers". *Marine Drugs* 16.11 (2018): 400.
11. Parjikolaei BR., *et al*. "Valuable biomolecules from nine north atlantic red macroalgae: amino acids, fatty acids, carotenoids, minerals and metals". *Natural Resources* 7.4 (2016): 157-183.
12. Rupérez P. "Mineral content of edible marine seaweeds". *Food Chemistry* 79.1 (2002): 23-26.
13. Chowdhury KN., *et al*. "Proximate composition of some selected seaweeds from coastal areas of Cox's Bazar and the St. Martin's Island, Bangladesh". *The Dhaka University Journal of Earth and Environmental Sciences* (2022): 113-122.
14. Mehedi MY., *et al*. "Biochemical composition of some seaweeds from St. Martin'S Island, Bangladesh". Khulna University Studies (1999): 283-287.
15. Islam MM., *et al*. "Diversity and occurrence of seaweeds from the south-eastern coast of Bangladesh". *Indian Journal of Geo-Marine Sciences* 49.8 (2020): 1379-1388.
16. Liu K. "Effects of sample size, dry ashing temperature and duration on determination of ash content in algae and other biomass". *Algal Research* 40 (2019): 101486.
17. AOAC Method 930.15. Direct Moisture Determination of Food and Feed Samples Comparing Automated Thermogravimetric and Air Oven loss-on-drying Techniques TGM800 Flow Diagram Methodology Method Flour-Method 1 Flour-Method 2 Flour-Method 3 Crucible Type 2.4 in Ø Al Foil (2015): 800.

18. Rasyid A., *et al*. "Nutrient composition of dried seaweed *Gracilaria gracilis*". *Ilmu Kelautan: Indonesian Journal of Marine Sciences* 24.1 (2019): 1-6.

19. Winarni S., *et al*. "Analysis proximate of sargassum seaweed sp". *Journal of Physics: Conference Series* (2021): 1943.

20. Ferreira M., *et al*. "Potential of red, green and brown seaweeds as substrates for solid state fermentation to increase their nutritional value and to produce enzymes". *Foods* 11.23 (2022): 3864.

21. Santoso J., *et al*. "Comparative contents of minerals and dietary fibers in several tropical seaweeds". *Bulletin Teknologi Hasil Perikanan* IX (2006): 1-11.

22. Galland-Irmouli AV., *et al*. "Nutritional value of proteins from edible seaweed *Palmaria palmata* (Dulse)". *Journal of Nutritional Biochemistry* 10.6 (1999): 353-359.

23. Goñi O., *et al*. "Seaweed carbohydrates". The Chemical Biology of Plant Biostimulants (2020): 57-95.

Volume 19 Issue 5 May 2024