Nutritional profile of Sargassum sp. from Pane Island, Tapanuli Tengah as a component of functional food

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Abstract. Most of The Pane Island Coastal communities are not yet aware of the potential of Sargassum in their coastal area even though its benefits as a foodstuff is quite high, for this reason, it is necessary to have scientific information about the importance of the nutritional content of Sargassum sp. such as proximate chemical composition and crude fibers as a components of functional food product. The proximate chemical composition and crude fibers of Sargassum were studied to understand the nutritional profile. The results show that physical-chemical parameters of waters play an essential role in the nutrients composition of Sargassum. Among the two seaweeds, S. cristaefolium contained highest protein and carbohydrates content (8.54% and 7.25%, respectively) and S. crassifolium possessed highest ash, fat and crude fiber (41.52%, 0.30%, and 24.54%, respectively). Nutrient content and crude fiber in Sargassum cristaefolium and Sargassum crassifolium can be used as components of functional foods.

1. Introduction
Sargassum sp. is a tropical and subtropical brown seaweed, commonly found in subtidal and intertidal zone consisting of 150 species [1]. Sargassum sp. contains alginate and iodine that used in the food industries, pharmaceutical, cosmetics and textile industries [2]. Alginate is most widely used in the textile industry (50%), following by the food industry (30%), the paper industry (6 %), welding rods (5%), pharmaceutical (5%), and others (4%) [3].

The growth and distribution of seaweed are influenced by physical, chemical and the dynamics of seawater and the substrate of their habitat. Seaweed takes nutrients from the surrounding area by diffusion through its thallus walls. The environment of Sargassum sp.habitat is low turbidity with several substrates such as coral reefs, dead coral, volcanic rock and massive objects that found at the bottom of the waters [2].

Pane Island located on the west coast of North Sumatra. Sargassum sp.is found abundantly in this area, but there is no information about the nutritional profile of Sargassum sp.from Pane Island, even their communities do not know much about the importance of Sargassum sp. as a component of functional food products. The chemical composition differs between species and intra-species depending on species,
habitat and season [4]. Environmental conditions will affect the chemical content of seaweed compost [5] [6] [7]. Changes in its composition will affect the biopotency of Sargassum sp. as a nutritional component for functional food. This study aims to determine the nutritional content through the chemical composition and fiber contained in Sargassum sp. from Pane Island.

2. Materials and method

2.1. Study site and sample collection
Sargassum sp. were collected from 3 stations: Station one (1°56’22.59” S and 98°29’56.85” E); Station two (1°56’21.27” S and 98°29’51.91” E); and Station three (1°56’16.94” S and 98°29’59.68” E) at the Pane Island. Collection of Sargassum sp. was done during low tide at the dry season (July-August 2019). Identification of Sargassum sp. conducted in the field, based on a morphological study by referring to book “FAO Species Identification Guide for Fishery Purses: The living marine resources of the Western Central Pacific” (1998). After collection, the seaweed samples were sorted and washed with sea water to remove sand and epiphyte, then samples were weighed to obtain the wet weight and taken into a plastic bag. Furthermore, seaweed samples were kept in coolbox immediately brought to the laboratory at the Integrated Laboratory of Water Resources Management Study Program, Faculty of Agriculture, USU. In the laboratory, Samples were oven-dried at 40°C for 8 days.

2.2. Physical-chemical parameters of water
Study the physical and chemical properties of water content, water sample was collected at the surface of the water. Parameters including temperature, pH, salinity, current speed, brightness, and depth were directly evaluated in the study area.

2.3. Rendemen simplicia
The wet weight of Sargassum sp. was directly weighed in the study area, then the samples were dried in the Aquatic Resources Management laboratory to obtain the dry weight. Then, cut into several pieces and crushed using a blender to obtain seaweed simplicia powder. Rendemen simplicia of seaweed was calculated using the formula proposed by [8]:

$$\text{Rendemen simplicia of Sargassum sp. (\%) = \frac{\text{weight of simplicia}}{\text{weight of raw material}} \times 100\%}$$ (1)

2.4. Proximate composition analysis
The proximate chemical composition (water, ash, protein, and fat content) of Sargassum sp. was determined according to the Indonesian National Standards, SNI 01-2354 (1-4) - 2006 [9] [10] [11] [12]. Carbohydrate content analysis refers to the AOAC method [8] and crude fiber refers to [13].

2.5. Data analysis
The study was conducted with three replications for all parameters. All data were performed using Microsoft Excel.

3. Results and discussions
Based on direct identification in the field by researchers, using the FAO identification book “Species Identification Guide for Fishery Purses: The living marine resources of Western Central Pacific (1998)”. Two species of Sargassum sp. were identified, Sargassum cristaeolium C. Agardh 1820 [14] and Sargassum crassifolium J. Agardh 1848 [14] (Figure 1 and Figure 2). Characteristics of the
substrate in this study area are appropriate to them, namely rock, sand and mud substrates. *S. crassifolium* was found at a depth of 0.5 m with a rock substrate and *S. cristaefolium* was found in deeper depths with sand and mud substrate. In general, Sargassum grows in protected or choppy waters and rock habitats [15].

![Figure 1. Sargassum crassifolium C. Agardh 1848](image1)

![Figure 2. Sargassum cristaefolium J. Agardh 1820](image2)

3.1. Physical-chemical parameters of water

The physical and chemical properties of Pane Island water were directly evaluated in the study area, at the depth of 0.5 - 0.7 m and brightness of 1.5 m. The depth for the growth of the Sargassum genus is from 0.5 to 10 m because brown algae need more sunlight intensity brown algae than red algae [2]. The growth of Sargassum requires the intensity of sunlight ranges from 6500 to 7500 lux [16]. The current velocity in Pane Island waters tends to be slow, ranged from 0.02 to 0.06 m/s, but these conditions are suitable for Sargassum growth. The research from [17] that good current for seaweed growth between 20-40 cm/s. The slow current velocity can keep clear the condition of coastal waters from turbidity, where turbidity can affect the photosynthesis process of seaweed [18]. Water quality parameters in the Pane island water can be seen in full in Table 1.

| Seaweed                     | Sargassum cristaefolium | Sargassum crassifolium |
|-----------------------------|-------------------------|------------------------|
| Parameters / Stations       | Station 1 | Station 2 | Station 3 | Station 1 | Station 2 | Station 3 |
| Current (m / s)             | 0.02       | 0.04      | 0.05      | 0.06   | 0.05      | 0.06      |
| Brightness (cm)             | 150        | 150       | 150       | 150    | 150       | 150       |
| Depth (m)                   | 0.52       | 0.50      | 0.50      | 0.65   | 0.70      | 0.68      |
The temperature of the waters of Pane Island ranged from 31.6 °C to 32.5 °C, and this temperature is still relatively reasonable for tropical waters. The optimal temperature range for growth and survival of macroalgae from the tropical waters were 15 °C to 30 °C, but the temperature threshold for growth of green algae, brown algae, and red algae is 34.5 °C [19]. Physiologically, low temperatures can be stopping the biochemical activity in the body of the thallus, whereas high temperatures will cause damage to the enzyme and destroy the biochemical mechanisms in the thallus macroalgae [20]. The salinity of the water was ranged from 21-32 ppt. Macroalgae are commonly found in seas or oceans with salinity ranges between 30-32 ‰ [19]. Salinity plays a vital role in macroalgae life cycles, highest salinity or lowest salinity will affect the physiology process [18].

In our study, pH value varies between 7.7 to 8.7, and this values are still good enough to support the growth of macroalgae. Macroalgae grow well at the coastal with pH range of 7 to 8. The pH range < 6.5 will suppress the growth of macroalgae and pH < 9 is the optimal range in the waters [21].

3.2. Rendemen Simplicia
Rendemen simplicia of seaweed is the ratio between wet weight and dry weight of seaweed expressed in percent (in Figure 3). The rendemen simplicia of S. cristaefolium at three station ranged from 1.56% to 17.06% and S. crassifolium ranged from 11.02% to 12.10%. Higher and lower levels of rendemen simplicia of seaweed can be influenced by differences in the level of dryness of seaweed because the water content is different in each seaweed species. The water content greatly influences the level of dryness of seaweed, the expected dry seaweed as food has a moisture content of 30% with a rendemen of dried seaweed of 10-30% [22].

![Figure 3. Graph of difference in rendemen simplicia of Sargassum sp.](image-url)
3.3. Proximate composition and crude fiber

Proximate composition of both seaweed species, *S. cristaefolium* and *S. crassifolium* is presented in Table 2. Except for moisture, all compositions are on dry weight basis. The result shows the difference in nutritional composition between two different habitats of seaweed, *S. cristaefolium* were found in dead coral habitat and showed highest protein and carbohydrates content (8.54% and 7.25%, respectively). On the other hand, *S. crassifolium* were found in sandy and muddy substrates and showed highest ash, fat and crude fiber content (41.52%, 0.30%, and 24.54%, respectively). The chemical composition of seaweed can vary due to several environmental factors which include temperature, water, salinity, light, and nutrition [6]. The chemical composition of seaweed can be influenced not only by concentration of aquatic nutrients but also temperature of the waters and the depth of the waters which are also influenced by seasonal variation and geographical location [23]. The two types of *Sargassum* above the majority live at depths < 2 m, can be categorized as upper sublittoral and upper subtidal algae. The composition of *Sargassum* in the Pane island water can be seen in Table 2.

Table 2. Proximate composition and crude fiber (dry weight basis)

| Proximate composition | *Sargassum cristaefolium* | *Sargassum crassifolium* |
|-----------------------|---------------------------|--------------------------|
| Moisture * (%)        | 89.34                     | 88.56                    |
| Ash (%)               | 41.28                     | 41.52                    |
| Protein (%)           | 8.54                      | 6.21                     |
| Lipid (%)             | 0.25                      | 0.30                     |
| Carbohydrates (%)     | 7.25                      | 3.79                     |
| Crude Fiber (%)       | 22.09                     | 24.54                    |

Note: * wet weight basis

3.3.1. Water content. The water content of *S. cristaefolium* and *S. crassifolium* were 89.34 % and 88.56, respectively. The water content will affect the final rendemen simplicia of *Sargassum*. Differences in water content in *Sargassum* can be affected by species, age of harvest, and environmental conditions [23]. Therefore, the content and composition are different from each species [24]. Although *Sargassum* has high water content, *Sargassum* is not a perishable product. This study can be evidenced, *Sargassum* is still fresh and flavorful specific after a long process (Sargassum ± 3 days in the coolbox when transported to the laboratory from the study area). The reduced water content in foodstuffs can increase the concentration of the protein, fat, ash, carbohydrates, and mineral-minerals [25].

3.3.2. Ash. The levels of ash content of *S. crassifolium* was lightly higher than that of *S. cristaefolium*, allegedly due to the differences in the substrate of the seaweed habitat. According to [26], *S. crassifolium* has a high ash content (41.52%), the result of the ash content in this study is relatively not much different from the study [27] with ash content in seaweed ranging from 40.66-41.83%. This is closely related to the level absorption of mineral nutrients, a side from adaptation to the environmental conditions of marine waters that containing various minerals with high concentrations. Mineral absorption of seaweed is carried through the entire surface of thallus (not through the roots), so that the absorption is effective. The amount of mineral absorbed were effects to the ash content in seaweed tissue, so the ash content becomes high [28]. Ash content of *Sargassum* is quite high in this study is associated with high macro and micro mineral content derived from its habitat and high salinity, not from contaminants. It can be seen from the measurement result of the chemical physics factors of Pane island water which states that oceanographic condition of the waters is still suitable for growth of *Sargassum*. Seaweed is a marine biota that is sensitive to changes in its habitat environment. Following [29] that seaweed community is influenced by several factors, one of which is oceanographic factors in water consisting of temperature,
light intensity, depth, salinity, pH, currents and waves. High macro and micro mineral content can be substituted in low mineral food.

3.3.3. Protein. The protein content of *S. cristaefolium* was not much different with other species (*S. crassifolium*). In general, brown algae including Sargassum are low in protein content than most of the algae. This is in line with the result found by [30], the lowest protein content in brown seaweed was 5-11% of the dry weight, but it is still comparable to the protein content in legumes. The lowest content of protein of *Sargassum* can be affected by differences in seaweed species and season period when the sample collected [31], the highest protein levels were obtained in winter and spring, while the lowest protein levels were recorded during the summer. This shows that *Sargassum* is very good to be used as a functional food source.

3.3.4. Lipid. Lipid content of *S. cristaefolium* and *S. crassifolium* were 0.25% and 0.30%, respectively. Geographical condition factors have a great influence on the results of this study because the length of sun exposure can influence the concentration of lipid in an individual od seaweed. Sargassum indeed requires a higher light intensity than other species of algae to carry out photosynthesis, this allegedly has caused the low level of lipid content of *Sargassum* sp. The lipid content of seaweed is not too high when compared with terrestrial plants [32]. Sargassum contains polyunsaturated fatty acids (PUFA, C18: 3ω3, C18: 2ω6, and C18: 1ω9), which are essential fatty acids for the human body, so they can be used as a functional food.

3.3.5. Carbohydrate. *S. cristaefolium* had the highest carbohydrates (7.25%) whereas *S. crassifolium* had the lowest carbohydrates (3.79%), this can be expected the alginate content in *S. cristaefolium* is higher than that of *S. crassifolium*, but there needs to be further research related to that. According to [33] that carbohydrates in brown seaweed consist of fucoidan, laminaran, cellulose, and alginate. Chemical compounds found in brown algae in large quantities are alginate, while other chemical compounds are present in small amounts such as laminaran, fucoidin, cellulose, mannitol, and other bioactive compounds. Alginate in Sargassum can be used as a functional food. Marine macro-algae and plants generally store their food reserves in the form of carbohydrates, especially polysaccharides. Polysaccharides are one of the constituent of carbohydrates. In general, Carbohydrates are related with fiber in a material [24]. The carbohydrate content of seaweed is generally in the form of fiber which cannot be digested by digestive enzymes so that it provides little calorie intake and suitable for use as a diet food [27].

3.3.6. Crude fiber. Crude fiber content in *S. Crassifolium* (24.54%) was not much different from that of *S.cristaefolium* (22.09%). This is consistent with [27] that the crude fiber content in seaweed ranges from 23-24%. Crude fiber is a component of carbohydrates that cannot be hydrolyzed by digestive enzymes. High polysaccharides can cause higher of fiber content in seaweed cells [24]. The physicochemical properties of algae fibers are the same as those available in commercial foods which are rich in fiber [24]. The high fiber content shows that *Sargassum* can be used as a functional food that can be used for diet. Crude fiber is a dietary fiber and functional fiber consisting of cellulose, hemicellulose and lignin [34].

4. Conclusions
This study revealed that the content of nutrients and crude fiber in *Sargassum sp.* are varies depending on the species and environmental factors of seaweed habitat. Nutrient content and crude fiber in *Sargassum cristaefolium* and *Sargassum crassifolium* can be used as a functional food.
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