Jurnal
Teknologi

Full Paper

NUTRITIONAL POTENTIAL OF DRIED SEAWEED *Turbinaria decurrens*: BIOCHEMICAL INSIGHTS AND HEALTH BANEFITS

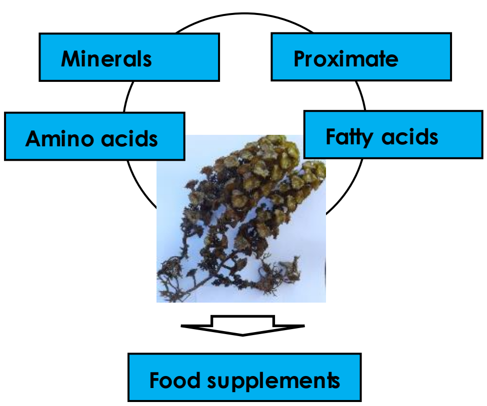
Abdullah Rasyid[a]*, Fauzy Rachman[a], Tri Handayani[b], Nurjamin[b], Raismin Kotta[c]

[a]Research Center for Vaccine and Drug, BRIN, Jl. Raya Jakarta-Bogor Km.46 Cibinong 16911, Indonesia
[b]Research Center for Oceanography, BRIN, Jl. Pasir Putih No.1 Ancol Timur, Jakarta 14430, Indonesia
[c]Research Center for Marine and Land Bioindustry, BRIN, Desa Teluk Kodek, Lombok Timur 83352, Indonesia

Article history
Received
1 August 2024
Received in revised form
4 November 2024
Accepted
3 December 2024
Published Online
26 June 2025

*Corresponding author
abdu025@brin.go.id

Graphical abstract



Abstract

Turbinaria decurrens, the tropical brown seaweed, was analyzed for its biochemical composition, which includes proximate, fatty acid, amino acid, and mineral contents. This research aims to investigate the feasibility of utilizing brown seaweed as an alternative source of human nutrition derived from the ocean. Proximate (moisture, fat, ash, protein, and carbohydrate) and minerals (calcium, sodium, potassium, magnesium, and iron) were determined by the standard method of AOAC. In contrast, phosphor was determined by the spectrophotometric method. Amino acid was determined by Ultra Performance Liquid Chromatography and fatty acid by gas chromatography. The results indicated that the significant proximate content was carbohydrates, ash, moisture, protein, and fat, which were 61.44%, 16.73%, 15.78%, 4.34%, and 1.71%, respectively. The primary mineral content was calcium, potassium, magnesium, sodium, phosphor, and iron, which were 42,991 mg/kg, 19,222 mg/kg, 10,402 mg/kg, 8,180 mg/kg, 237 mg/kg, and 166.9 mg/kg, respectively. The significant component of saturated fatty acids was palmitic acid, myristic acid, lauric acid, and stearic acid, which were 0.61%, 0.08%, 0.08%, and 0.06%, respectively. The two significant monounsaturated fatty acid components were oleic acid and palmitoleic acid, which were 0.39% and 0.04%, respectively. In comparison, polyunsaturated fatty acids were arachidonic acid, linoleic acid, linolenic acid, eicosatrienoic acid, and eicosapentaenoic acid, which were 0.19%, 0.1%, 0.07%, 0.02%, and 0.02%, respectively. The major component of the essential amino acids was leucine (3,377.45 mg/kg), while the non-essential amino acid was glutamic acid (5,828.29 mg/kg). According to the information above, *T. decurrens* can be a functional ingredient for human food supplements.

Keywords: Ambon Bay waters, Brown seaweed, *Turbinaria decurrens*

1.0 INTRODUCTION

Marine macroalgae, or seaweed, have been used as medicines, sea vegetables, and fertilizer for centuries [1]. Their biochemical composition has been widely studied and differs according to the species, their seasonal condition, and their geographic origin. In addition to their nutritional value, seaweeds have a variety of therapeutic applications, including antioxidant, antitumor, hypercholesterolemic, weight control, and others [2].

Consumer interest in healthy food has increased, and healthy food is the primary source of a healthy life. Nutrition is the primary consideration while developing food products. Seaweeds are intensively investigated for human nutrition and are used as a functional food [3].

Although seaweed is low in fat content, it is frequently referred to as a "superfood" considering its high concentration of proteins and carbohydrates [4]. Seaweed protein is referred to as a "complete protein" because it comprises all of the essential amino acids. This contrasts with most plant-based diets using less net protein [5].

Research on the biochemical composition of brown seaweeds found in the Ambon Bay waters of Indonesia has been extensively documented, and the local population does not understand how these seaweeds could be utilized. As a result, the main objective of this study is to investigate the biochemical composition of brown seaweed *and Turbinaria decurrens* to optimize them for future human needs.

2.0 METHODOLOGY

Sample Collection. *Turbinaria decurrens* (Figure 1), a brown seaweed, was collected from Ambon Bay waters, Indonesia. The seaweed sample was collected by hand, washed, and rinsed with seawater to eliminate sand, debris, and other superfluous stuff before being transported to the laboratory.

Figure 1 A picture of brown seaweed *Turbinaria decurrens,* scale 3 cm

Sample Preparation. The salty elements were removed from the sample after being separated and thoroughly cleaned by being rinsed in distilled water. It was exposed to indirect air drying in the sun for three to four days before being ground in a blender. The powdered materials were stored in a dark container at room temperature to prepare for further examination.

Proximate Analysis. Proximate contents were analyzed referring to the standard method of AOAC. The moisture content based on the dry weight (D.W.) was evaluated by drying a 2 g sample at 105°C for 4 hours. The ash content (% D.W.) was evaluated by subjecting a 2 g sample to 550°C using a muffle furnace for 4 hours. The sample either became white and became carbon or remained unchanged [6].

Determination of fat content (% D.W.) was done by wrapping a 2 g sample in filter paper and placing it in a thimble. The thimble was then attached to a clean round-bottom flask. The conversion factor of nitrogen-protein (6.25) was used to figure out how much protein there was (% D.W.), and the carbohydrate value (% D.W.) was calculated by the difference: 100 – (moisture + protein + ash + fat) %.

Mineral Analysis. The mineral value was evaluated using inductivity-coupled plasma-optical emission spectroscopy, which included calcium, potassium, sodium, phosphor, magnesium, and iron.

Fatty Acids Analysis. *The fatty acid profile was analyzed using gas* chromatography (Clarus 580 GC-Perkin Elmer). The apparatus was in good condition: detector FID (240°C), column (Superco SP-2560 Capillary G.C. Column), flow rate (18.0 cm per second), split (1:100), injector temperature (225°C), and carrier gas (Nitrogen).

Amino Acids Analysis. Ultra Performance Liquid Chromatography analyzed the amino acid profile according to procedures in the literature [7]. The following conditions apply to the apparatus condition: mobile phase (A = AccQ Taq Ultra eluent A concentrate; B = 10% mobile phase D; C = aquabidest; D = eluent B Accq Taq Ultra); temperature (49°C); column (AccQ Taq ultra C18); injection volume (1 L); and flow rate (0.5 mL/min).

3.0 RESULTS AND DISCUSSION

Figure 2 displays the results of the proximate profile that was performed. In fresh conditions, the moisture content of seaweed can reach 80–90% wet weight [8]. This content resembled *Turbinaria ornata* (83.62%) [9]. Olsson *et al.,* 2020 [10] also found the moisture value ranged from 63.3% to 87.6% in nine brown seaweeds collected from the Swedish west coast, while four brown seaweeds reported by Ahmad *et al.,* 2012 [4] collected from Semporna, Sabah, ranged from 83.51% to 86.86%.

The National Standardization Agency of Indonesia issued a regulation in 2015 that states the maximum moisture content for some commercial seaweeds, such as 20% D.W. for *Eucheuma* sp., *Sargassum* sp., and *Turbinaria* sp., and 25% D.W. for *Gracilaria* sp. The moisture content analyzed in this study (15.78% D.W.) was lower than these criteria. Like other brown seaweeds reported by D'Armas, 2019 [11] collected from Salinas Bay, Ecuador, *Spatoglossum scroederi* and *Padina pavonica* were 20.47% and 12.84%, respectively. Six types of brown seaweeds collected from Cox's Bazar and St. Marine's Island waters in Bangladesh reported having moisture content ranging from 12.09% to 29.65% D.W. [12].

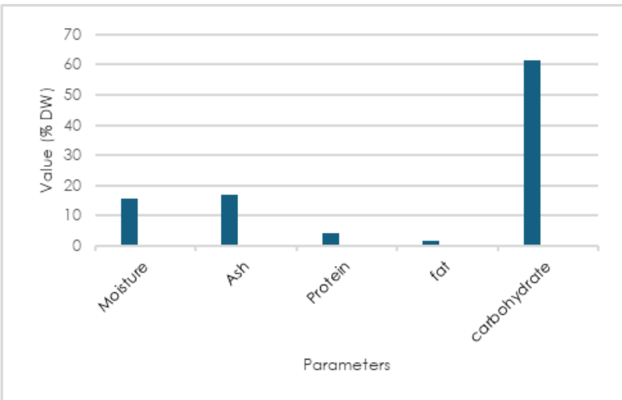


Figure 2 Proximate composition of *Turbinaria decurrens*

The moisture value of seaweed is a significant component that influences its beneficial effects and the quality of seaweed for human consumption. Excessive moisture values may accelerate microorganism growth [13]. In addition, moisture value is one of the main criteria for trading seaweed in the international market.

The present study found the ash content to be 16.73% of the dry weight. According to the previous study, ash contents were diverse among the brown seaweeds examined. Tibbetts *et al.*, 2016 [14] evaluated that the ash value of four types of brown seaweeds studied ranged from 17.6% to 24.9% D.W. A similar report was given by Olsson *et al.,* 2020 [10] that the ash value of nine different types of brown seaweeds harvested from the Swedish west coast ranged from 11.8% to 39% D.W., while the brown seaweed *S. ilicifolium* harvested in the Persian Gulf of Iran was 29.9% D.W. [13]. The ash values of *P. japonica* and *S. scroederi* harvested from Salinas Bay in Ecuador at 24.85% and 34.58% D.W., respectively [11]. According to Siahaan *et al.,* 2018 [15], the ash value of two different types of brown seaweeds harvested in Karimun Jawa waters in Indonesia, *P. australis* and *T. conoides,* was 14.09% and 28.56% D.W., respectively.

On the other hand, four brown seaweeds examined by Ahmad *et al.* (2012) [4] harvested from Semporna, Sabah, ranged from 21.37% to 45.04% D.W., while six different types of brown seaweeds that were harvested in the St. Martin's and Cox's waters in Bangladesh ranged from 14.49% to 61.98% D.W. [12]. Fouda *et al.,* 2019 [16] also reported that the ash content of six different types of brown seaweeds harvested from the Hurghada coast in Egypt ranged from 19.6% to 45.48% D.W. According to Holdt and Kraan, 2011 [17], seaweeds have a high ash value when compared to plant foods. It contains trace elements and micronutrients with seasonal and environmental changes in composition.

This study found that the carbohydrate content was 61.44% of the dry weight. In general, carbohydrates are the most significant proximate component of seaweed. In fact, according to Ruperez and Saura-Calixtro, 2001 [18], the carbohydrate content in seaweed can reach up to 50% D.W. The high carbohydrate content is essential for the organism's metabolism because it provides the energy required for respiration and other metabolic activities. In addition, it typically contains polysaccharides, including fucoidan and alginate, in significant amounts [19]. The carbohydrate value of nine different brown seaweeds harvested on the Swedish west coast ranged from 23.7% to 55.7% D.W. [10]. Ahmad *et al.* (2012) [4] examined four brown seaweeds harvested in Semporna, Sabah, ranging from 26.86% to 41.03% D.W. *Turbinaria decurrens* harvested on the Red Sea coast in Egypt reported containing 33% carbohydrates [20], while four brown seaweeds examined by Tibbetts *et al. (*2016 [14]) had carbohydrate content ranging from 53.7% to 59.8% D.W.

The carbohydrate content of *P. pavonica* and *S. scroederi* was 43.39% and 40.04% D.W., respectively [11], while Chowdhuryet *al.,* 2022 [12] evaluated the carbohydrate content of six types of brown seaweed harvested in St. Martin's and Cox's Bazar islands in Bangladesh, which ranged from 10.7% to 43.6% D.W. Fouda *et al.,* 2019 [16] stated that the carbohydrate content of six different types of brown seaweeds harvested in the Red Sea in Egypt ranged from 24.78% to 41.66% D.W., while four brown seaweeds that were harvested from the Gulf of Mannar in India varied from 40.21% to 59.30% D.W. [21].

The value of protein that was discovered in this investigation was 4.34% D.W. This result is similar to the protein value of other types of brown seaweeds, such as *P. pavonica* (5.53%) and *S. scroederi* (5.21%) collected from Salinas Bay, Ecuador [11]. Nine brown seaweeds examined by Tibbetts *et al.,* 2016 [14] reported protein ranging from 8.8% to 13.1% D.W. On the other hand, nine different types of brown seaweeds harvested from the Swedish west coast ranged from 5.9% to 12% D.W. [10]. Six brown seaweeds harvested in the St. Martin's and Cox's Bazar islands waters in Bangladesh contained a protein ranging from 7.15% to 13.36% D.W. [12]. Fouda *et al.,* 2019 [16] examined the protein values of six different types of brown seaweeds harvested from Hurghada coast in Egypt, which ranged from 2.81% to 5.31% D.W., while the protein values of four brown seaweeds harvested from Mandapam region in India varied from 7.11% to 15.34% D.W. [21].

The fat value found in this investigation was 1.71% D.W. Compared to the previous study, this result was higher than six different types of brown seaweed on the Hurghada coast in Egypt, ranging from 0.12% to 0.27% D.W. [16]. D'Armas *et al.,* 2019 [11] examined the ash content of *P. pavonica* harvested in Salinas Bay, Ecuador, ranging from 0.83% to 3.07% D.W., respectively. Six different types of brown seaweed harvested in St. Martin's and Cox's Bazar Islands waters in Bangladesh ranged from 0.15% to 2.75% D.W. Kokilam *et al.,* 2013 [21] examined the fat content of four different types of brown seaweed harvested in the Gulf of Mannar in India, which varied from 0.11% to 0.55% D.W., while four different types of brown seaweeds harvested in the Fink Cove waters of Canada ranged from 5.5% to 8.6% D.W. [14].

Mineral Composition

The results of mineral composition are presented in Figure 3. Results showed that the higher mineral composition was calcium (42,911 mg/kg), followed by potassium, magnesium, sodium, phosphor, and iron, which were 19,222 mg/kg, 10,402 mg/kg, 8,180 mg/kg, 237 mg/kg, and 166.9 mg/kg, respectively. Similar to three types of brown seaweeds collected from the Brazilian coast, calcium, potassium, and magnesium were significant components of mineral content. *Dictyopteris jolyana* indicated calcium, potassium, and magnesium content were 5,800 mg/kg, 5,600 mg/kg, and 3,300 mg/kg, respectively. *Spatoglossum schroederi* indicated calcium, magnesium, and potassium content were 43,100 mg/kg, 3,000 mg/kg, and 2,600 mg/kg, respectively. At the same time, *Zonaria tournefortii* showed calcium, potassium, and magnesium were 27,500 mg/kg, 12,800 mg/kg, and 8,600 mg/kg, respectively [22].

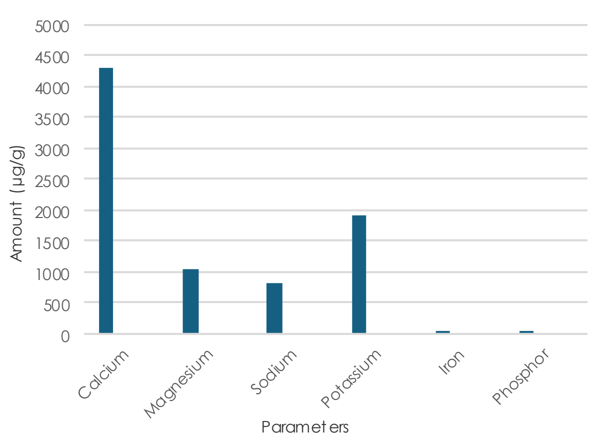


Figure 3 Mineral content of *Turbinaria decurrens*

The mineral content of the brown seaweed *Labophora variegate* harvested in India's Gulf of Mannar Biosphere was analyzed. Magnesium had the highest mineral content (17,126 mg/kg), followed by sodium, phosphor, potassium, calcium, and iron, which were 15,166 mg/kg, 14,773 mg/kg, 19,783 mg/kg, 10,206 mg/kg, and 9,136 mg/kg, respectively [23]. Six different types of brown seaweed harvested in the Red Sea waters in Egypt indicated that the higher component of the mineral was potassium, ranging from 12,000 mg/kg to 78,000 mg/kg, followed by calcium, ranging from 9,769 mg/kg to 19,360 mg/kg, and magnesium, ranging from 4,513 mg/kg to 9,264 mg/kg [16].

Two different types of brown seaweed harvested from the Portuguese coast were examined for their mineral composition. *Saccothiza polyschides* indicated the highest mineral content was potassium (85,000 mg/kg), followed by sodium (77,000 mg/kg) and calcium (14,000 mg/kg). In contrast, *Undaria pinnatifida* indicated the highest mineral content was sodium (97,000 mg/kg), followed by potassium (76,000 mg/kg) and magnesium (13,500 mg/kg) [24]. The highest mineral content of brown seaweed *Sargassum linoleum* harvested in Abu Qir Bay in Egypt was potassium (509.3 mg/kg), followed by sodium, magnesium, and calcium, which were 203.9 mg/kg, 168.5 mg/kg, and 28.35 mg/kg, respectively.

Fatty Acids Composition

The components of fatty acids identified in this study are presented in Figure 4. The significant components of Saturated Fatty Acid (SFA) were palmitic acid, myristic acid, lauric acid, and stearic acid, which were 0.61%, 0.08%, 0.08%, and 0.06%, respectively. Two types of Monounsaturated Fatty Acids (MUFA) identified were oleic acid (0.39%) and palmitoleic acid (0.04%). At the same time, the significant components of Polyunsaturated Fatty Acids (PUFA) were arachidonic acid, linoleic acid, linolenic acid, eicosatrienoic acid, and eicosapentaenoic acid, which were 0.19%, 0.11%, 0.07%, 0.02%, and 0.02%, respectively.

The contents of fatty acids examined in the present study were lower than in previous studies. Brown seaweed *Sargassum linoleum* harvested from Abu Qir Bay, Egypt, reported that the major component of fatty acids was pentadecanoic acid, palmitic acid, myristic acid, and 14,pentadecanoic acid, which were 22.441%, 21.887%, 11.895%, and 10.128%, respectively [25]. Two types of brown seaweeds harvested in the Persian Gulf of Iran were investigated: Colpomenia *sinuosa* and *Sargassum ilicifolium.* The primary SFA content of *C. sinuosa* was palmitic acid, myristic acid, and eicosanoic acid, which were 38%, 12.4%, and 1%, respectively. At the same time, *S. ilicifolium*was palmitic acid, myristic acid, and stearic acid, which were 46.1%, 4.8%, and 1.9%, respectively.

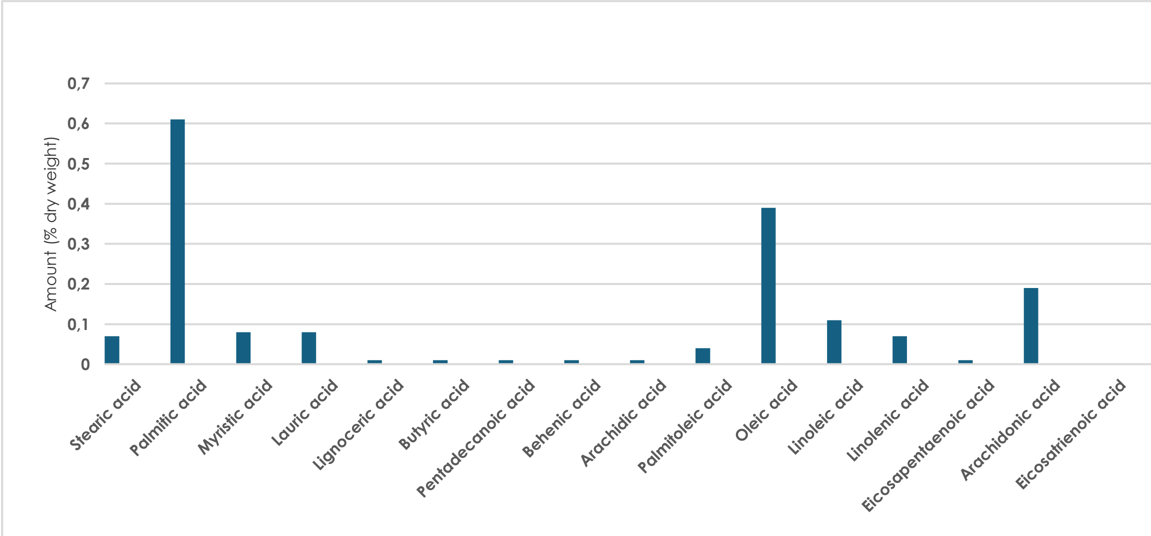


Figure 4 Fatty acids profile of *Turbinaria decurrens*

The significant component of MUFA in *C. sinuosa* was oleic acid, palmitoleic acid, and vaccenic acid,which were 28.6%, 3.7%, and 0.4%, respectively, while in *S. ilicifolium* was oleic acid, palmitoleic acid, and cetoleic acid, which were 18.8%, 8.2%, and 0.2%, respectively. The significant components of PUFA in *C. sinuosa* were eicosapentaenoic acid, eicosadienoic acid, and linoleic acid, which were 5.4%, 3.9%, and 3.1%, respectively. In contrast, in *S. ilicifolium*, linoleic acid, alpha-linolenic acid, and eicosapentaenoic acid were 7.9%, 5.9%, and 1.9%, respectively [13].

Two different types of brown seaweeds harvested in the Karimun Jawa waters, Indonesia, namely *Turbinaria conoides* and *Padina australis,* were studied. The significant component of SFA in *P. australis* was palmitic acid, myristic acid, and stearic acid, which were 30.24%, 7.43%, and 4.97%, respectively, while in *T. conoides* was palmitic acid, myristic acid and stearic acid, which were 16.29%, 4.81%, and 2.36%, respectively. The major component of MUFA in *P. australis* was oleic acid, palmitoleic acid, arachidonic acid, and pentadecanoic acid, which were 20.83%, 8.21%, 1.08%, and 1.01%, respectively. The significant component of PUFA in *P. australis* was linoleic acid, docosahexaenoic acid, and eicosapentaenoic acid, which were 7.7%, 3.79%, and 3.71%, respectively, while in *T. conoides* was linoleic acid, eicosapentaenoic acid, docosahexaenoic acid, and eicosatrienoic acid, which were 9.29%, 8.58%, 6.05%, and 5.47%, respectively [15].

Eight different types of brown seaweed harvested on Morocco's Atlantic coast were investigated. The significant component of SFA was palmitic acid, which varied from 20.97% to 43.15%, and myristic acid, which varied from 1.57% to 6.8%. The significant component of MUFA was vaccenic acid varied from 13.69% to 23.34%and palmitoleic acid varied from 0.71% to 12.47%, while in PUFA, arachidonic acid varied from 12.28% to 24.25%, palmitoleic acid varied from 4.64% to 10.62%, and eicosapentaenoic acid varied from 4.6% to 11.79% [26].

Four different types of brown seaweeds harvested in the South Jeddah coast, Arab Saudi, were examined. The significant component of SFA was palmitic acid varied from 17.4% to 38.41%; stearic acid varied from 3.41% to 4.38%; and myristic acid varied from 0.39% to 4.59%. The significant component of MUFA was oleic acid, which varied from 11.06% to 35.05%. Palmitoleic acid varied from 2.77% to 8.99%, PUFA arachidonic acid varied from 3.08% to 5.92%, and eicosapentaenoic acid varied from 0.11% to 0.59% [27].

Al-Adilah *et al.*, 2021 [28] also evaluated the fatty acid value of four brown seaweeds collected in Kuwait's coastal waters where the significant component of SFA was palmitic acid, which varied from 49% to 53.7%, followed by myristic acid, varied from 3.2% to 7.6% and stearic acid varied from 1.9% to 3.2%. The significant component of MUFA was oleic acid, which varied from 16.8% to 19.8%, and palmitoleic acid, which varied from 1.5% to 4.9%. In comparison, PUFA was alpha-linoleic acid varied from 2.2%to 5.1%, followed by arachidonic acid from 1.1% to 4.3%, and linoleic acid varied from 2.0% to 3.7%.

Amino Acids Composition

The amino acid component identified in this study is presented in Figure 5. Leucine (3,377 mg/kg) was found to have the highest value of all the Essential Amino acids (EAA), followed by valine, threonine, phenylalanine, isoleucine, and lysine, which were 2,582 mg/kg, 2,412 mg/kg, 2,355 mg/kg, 1,902 mg/kg, and 1,767 mg/kg, respectively. Glutamic acid had the highest Non-Essential Amino Acid (NEAA) concentration. It was found to be 5,828 mg/kg, followed by aspartic acid, alanine, serine, proline, arginine, and tyrosine, which were 4,466 mg/kg, 2,903 mg/kg, 2,644 mg/kg, 2,082 mg/kg, 1,938 mg/kg, and 1,274 mg/kg, respectively. This result is higher than the previous study. Fouda *et al.*, 2019 [16] examined the amino acid content of six different brown seaweeds harvested on Hurghada coast in Egypt, where the major EAA was leucine varied from 0.90 mg/kg to 1.82 mg/kg, while the significant component of NEAA was glutamic acid varied from 1.54 mg/kg to 3.65 mg/kg.

Brown seaweed *Sargassum linifolium* harvested from Abu Qir Bay in Egypt reported that the major components of EAA were histidine, leucine, and threonine, which were 360 mg/kg, 352 mg/kg, and 269 mg/kg, respectively. At the same time, NEAA was proline, glutamic acid, and aspartic acid, 889 mg/kg, 736 mg/kg, and 662 mg/kg, respectively [25]. Three brown seaweeds harvested from the Brazilian coast, namely *Dictyopteris jolyana, Spatoglossum,* and *Zonaroa tournefortii,* were examined for their amino acid components. *Dictyopteris jolyana* showed that the main components of EAA were glutamic acid, aspartic acid, and asparagine, which were 184.8 mg/kg, 96 mg/kg, and 51.7 mg/kg, respectively. The main components of NEAA were phenylalanine, tryptophan, and lysine, which were 46.8 mg/kg, 32.7 mg/kg, and 9 mg/kg, respectively. *Spatoglossum schroederi* indicated that the significant EAAs were serine, aspartic acid, and glutamic acid, which were 64.5 mg/kg, 41.6 mg/kg, and 41.2 mg/kg, respectively. At the same time, the NEAAs were tryptophan, lysine, and leucine, which were 64.5 mg/kg, 7.1 mg/kg, and 3.6 mg/kg, respectively. *Zonaria tournefortii* showed significant EAAs in aspartic acid, alanine, and glutamic acid, 66.4 mg/kg, 24.9 mg/kg, and 24.5 mg/kg, respectively. At the same time, the NEAAs were phenylalanine, valine, and lysine, which were 12.7 mg/kg, 6.7 mg/kg, and 3.1 mg/kg, respectively [22].

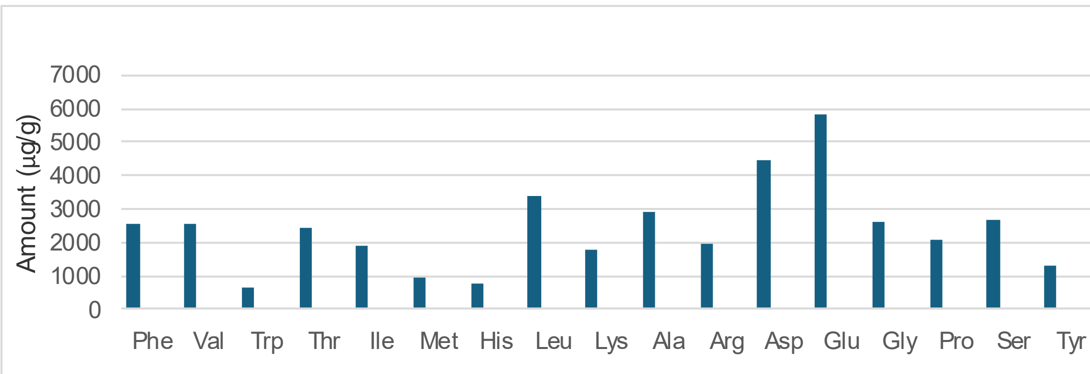


Figure 5 Amino acids profile of *Turbinaria decurrens*

Amino acids profile in two different types of brown seaweeds harvested on the Red Sea coast in Egypt, namely *Dictyota dichotoma* and *Turbinaria decurrens,* was studied. The significant component of EAA in *D. dichotoma*was leucine, threonine, valine, arginine, histidine, and isoleucine, which were 105 mg/kg, 72 mg/kg, 63.9 mg/kg, 58.5 mg/kg, 48.5 mg/kg, and 44 mg/kg, respectively. While in *T. decurrens* was leucine (89.5 mg/kg) [20].

The amino acid profile of brown seaweed, *Labophora variegate,* harvested from India's Gulf of Mannar Biosphere, was studied. The significant components of EAA were lysine, phenylalanine, isoleucine, histidine, valine, and tryptophan, which were 18.9 mg/kg, 18.3 mg/kg, 18.3 mg/kg, 18.2 mg/kg, 12.6 mg/kg, and 10.2 mg/kg, respectively, while the NEAAs were asparagine, glycine, serine, alanine, and glutamic acid, which were 27.3 mg/kg, 26.1 mg/kg, 19.8 mg/kg, 18.4 mg/kg, and 14.8 mg/kg, respectively [23].

On the other hand, the EAA of *Macrocystis pyrifera* harvested on the Southern coast of Ilo in Peru was leucine, threonine, methionine, phenylalanine, and valine, which were 1,183 mg/kg, 991 mg/kg, 896 mg/kg, 602 mg/kg, and 510 mg/kg, respectively. At the same time, the NEAA were proline, glycine, serine, glutamic acid, alanine, and arginine, which were 2,270 mg/kg, 2,060 mg/kg, 1,552 mg/kg, 1,526 mg/kg, and 1,104 mg/kg, respectively [29]. The Egyptian brown seaweed, *Sargassum subrepandum,* showed the significant components of EAA were valine, histidine, leucine, threonine, lysine, and isoleucine, which were 7,890 mg/kg, 7,450 mg/kg, 5,930 mg/kg, 4,470 mg/kg, 4,410 mg/kg, and 4,140 mg/kg, respectively. At the same time, the NEAA were glutamic acid, aspartic acid, alanine, glycine, serine, and proline, which were 8,860 mg/kg, 7,440 mg/kg, 6,680 mg/kg, 5,030 mg/kg, 4,600 mg/kg, and 2,000 mg/kg, respectively [30].

Most of the research was done on naturally acquired seaweeds worldwide. However, the nutritional benefits of seaweeds are not well understood because factors such as habitats, species, seaweeds' ages, seasons, and environmental circumstances, among others, can influence their chemical and nutritional content [11, 31]. The difference in the chemical composition of seaweed makes it always interesting to study. Based on the description above, the chemical composition is sometimes different even though the species are the same. Likewise, the dominant chemical component of a species also varies.

4.0 CONCLUSION

Brown seaweed *Turbinaria decurrens* from Ambon Bay waters in Indonesia have similar nutritional values to those found in several other seaweeds worldwide. Hence, this species could be used as an alternative source of minerals, protein, carbohydrates, and amino acids for human consumption.

Acknowledgement

The Research Center for Oceanography, National Research and Innovation Agency (BRIN), Indonesia, fully supports this research.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

References

[1] Kluru, P., D'Auria, M. V., Muller, C. D., Tammela, P., Vuorela, H. & Yli-Kauhaluoma, J. 2014. Exploring Marine Resources for Bioactive Compounds. *Planta Medica*. 80: 1234–1246. Doi: https://doi.org/10.1055/s-0034-1383001.

[2] Patarra, R. F., Paiva, L., Neto, A. I., Lima, E. Baptista, J. 2011. Nutritional Value of Selected Macroalgae. *Journal of Applied Phycology*. 23(2): 205–208. Doi: https://doi.org/10.1007/s10811-010-9556-0.

[3] Alisha, Dubey, R. P. & Haider, A. 2019. Seaweed: Nutritional and Health Benefits. *The Pharma Innovation Journal*. 8(8): 80–83.

[4] Ahmad, F., Sulaiman, M. R., Saimon, W., Yee, F. C. & Matanjun, P. 2012. Proximate Composition and Total Phenolic Contents of Selected Edible Seaweed from Semporna, Sabah, Malaysia. *Borneo Science*. 31: 74–83.

[5] Chakraborty, S. & Bhattacharya, T. 2012. Nutrient Composition of Marine Benthic Algae Found in the Gulf of Kutch Coastline, Gujarat, India. *Journal of Algal Biomass Utilization*. 3: 32–38.

[6] AOAC. 1990. Official Methods of Analysis of the Association of Official Analytical Chemists 15th ed., Washington D.C. 771.

[7] Waters, 2012. Acquity UPLC H-Class and H-Class Bio Amino Acid Analysis System Guide. Waters Cooperation, USA., 170.

[8] Berna, K., Semra, C., Gamze, T., Halice, T. & Edis, K. 2013. Seaweeds for Food and Industrial Applications. In book: Food Industry 1st Edition Chapter 31 (Editor: Innocenzo Muzzalupo). *Intech*: 735–748. Doi: http://dx.doi.org/10.5772/53172.

[9] Remya, R. R., Rajasree, S. R. R., Suman, T. Y., Aranganathan, L., Gayathri, S., Gobalakrishnan, M. & Karthi, M. G. 2019. Studies on Proximate Composition and Phytochemical Profiling of *Turbinaria ornate* and Its Antiproliferative Effect on Y79 Cell Lines. *Thalassas: An International Journal of Marine Sciences*. 8. Doi: https://doi.org/10.1007/s41208-019-00159-x.

[10] Olsson, J., Toth, G. B. & Albers, E. 2020. Biochemical Composition of red, green and brown seaweeds on the Swedish west coast. *Journal of Applied Phycology* 32(5): 3305–3317. Doi: https://doi.org/10.1007/s10811-020-02145-w.

[11] D'Armas, H., Jaramillo, C., D'Armas, M., Echavaria, A. & Valverde P. 2019. Proximate Composition of Several Macroalgae from the Coast of Salinas Bay, Ecuador. *Revista de Biologia Tropical*6. (7): 61–68. Doi: http://dx.doi.org/10.15517/rbt..33380.

[12] Chowdhury, K. N., Ahmed, M. K., Akhter, K. T., Alam, M. J., Rani, S. & Khan, M. I. 2022. Proximate Composition of Some Selected Seaweeds from Coastal Areas of Cox's Bazar and St. Martin's Island, Bangladesh. *The Dhaka University Journal Earth Environment Sciences*. 10(3): 113–122. Doi: https://doi.org/10.3329/dujees.v10i3.59077.

[13] Rohani-Ghadikolaei ,K., Abdulalian, E. & Ng, W. K. 2012. Evaluation of the Proximate, Fatty Acid, and Mineral Composition of Representative Green, Brown, and Red Seaweeds from the Persian Gulf of Iran as Potential Food and Feed Resources. *Journal of Food Science and Technology*. 49(6): 774–780. Doi: https://doi.org/10.1007/s13197-010-0220-0.

[14] Tibbetts, S. M., Milley, J. E. & Lall, S. P. 2016. Nutritional Quality of Some Wild and Cultivated Seaweeds: Nutrient Composition, Total Phenolic Content and in Vitro Digestibility. *Journal of Applied Phycology*. 28: 3575–3585. Doi: https://doi.org/10.1007/s10811-016-0863-y.

[15] Siahaan, E. A., Asaduzzaman, A. K. M. & Pangestuti, R. 2018. Chemical Composition of Two Brown Seaweed Species from Karimun Jawa, Indonesia. *Marine Research in Indonesia*. 48(2): 71–78. Doi: https://doi.org/10.14203/mri.v43i2.480.

[16] Fouda, W. A., Ibrahim, W. M., Ellamie, A. M. & Ramadan, G. 2019. Biochemical and Mineral Composition of Six Brown Seaweeds Collected from the Red Sea at Hurghada Coast. *Indian Journal of Geo-Marine Sciences*. 48(04): 484–491.

[17] Holdt, S. L. and Kraan, S. 2011. Bioactive Compounds in Seaweed: Functional Food Applications and Legislation. *Journal of Applied Phycology*. 23(3): 543–597. Doi: https://doi.org/10.1007/s10811-010-9632-5.

[18] Ruperez, P. and Saura-Calixto, F. 2001. Dietary Fibre and Physicochemical Properties of Edible Spanish Seaweeds. *European Food Research and Technology*. 212(3): 349–354. Doi: https://doi.org/10.1007/s002170000264.

[19] Venkatesan, J., Anil, S. & Kim, S. 2017. Seaweed Polysaccharides: Isolation, Biological and Biomedical Applications. Amsterdam, Germany; Elsevier.

[20] El-Shenody, R. A., Ashour, M. & Ghobara, M. M. E. 2019. Evaluating the Chemical Composition and Antioxidant Activity of Three Egyptian Seaweeds: *Dictyota dichotoma, Turbinaria decurrens* and *Laurencia obtusa*. *Brazilian Journal of Food Technology*. 22: e2018203. Doi: https://doi.org/10.1590/1981-6723.20.

[21] Kokilam, G., Vasuki, S. & Sajitha N. 2013. Biochemical Composition, Alginic Acid Yield and Antioxidant of Brown Seaweeds from Mandapam Region Gulf of Mannar. *Journal of Applied Pharmaceutical Science*. 3(11): 99–104. Doi: https://doi.org/10.7324/JAPS.2013.31118.

[22] Mandalka, A., Cavalcanti, M. I. L. G., Harb, T. B., Fujii, M. T., Eisner, P., Weisz, U. S. & Chow, F. 2022. Nutritional Composition of Beach-cast Marine Algae from the Brazilian Coast: Added Value for Algal Biomass Considered as Waste. *Foods*. 11: 1201. Doi: https://doi.org/10.3390/foods11091201.

[23] Nithya, P., Archana, L., Kokila, P., Saranya, K., Viji, M., Murugan, P. Maruthupandian, A. 2022. Nutritional Assessment on Brown Macroalgae *Lobophora variegate*

from GOMBR, Tamil Nadu, India. *Journal of Advanced Applied Scientific Research*. 4(2): 1–8. Doi: https://doi.org/10.46937/joaasr422022157.

[24] Milinovic, J., Fernando, A. L., Campos, B., Leite, B., Mata, P., Diniz, M., Sardinha, J. & Noronha, J. P. 2021. Nutritional Benefits of Edible Macroalgae from the Central Portuguese Coast: Inclusion of Low-calorie 'Sea Vegetables' in the Human Diet. *International Journal of Environmental Sciences & Natural Resources*. 28(5): 10p. Doi: https://doi.org/10.19080/IJESNR.2021.28.556250.

[25] Ismail, M. & Osman, M. 2017. Seasonal Fluctuation of Photosynthetic Pigments of Most Common Red Seaweeds Species Collected from Abu Qir, Alexandria, Egypt. *Revista de Biologia Marina Y Oceanografia*. 51(3): 515–525. Doi: https://doi.org/10.4067/S0718-19572016000300004.

[26] Belattmania, Z., Engelen, A. H., Pereira, H., Serrao, E., Custodio, L., Varela, J. C., Zrid, R., Reani, A. & Sabour, B. 2018. Fatty Acid Composition and Nutraceutical Perspective of Brown Seaweeds from the Atlantic Coast of Morocco. *International Food Research Journal*. 25(4): 1520–1527.

[27] Hawas, U. W., Hussein, S., El-Kassem, L. T. A., Tale, H. A. A. & El-Sherbiny, M. M. 2023. Biochemical Assessment of Some Red Sea Brown Algae with Potential of Antioxidant and Antimicrobial Agents. *Thalassas: An International Journal of Marine Sciences*. 40(2): 1–13. Doi: https://10.1007/s41208-024-00684-4.

[28] Al-Adilah, H., Al-Sharrah, T. K., Al-Bader, D., Ebel, R., Kupper, F. C. & Kumari, P. 2021. Assessment of Arabian Gulf Seaweeds from Kuwait as Sources of Nutritionally Important Polyunsaturated Fatty Acids (PUFAs). *Foods*. 10: 2442. Doi: https://doi.org/10.3390/foods10102442.

[29] Vilcanqui, Y., Mamani-Apaza, L. O., Flores, M., Ortiz-Viedma, J., Romero, N., Mariotti-Cells, M. S, and Huaman-Castilla, N. L. 2021. Chemical Characterization of Brown and Red Seaweed from Southern Peru, a Sustainable Source of Bioactive and Nutraceutical Compounds. *Agronomy*. 11(8): 1669. Doi: https://doi.org/10.3390/agronomy11081669.

[30] Abou-El-Wafa, G. S. E., Shaaban, K. A., El-Naggar, M. E. E. & Shaaban M. 2021. Bioactive Constituent and Biochemical Composition of the Egyptian Brown Alga *Sargassum subrepandum* (Forsk). *Revista Latinoamericana de Quimica*. 39(1–2): 62–74.

[31] Saroja, P. M. 2016. Nutritional Evaluation of Three Marine Macroalgae on the Coast of Kanyakumari District. *International Journal of Pure & Applied Bioscience*. 4(1): 193–198. Doi: http://dx.doi.org/10.18782/2320-7051.2198.