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NUTRITIONAL CONTENT OF GREEN ALGAE *Caulerpa racemosa* AND BROWN ALGAE *Sargassum polycystum* AT RANOWANGKO II BEACH, KOMBI DISTRICT, MINAHASA REGENCY

Joana Hope Rorong[1], Mercy Maggy Franky Rampengan[2], Verawati Ida Yani Roring[2*], Nova Laurin Isye Mourein Ogi[2]

[1] Graduate of Biology, Faculty of Mathematics, Natural and Earth Sciences, Universitas Negeri Manado. Jl. Kampus Unima, Tondano 95618, Indonesia
[2] Department of Biology, Faculty of Mathematics, Natural and Earth Sciences, Universitas Negeri Manado. Jl. Kampus Unima, Tondano, 95618, North Sulawesi, Indonesia.

**Corresponding Author via E-mail*: veraroring@unima.ac.id

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ABSTRACT

Ranowangko II beach is famous for its beautiful beaches and is a natural habitat for macroalgae including *Caulerpa racemosa* and *Sargassum polycystum*. Despite its great potential and abundance, information about the nutritional content of both types of algae, especially in the Ranowangko II beach area is still limited. This study aimed to determine the nutritional content (water content, ash content, protein, lipid, crude fiber, carbohydrate) of green algae *Caulerpa racemosa* and brown algae *Sargassum polycystum* in Ranowangko II beach. The type of research used is descriptive quantitative to determine the proximate nutrient content of two types of algae tested by proximate analysis in the laboratory. Based on the study results, there were variations in the nutritional content of the two types of algae tested. Green algae *Caulerpa racemosa* has a moisture content of 71.29%, ash content of 6.90%, protein of 2.78%, fat of 1.34%, crude fiber of 3.53%, and carbohydrates of 17.69%. Brown algae *Sargassum polycystum* has a water content of 83.23%, ash content of 1.82%, protein of 9.93%, fat of 1.72%, crude fiber of 11.18%, and carbohydrates of 3.30%. The conclusion obtained after conducting this research is that *Caulerpa racemosa* (green algae) and *Sargassum polycystum* (brown algae) have different nutritional content.

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INTRODUCTION

Algae are the most important component of coastal ecosystems and are food producers. In addition, algae can manage the balance in the ocean ecosystem. Ecologically, algal communities benefit the surrounding environment. They serve as nurseries and refuges for certain types of fish, spawning grounds, and natural feeding grounds for fish and herbivorous animals (Nome et al., 2019). Algae is an aquatic commodity with high economic value that can be utilized in various sectors such as food, medicine, cosmetics, and others. With its chemical content, macroalgae, as a natural product, is a very economical commodity to develop (Nome et al., 2019). One use of algae is as an alternative food source that is rich in nutrients such as protein, vitamins, minerals, dietary fiber, and other bioactive compounds.

Proximate analysis, the study of the composition and nutrient content of macroalgae, is very important as it can provide information on the nutritional value and possible uses of macroalgae in the food, cosmetic, and pharmaceutical industries. Proximate analysis includes moisture content, ash content, dry matter, crude protein analysis, lipids, and carbohydrates (Nugrani, 2022). Ranowangko II is a village located in Kombi District, Minahasa Regency. The coastal waters of Ranowangko II are famous for their beautiful beaches and natural habitat for macroalgae. With a shoreline length of approximately 250 meters and an intertidal width of approximately 50 meters, the beach in this village consists mostly of seagrasses and coconut trees. (Sembiring, 2018). The research location at Ranowangko II Beach, Kombi District, Minahasa Regency, is one of the areas rich in marine algae resources, so this research is necessary to explore the nutritional potential of algae growing in the area. *Caulerpa racemosa* and *Sargassum polycystum* are two algae types commonly found in Indonesian marine waters, including Ranowangko II Beach. *Caulerpa racemosa*, known as green algae or "coral flower," belongs to the green algae group (*Chlorophyta*). Meanwhile, *Sargassum polycystum* is a brown alga (*Phaeophyta*) abundant in tropical waters.

However, information on the nutritional content of these two types of algae, especially in the Ranowangko II beach area, still needs to be made available. Lack of information or data regarding the nutritional content of marine algae in the region, so this research is important to complete the necessary data and information. Another problem is that the nutritional content of *Caulerpa racemosa* and *Sargassum polycystum* in Ranowangko II beach is still being determined. Therefore, analyzing the nutritional content of *Caulerpa racemosa* and *Sargassum polycystum* is expected to provide important data and information about their nutritional value in Ranowangko II beach. The results of this study can be a reference for the development of marine algae utilization as a source of food and industrial raw materials in the region or other areas that have similar environmental characteristics.

MATERIALS AND METHOD

Time and Place of Research

This research was conducted from October to December 2023 at Ranowangko II Beach. and proximate analysis was carried out at Balai Standardisasi dan Pelayanan Jasa Industri Manado.

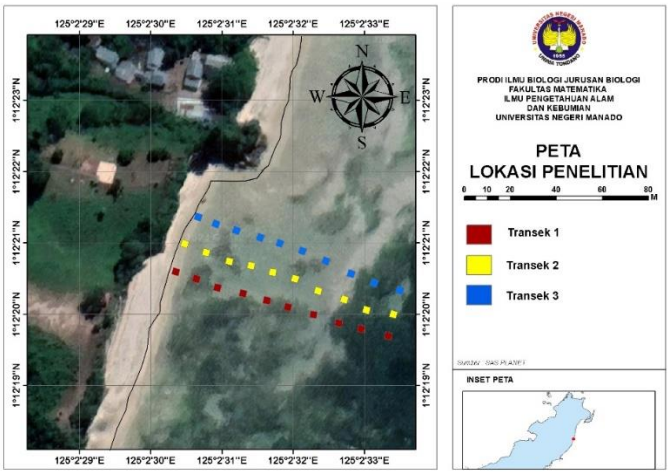

Figure 1. Sampling site *C. racemosa* and *S. polycystum* from Ranowangko II

Tools and Materials

The tools used in this research are a coolbox and plastic clips. Moisture content: weighing bottle with lid, exicator, oven, analytical balance. Ash content: porcelain cup, electric furnace, analytical balance. Protein content: 100 ml Kjedahl flask, distiller, electric heater/burner, analytical balance. Fat content: filter paper, fat flask, Soxhlet apparatus, electric heater, oven, analytical balance, fat-free cotton. Crude fiber content: analytical balance, cooler, Buchner funnel, vacuum pump. The materials used in this research are samples of green algae *Caulerpa racemosa* and brown algae *Sargassum polycystum* and 70% alcohol to preserve the samples. The materials used in this study are samples of green algae Caulerpa racemosa and brown algae Sargassum polycystum and 70% alcohol to preserve the samples.

Type of Research

The type of research used is descriptive quantitative. Quantitative descriptive research is a method used to examine specific samples by sampling and collecting data with quantitative research instruments. Quantitative research in this study is to determine the proximate content of green algae *Caulerpa racemosa* and brown algae *Sargassum polycystum* by conducting laboratory analysis.

Sample

Samples were taken from the waters of Ranowangko II beach at noon at 12:20 WITA. Sampling was done at the lowest low tide. The sampling is done using a random sampling method to ensure that the samples taken are representative of the algae population at the research site. The samples obtained were then washed thoroughly to remove dirt and other attached organisms. After that, it was confirmed again with a web-based identification of marine organisms. Then, the algae samples were preserved in 70% alcohol. Store samples in tight plastic clips and then store them in the refrigerator or freezer to maintain stability and prevent the growth of microorganisms.

Proximate analysis

1. **Water content.** The water content was determined according to the method described by SNI-08-2891-1992. Carefully weigh 1 - 2 grams of the sample in a weighing bottle with a lid of known weight. The weighing bottle has a stirrer and quartz sand/folded filter paper for liquid samples. Then dry in an oven at 105°C for 3 hours. Then cool in an exicator. Next, weigh and repeat this work until a fixed weight is obtained.

   Percentage of water content = $\frac{W_1 - W_2}{W_1 - W_0} \times 100\ \%$

   where:

   w_1 = weight of cup + sample
   w_2 = weight of dry sample after oven (gr)
   w_0 = weight of empty cup
2. **Ash content.** The ash content was determined according to the method described by SNI-08-2891-1992. Weigh 2 - 3 g of the sample into a porcelain cup with the known weight. For liquid samples evaporate them in a water bath until dry. Ignite over the flame of a burner, then fuse in an electric furnace at a maximum temperature of 550°C until complete ignition (occasionally the furnace door is slightly opened, so that oxygen can enter). Cool in an exicator, then weigh to a fixed weight.

   Percentage of ash content = $\frac{w_1 - w_2}{w} \times 100\ \%$

   where:

   w = sample weight before ashing
   w_1 = sample weight + cup
   w_2 = weight of the empty cup
3. **Protein content.** The protein content was determined according to the method described by SNI 08-2891-1992. weigh 0.51 g of snippet and put it into a 100 ml Kjeldahl flask. Add 2 g of selen mixture and 25 ml of concentrated sulfuric acid (H_2SO_4). Heat over an electric heater or burner flame until boiling and the solution becomes clear greenish (about 2 hours). Allow to cool, then dilute and put into a 100 ml volumetric flask up to the line mark. Pipette 5 ml of solution and put it in a distiller; add 5 ml of 30% sodium hydroxide (NaOH) and a few drops of phenolphthalein (PP) indicator. Distill for about 10 minutes; as a reservoir, mix 10 ml of 2% boric acid solution with the indicator. Flush the cooling tip

with distilled water. Titrate with 0.01 N hydrogen chloride solution (HCl). Carry out the blank determination.

Percentage of protein content = $\frac{(V_1 - V_2) \times N \times 0{,}014 \times f.k \times fp}{w}$

where:

w = weight of the sample

V_1 = volume of 0.01 N HCl used for sample determination

V_2 = volume of HCl used for blank determination

N = normality of HCl

fk = conversion factor for protein from food in general: 6,25; milk & processed products: 6,38; peanut butter: 5,46

fp = dilution factor

4. **Lipid content.** The lipid content was determined according to the method described by SNI 08-2891-1992. Weigh carefully 1 - 2 g of sample, and put it in a paper sleeve covered with cotton. Plug the paper sleeve containing the sample with cotton, dry it in an oven at a temperature of not more than 80°C for about one hour, then put it in a Soxhlet apparatus that has been connected to a fat flask containing boiling stones that have been dried and have known weights. Extract with hexane or other fat solvent for about 6 hours. Distill the hexane and dry the fat extract in an oven at 105°C. Then cool and weigh. Repeat this drying until a fixed weight is reached.

   Percentage of lipid content = $\frac{w - w_1}{w_2} \times 100\ \%$

   w = sample weight

   w_1 = weight of fat before extraction (gr)

   w_2 = weight of fat flask after extraction

5. **Crude fiber content.** The lipid content was determined according to the method described by SNI 08-2891-1992. Weigh carefully 2 - 4 g of the sample. Remove the fat by extraction using Soxhlet or by stirring, precipitating, and pouring the sample into an organic solvent 3 times. Dry the sample and put it in a 500 ml Erlenmeyer. Add 50 ml of 1.25% sulfuric acid solution then boil for 30 minutes using an upright cooler. Add 50 ml of 3.25% sodium hydroxide and boil again for 30 minutes. In the hot state, filter with a Bucher funnel containing Whatman 54.41 or 541 grayless filter paper that has been dried and known weight. Wash the precipitate on the filter paper successively with 1.25% sulfuric acid, hot water, and 96% ethanol. Remove the filter paper and its contents, put it in a box of known weight, dry it at 105°C, cool it, and weigh it until the weight remains. If it turns out that the crude fiber content is greater than 1%, remove the filter paper and its contents, and weigh it to a fixed weight.

   Crude fiber < 1%

   % crude fiber = $\frac{w}{w_1} \times 100\%$

   Crude fiber > 1%

   % crude fiber = $\frac{w - w_1}{w_2} \times 100\%$

   w = sample weight

   w_1 = ash weight (gr)

   w_2 = weight of sediment on filter paper

6. **Carbohydrate content.** The value of total carbohydrates was obtained from 100 – (percentage of water + percentage of ash + percentage of protein + percentage of total lipid).

Data analysis

Quantitative data is used to calculate proximate content testing (data categorized as numbers), and the analysis used is descriptive quantitative, in the form of percentages and averages displayed in tabular form.

RESULTS AND DISCUSSION

Results

Table 1. Proximate composition of *Caulerpa racemosa* and *Sargassum polycystum*

Component	Content (%)	
	Caulerpa racemosa	***Sargassum polycystum***
Moisture	71,29	83,23
Ash	6,90	1,82
Protein	2,78	9,93
Lipid	1,34	1,72
Crude fiber	3,53	11,18
Carbohydrate	17,69	3,30

Based on the results of proximate analysis of green algae (Caulerpa racemosa) and brown algae (Sargassum polycystum) shown in Table 2, there are variations in the nutritional content of the two algae tested. Green algae (Caulerpa racemosa) has a moisture content of 71.29%, ash content of 6.90%, fat of 2.78%, protein of 1.34%, crude fiber of 3.53%, and carbohydrates of 17.69%. In comparison, brown algae (Sargassum polycystum) has a moisture content of 83.23%, ash content of 1.82%, fat of 9.93%, protein of 1.72%, crude fiber of 11.18%, and carbohydrates of 3.30%.

Discussion

Moisture content is an important parameter that can provide information about the shelf life of a food. High moisture content can result in a short shelf life of a food item caused by microbiological damage. (Herliany et al., 2023). Moisture content testing aims to determine how much water content is in a food ingredient. Moisture content greatly affects its shelf life, and the higher the moisture content of a food ingredient, the higher the possibility of the material being damaged (Ate et al., 2017). Based on the research results, the water content obtained by green algae (*Caulerpa racemosa*) is 71.29% and brown algae (*Sargassum polycystum*) is 83.23%. This comparison shows that the water content of *S. polycystum* from Ranowangko II Beach is much higher than that of *C. racemosa* from Natuna Riau Sea, found at 13.39% (Jumsurizal et al., 2021). Similarly, the water content of *S. polycystum* from Ranowangko II Beach is higher than that of S. *polycystum* from Pohuwato waters, Gorontalo, which is 17.69% (Manteu & Nurjanah, 2018). Many variables can cause this difference in water content, including the environmental conditions in which the algae grows is one of them. For example, the water content of *Caulerpa racemosa* in Ranowangko II Beach may be influenced by higher air humidity levels or the composition of certain minerals in the water in the area. The water content of Sargassum polycystum in Ranowangko II Beach can also be affected by the environmental conditions where it grows, such as the amount of rainfall and water temperature.

Algae are foodstuffs that contain high mineral content, due to their ability to absorb minerals from the environment. The amount of minerals present in seaweed is influenced by its habitat. Based on the study results, *Caulerpa racemosa* has a higher ash content of 6.90% than *Sargassum polycystum*, which has 1.82%. This comparison shows that the ash content of *Caulerpa racemosa* from Ranowangko II is much lower than that of *Caulerpa racemosa* from Takalar, South Sulawesi, which was found to be 34.44% (Kasmiati et al., 2022). Similarly, the ash content of *Sargassum polycystum* from Ranowangko II was lower than *Sargassum polycystum* from Pohuwato, Gorontalo which was found to be 24.51% (Manteu & Nurjanah, 2018). The ash content of *Caulerpa racemosa* may be influenced by higher mineral levels in the water, which resulted in higher ash content. Similarly, the composition of certain minerals present in Pohuwato waters may have affected the ash content of *Sargassum polycystum*. *C. racemosa* usually accumulates inorganic minerals such as silicate, calcium, magnesium, iron, and magnesium in the form of calcium oxalate and silica crystals. After combustion, these minerals will be left behind as ash. However, the mineral content of brown algae S. polycystum is lower. In addition, the habitat and growth environment of C. racemosa grows in shallow water, where it is more exposed to sedimentation and mineral accumulation from land. Meanwhile, *S. polycystum* grows in the intertidal zone, which is far away from terrestrial influences, leading to less exposure to mineral accumulation.

Food sources of fat (triglycerides) can come from animals called animal fats and can come from plants called vegetable fats (Otu, 2017). Based on the results of research on green algae, Caulerpa racemosa is 1.34% brown algae, and Sargassum polycystum is 1.72%. The results of this study are not much different from the fat content of Caulerpa racemosa in the Natuna Sea of Riau Islands, obtained at 1.58%, and the fat content of Sargassum polycystum from Pohuwato Gorontalo waters of 0.50% (Jumsurizal et al., 2021; Manteu & Nurjanah,

2018). The fat content of Caulerpa racemosa in Natuna may be influenced by higher nutrient levels in the water, resulting in higher lipid content. Similarly, the composition of certain minerals in Pohuwato waters may have influenced the lipid content of Sargassum polycystum.In general, the lipid content of all algae species is low at around 1%-5% of their dry weight. Thus, the fat content in Caulerpa racemosa and Sargassum polycystum in this study is still in the range of fat content in general. The low-fat content is due to algae generally storing food reserves in carbohydrates, especially polysaccharides (Yanuarti et al., 2017). In addition, the low-fat content in algae supports the potential of algae as one of the healthy diet foods.

Protein levels in red and green algae range from 10 - 30%, and brown algae range from 5 - 15% (Otu, 2017). Based on the study results, Caulerpa racemosa has a protein content of 2.78% and Sargassum polycystum has a protein content of 9.93%. This comparison shows that the protein content of Caulerpa racemosa from Ranowangko II Beach is much lower than Caulerpa racemosa from Natuna Sea which was found to be 10.41% (Jumsurizal, 2021). Similarly, the ash content of Sargassum polycystum from Ranowangko II Beach was higher than that of Sargassum polycystum from Pohuwato, Gorontalo which was found at 3.65% (Manteu & Nurjanah, 2018). Different water conditions cause different protein levels, so the nutrient intake for each type of seaweed is different (Jumsurizal et al., 2021). It certainly has to do with environmental parameters such as nutrient availability, light intensity, temperature, salinity, and pH, which significantly affect algae protein levels (Gour & Pal, 2011). High and low protein levels can be associated with amino acids contained in a material. The more amino acids in the material, the more protein is contained. The protein content of algae varies by species, season, and geographical conditions (Jacoeb et al., 2018).

The carbohydrate content of algae mostly contains fibers that human digestive enzymes cannot digest, so it provides few calories and is suitable as a diet food for obese people. Algae contain fibers the body cannot digest, such as lignin, cellulose, and hemicellulose. Based on the research results, *C.racemosa* has a carbohydrate content of 17.69% and *S.polycystum* of 3.30%. The results of this study are much lower than C.racemosa from the Natuna Sea at 35.69% and S.polycystum from Pohuwato waters at 53.66% (Jumsurizal et al., 2021; Manteu & Nurjanah, 2018). The difference in carbohydrate content between Caulerpa racemosa and Sargassum polycystum is influenced by factors such as species differences, morphology, and environmental conditions. Unlike brown algae (*Phaeophyta*), green algae (Chlorophyta) Caulerpa racemosa have a more efficient carbohydrate biosynthesis pathway. Due to their more developed chloroplasts and better carbohydrate storage mechanisms, green algae can produce carbohydrates more easily. Morphologically, Caulerpa racemosa has a simpler talus structure and tends to have more carbohydrate storage tissues than Sargassum polycystum, which has a more complex talus structure with specialized tissues. Environmental factors such as nutrient amount, light intensity, and temperature affect carbohydrate synthesis and accumulation in algae. Other nutritional components that affect the amount of carbohydrates are protein, fat, water, and ash content (Destri, 2023)

Crude fiber is a compound that is indigestible by the digestive organs of humans and animals. Crude fiber consists of gum, cellulose, hemicellulose, pectin, and lignin. Under certain conditions, fiber is insoluble in alkali and dilute acid. Based on the research results, C. racemosa has a crude fiber content of 3.53% and S. polycystum 11.18%. The crude fiber content of C. racemosa is lower than the crude fiber content of C. racemosa from Takalar, South Sulawesi, which is 6.55% (Kasmiati et al., 2022). Meanwhile, the crude fiber content of S. polycystum is higher than the crude fiber content of S. polycystum from Pohuwato waters, which is 6.52% (Manteu & Nurjanah, 2018). Season, geographic location, species type, and environmental conditions affect algal fiber content. Seasonally, due to low temperatures and upwelling that increase nutrient availability for cell wall biosynthesis, Sargassum polycystum tends to have higher fiber content in winter and spring. Caulerpa racemosa may also have a higher fiber content in summer and dry seasons. To provide structural support and protect against strong hydrodynamic forces, Sargassum polycystum growing in choppy or strong current waters tends to have higher fiber content. On the other hand, Caulerpa racemosa living in sheltered waters has a lower fiber content. Regarding species type, the biosynthetic pathways of green algae are simpler and limited. In contrast, brown algae have more complex biosynthetic pathways to produce compounds such as fucoidan, alginate, and other fiber polysaccharides that contribute to high crude fiber content. In terms of environmental conditions, in aquatic environments with high nutrient availability and ideal light intensity, Sargassum polycystum tends to have higher fiber content to support growth and cell wall biosynthesis. On the other hand, in environments with low nutrient availability or excessive light intensity, Caulerpa racemosa may increase fiber production as a defense mechanism to strengthen the cell wall.

CONCLUSION

Caulerpa racemosa (green algae) and *Sargassum polycystum* (brown algae) have different nutritional content. The proximate analysis for Caulerpa racemosa, 71.29% moisture content, 6.90% ash content, 2.78% protein content, 1.34% fat content, 3.53% crude fiber, and 17.69% carbohydrate content was obtained. As for Sargassum polycystum, the water content was 83.23%, ash content 1.82%, protein content 9.93%, fat content 1.72%, crude fiber 11.18%, and carbohydrate content 3.30%. The results of this study provide useful information about the nutritional potential of green algae and brown algae that can be utilized in various applications, such as food, feed, or industrial raw materials.

AUTHORS CONTRIBUTION

Rorong, J. H. designed and conducted the research, analyzed and interpreted the data, and wrote the draft of the manuscript. Rampengan, M. M. F., Roring, V. I. Y and Ogi, L.I.M designed the research, reviewed the draft of the manuscript, and supervised the process

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