

Chemical Composition, Phytochemical Constituent, and Toxicity of Methanol Extract of Brown Algae (*Padina* sp.) from Puntondo Coast, Takalar (Indonesia)

by

Submission date: 11-Sep-2022 10:57AM (UTC+0700)

Submission ID: 1896772668

File name: 2021-Khadijah-Chemical_Composition.pdf (409.92K)

Word count: 5133

Character count: 27512



Chemical Composition, Phytochemical Constituent, and Toxicity of Methanol Extract of Brown Algae (*Padina* sp.) from Puntondo Coast, Takalar (Indonesia)

K. Khadijah^{1,2}, N.H. Soekamto^{3*}, F. Firdaus³, S.M.T. Chalid⁴, Y.M. Syah⁵

1. Doctoral Program, Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Hasanuddin, Jl. Perintis Kemerdekaan No.KM.10, Makassar 90245, South Sulawesi, Indonesia
2. Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Khairun, Jalan Pertamina Kampus II Gambesi, Ternate 97719, North Maluku, Indonesia
3. Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Hasanuddin, Jl. Perintis Kemerdekaan No.KM.10, Makassar 90245, South Sulawesi, Indonesia
4. Department of Medical, Faculty of Medicine, Universitas Hasanuddin, Jl. Perintis Kemerdekaan No.KM.10, Makassar 90245, South Sulawesi, Indonesia
5. Department of Chemistry, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, Jl. Ganesa No.10, Bandung 40132, West Java, Indonesia

HIGHLIGHTS

- *Padina* sp. from Puntondo coast is rich in nutrients (protein, carbohydrates, and minerals).
- *Padina* sp. has bioactive components such as alkaloids, flavonoids, steroids, and tannins.
- *Padina* sp. can be developed as a raw material source for the functional foods.

Article type

Original article

Keywords

Phaeophyta
Nutritive Value
Phytochemicals
Toxicity
Functional Food
Indonesia

Article history

Received: 15 Feb 2021
Revised: 24 May 2021
Accepted: 1 Aug 2021

Acronyms and abbreviations

AAS=Atomic Absorption Spectrophotometry
FTIR=Fourier-Transform Infrared Spectroscopy
GC-MS=Gas Chromatography-Mass Spectrometry

ABSTRACT

Background: *Padina* sp. is an algae that has potential as a functional food. This study aimed to explore the chemical and photochemical constituent in the methanolic extract of *Padina* sp.

Methods: Brown algae of *Padina* sp. from Puntondo coast Takalar, Indonesia was prepared. The algae characterization was carried out based on the standard procedure of Association of Official Agricultural Chemists (AOAC). Toxicity of *Padina* sp. was determined with Brine Shrimp Lethality Test (BSLT).

Results: Chemical contents were 13.46% water, 38.02% ash, 12.33% protein, 1.60% fat, 20.02% fiber, and 48.06% carbohydrate. The FTIR spectrum displayed the presence of hydroxyl, carboxylic acids, aldehydes, aliphatic hydrocarbons, fatty acids, and unsaturated hydrocarbons. *Padina* sp. extract consisted of phytol compound which had 70-96% similarity with steroids, fatty acids, carboxylic acids, terpenoid, and proteins. The result of toxicity was 6344.54 p₅₀ indicating not toxic.

Conclusion: *Padina* sp. can be used as a raw material source for functional food and pharmaceutical industry.

© 2021, Shahid Sadoughi University of Medical Sciences. This is an open access article under the Creative Commons Attribution 4.0 International License.

Introduction

Indonesia, as a maritime country with $\frac{3}{4}$ an area in the form of oceans, has abundant natural resources, including

various types of algae. Algae are a group of chlorophyll plants that consists of one or many cells and forms

* Corresponding author (N.H. Soekamto)

E-mail: nunukhariyani@unhas.ac.id

ORCID ID: <https://orcid.org/0000-0001-8281-1752>

To cite: Khadijah K., Soekamto N.H., Firdaus F., Chalid S.M.T., Syah Y.M. (2021). Chemical composition, phytochemical constituent, and toxicity of methanol extract of brown algae (*Padina* sp.) from Puntondo Coast, Takalar (Indonesia). *Journal of Food Quality and Hazards Control*. 8: 178-185.

colonies. Algae contain organic materials such as polysaccharides, hormones, vitamins, as well as secondary metabolite compounds that can act as bioactive compounds. Antioxidants and antibacterial properties have been found in marine algae (Renhoran et al., 2017; Sang-er et al., 2013; Shannon and Abu-Ghannam, 2016). Algae also have anti-inflammatory, anti-diabetic, anti-cancer, and the other properties (Chew et al., 2008; Kim et al., 2008). So far, the use of algae as a trade commodity or industrial raw material is still relatively small compared to the diversity of algae species in Indonesia (Kadi, 2004). The high diversity of algae species provides great opportunities for the exploration of bioactive compounds.

Biological active compounds are secondary metabolites, including alkaloids, flavonoids, terpenoids, tannins, and saponins. The content of secondary metabolite compounds in algae can be determined with an approach method that can provide information on the presence of secondary metabolite compounds. The phytochemical assay is a method that can be used to analyze the phytochemical components possessed by algae (Qin, 2020). Some algae also have pigments utilized as dyes and have many health benefits. The type of photosynthetic pigments of algae consists of chlorophyll (a, b, c), carotenoids (carotene and xanthophyll), and phycobilin (phycoerythrin and phycocyanin) (Pesang et al., 2020).

In addition, algae are admitted to be utilized in the food sector and are potential as a new source of the bioactive compound for humans, animals, plant fertility, as well as a source of synthons and biocatalysts in sustainable chemistry studies (Wells et al., 2017). Therefore, algae can be a source of functional food.

Brown algae are one of the resources that grow on the plains of coral reefs. Several types of brown algae that have been known are *Padina*, *Sargassum*, and *Turbinaria* (Wouthuyzen et al., 2015). Brown algae contain 54.3-73.8% carbohydrates, 0.3-5.9% protein, vitamins (vitamins B1, B6, B16, C, and niacin), and minerals, especially calcium (Ca), sodium (Na), magnesium (Mg), potassium (K), iodine (I), iron (Fe), and contain several bioactive components, namely phenolic compounds, natural pigments, sulfate polysaccharides, fiber, and other bioactive components that have been studied for health benefits (Qin, 2020). Santoso et al. (2013) stated that algae have a high mineral content that can be consumed by humans.

Brown algae in Indonesian waters have not been utilized by coastal communities. For example, in the waters of Puntondo, Takalar Regency in South Sulawesi Province, brown algae, especially *Padina* sp. type is still considered as ocean waste because of the lack of public knowledge about the benefits of this type of brown algae.

The chemical composition, even the phytochemicals constituent of brown algae, namely *Padina* sp., from the

coastal waters of Puntondo has not been widely reported. Thus, this study aimed to explore the chemical and phytochemical constituent of *Padina* sp. in a form of methanolic extract. Research on chemical composition and phytochemicals in brown algae of *Padina* sp. is expected to provide useful information, especially for coastal communities, so that brown algae can have a useful value that can benefit society.

Materials and methods

Materials

The raw material in this study is *Padina* sp., brown algae from Puntondo, Takalar regency (Indonesia) which taken at a water depth of ±1 meter. The chemicals used for analysis were methanol p.a (Merck, Germany), Kjeldahl tablets (Merck, Germany), K₂SO₄ (Merck, Germany), CuSO₄ (Merck, Germany), concentrated H₂SO₄ (Merck, Germany), H₂O₂ (Merck, Germany), H₃BO₃ 4% (Merck, Germany), NaOH 40% (Merck, Germany), HCl 0.2 N (Merck, Germany), Chloroform (Merck, Germany), NH₄OH (Merck, Germany), Mayer's witness (solution A 1.36 g HgCl₂ (Sigma Aldrich, US) dissolved in 60 ml of distilled water, solution B 0.5 g KI (Merck, Germany) dissolved in 10 ml distilled water, Wagner reagen (2.5 g I₂, 3 KI (Merck) and 10 ml aquades), Dragendroff reagen (solution A 0.85 g bismuth nitrate (Sigma Aldrich, US), 2 ml concentrated HCl (Merck, Germany) and 10 ml distilled water, solution B 8 g KI₂ (Merck) and 10 ml distilled water), CH₃OH 70% (Merck), Mg (Merck, Austria), FeCl₃ 1% (Merck, Germany), Na₂CO₃ (Merck, Germany). The tools used were Blenders (Miyako CH-501, China), glasswares (Pyrex, Japan), destructive pumpkins (Pyrex, Japan), hot plate (Favourite HP0707V2, Japan), Fourier-transform Infrared Spectroscopy (FTIR) (Shimadzu 8,501, Japan), Atomic Absorption Spectrophotometry (AAS) (Shimadzu AA 7,000, Japan), Gas Chromatography-Mass Spectrometry (GC-MS) (Shimadzu QP-2010, Japan).

Algae identification and characterization

Samples of brown algae of *Padina* sp. were obtained from Puntondo coast, Takalar Regency, washed with seawater to clean from dirt and sands. Those samples were dried by wind and grounded using a crusher machine, also sieved with a size of 60 mesh to obtain algae flour. The identification of brown algae species was carried out by observing the morphology characteristics and identifying algae species (Lanyon, 1986).

The chemical characterization of brown algae (*Padina* sp.) consisted of proximate and mineral analysis. Proximate analysis refers to the Association of Official

Analytical Chemists (AOAC, 2005) method which analyzes moisture content, protein, fat, ash, carbohydrates, and coarse fiber. Mineral analysis of K, Ca, Fe was carried out following the AOAC method (2005) by using AAS. Five ml HNO₃ was added to 1 g sample then left for 1 h at temperature room. The sample was left 12 h in a closed container. Then, it was added with 0.4 ml H₂SO₄ and heated on a hot plate until the solution was reduced or more concentrated (± 1 h). The sample then added with a mixture solution of HCl and HNO₃ as much as 2-3 drops. The sample remains placed on a hot plate and the heating continued until the mixture changed the color from brown to dark yellow and turned to light yellow. After a discoloration, heating continued for 10-15 min, the sample was moved, then cooled and added with 2 ml distilled water and 0.6 ml HCl. The destructive result was analyzed using AAS at wavelengths of 766.5 nm for K, 422.7 nm for Ca, and 248.3 nm for Fe.

The characterization of the chemical contents of *Padina* sp. included proximate and mineral analysis, which followed AOAC (2005) standard method. The proximate analysis comprised moisture content, protein, fat, ash, carbohydrate, and coarse fiber. Meanwhile, mineral analysis consisted of K, Ca, and Fe by using ³¹S. A weight of 1 g sample was added with 5 ml HNO₃ and left at room temperature for 1 h. The sample was closed for 12 h and then added with 0.4 ml H₂SO₄.

Preparation of Methanol Extract

The extraction was carried out following Lee et al. (2017) method. About 50 g dried samples were placed into Erlenmeyer and added with 250 ml methanol for 72 h. The extract was evaporated using a vacuum evaporator at a temperature of 60 °C and the extract obtained was in a paste form.

Phytochemical analysis

The phytochemical analysis referred to Marimuthu and Gurumoorthi (2013) and Paul and Yuvaraj (2013) with modification. The analysis aimed to find out the active compound in *Padina* sp. This phytochemical analysis included alkaloid, flavonoid, tannin, saponin, steroid, and triterpenoid.

Toxicity test

For toxicity test, Brine Shrimp Lethality Test (BSLT) method was performed on the methanol extract *Padina* sp. based on the Meyer et al. (1982) procedure with several stages. At first, 20 mg extract was dissolved in a mixture of 200 μ l Dimethyl Sulfoxide (DMSO) and 9,800 μ l seawater. Hence, the concentration of the stock solution was 2,000 ppm. Then, the concentrations of 0.1,

1, 10, 100, and 1,000 ppm were varied from the stock solution. Each concentration was made three times for triple measurements. The control solution was made by using the same procedure as the procedure above out a sample. For hatching evaluation, *Artemia salina* shrimp eggs were put in a container filled with seawater. Furthermore, it was aerated under 40-60 W incandescent lamps. Then, it was left for 2 days (48 h) to be *A. salina* larvae.

Elucidation structure

The structural analysis was carried out by using FTIR instruments in Integrated Laboratory, Department of Chemistry, Hasanuddin University and GC-MS from Department of Chemical Engineering, Politeknik Negeri Ujung Pandang.

Results

The chemical composition of *Padina* sp. referred to the proximate analysis. Proximate analysis indicated that *Padina* sp. contained water (13.64%), ash (38.02%), protein (12.33%), fat (1.6%), fiber (20.02%), and carbohydrate (48.06%). Moreover, this study presents that *Padina* sp. from Takalar contained Ca (7.61%), K (1.5%), and Fe (0.26%).

Phytochemical analysis of methanol extract in *Padina* sp. shows the presence of several active compounds in the form of alkaloids, flavonoids, steroids, phenolic compounds, and tannins (Table 1). The LC₅₀ value of *Padina* sp. extract in methanol was found to be non-toxic over *A. salina* larvae. The value was 6344.54 ppm, as indicated by LC₅₀>1,000 ppm. The results explain that *Padina* sp. from Puntondo coast was non-toxic and safe to be used as a functional food, even in the other place, extract of *Padina* sp.

Meanwhile, the bioactive compounds of methanol extract were investigated by using FTIR and GC-MS. Figure 1 presents the FTIR spectrum data of methanol extract which indicated the presence of OH groups (3,412 1/cm). This OH group is suspected from C-O-H since it was also found at 1,074 1/cm and supported by the absorption at 1,095 1/cm. This absorbance indicates the presence of aliphatic groups. C-H stretch from alkanes was also found at 2,922 and 2,852 1/cm which was supported by the presence of the absorbance at 1,458 1/cm (CH₂) and 1,404 1/cm (CH₃) groups. The extract also contained a carbonyl (C=O) group that was shown by the absorbance at 1,647 1/cm. This carbonyl group was suspected to have a substitution of para amplified since there was a signal at the wavenumber of 804 1/cm. Furthermore, the absorbances at 1,739 and 1,712 1/cm indicated the presence of C=O ketone and ester groups.

The spectrum also presents C=C olefin group that was found at 1,629 1/cm. The inorganic content and fatty acid were found at 678-383 1/cm and 2,376-2,312 1/cm, respectively.

The findings of compounds contained in methanol extract of *Padina* sp. were also determined by using GC-MS (Figure 2) while the phytochemical constituent is

shown in Table 2. The active compound test of *Padina* sp. extract in methanol by using GC-MS method resulted in 25 compounds, shown in Table 2. Those compounds had the percentage of similarity ranging from 70-96%. In line with the phytochemical test results, *Padina* sp. was suspected containing several compounds, such as alkaloid, steroid, terpenoid, phenolic, and tannin.

Table 1: Phytochemical assay of extract methanol brown algae *Padina* sp.

No.	Phytochemical Assay	<i>Padina</i> sp.	Remarks
1	Alkaloid a. Dragendorff b. Mayer c. Wagner	- + +	White sediment Violet ring
2	Flavonoid a. Lead(II) acetate b. Mg	+ -	Yellow sediment
3	Steroid	+	Green to blue color
4	Phenolic	+	Yellow-green color
5	Saponin	-	
6	Tannin	+	Dark Green

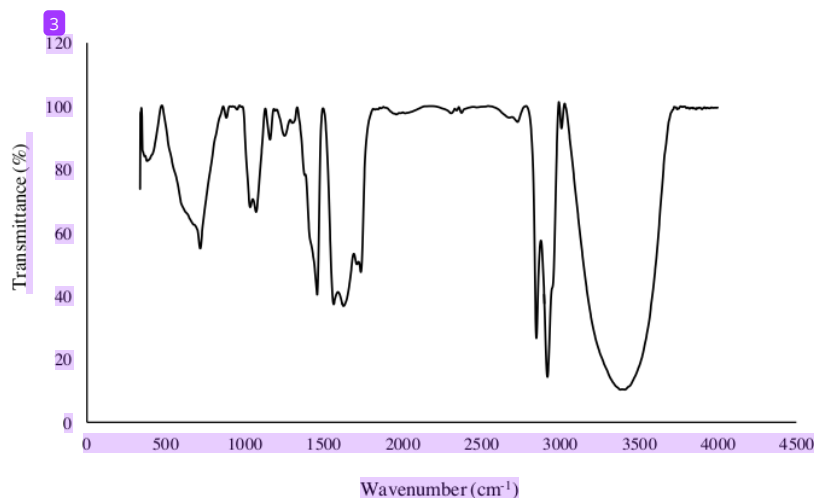


Figure 1: Fourier-transform Transform Infrared Spectroscopy (FTIR) analysis from methanol extract of *Padina* sp. from Puntondo coast, Takalar

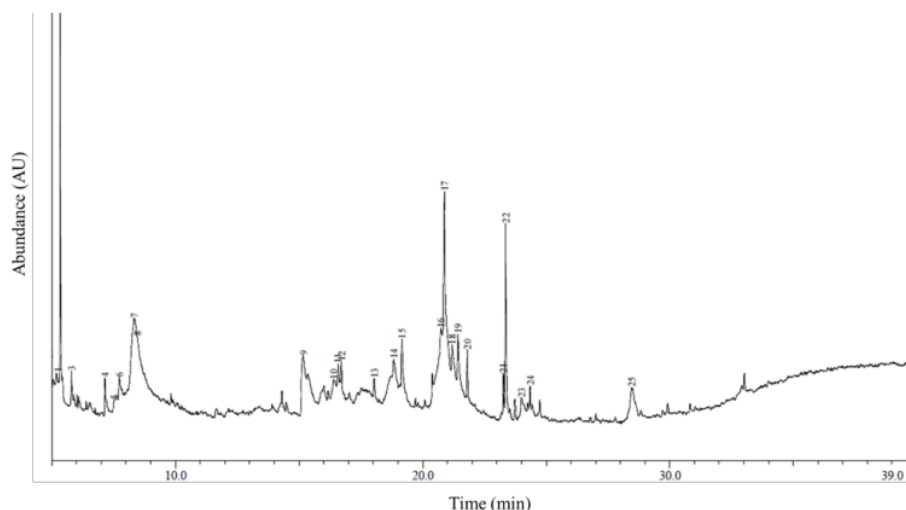


Figure 2: Chromatogram from methanol extract of *Padina* sp. from Puntondo coast, Takalar

Table 2: Constituents of methanol extract of brown algae *Padina* sp. from Puntondo coast, Takalar

Peak#	R.Time	Area %	Name	SI (%)
17	20.883	15.29	Hexadecanoic acid, methyl ester (asam lemak jenuh)	93
2	5.344	14.01	2-Propanone, 1,1-dimethoxy	85
7	8.345	12.83	Glycerin	95
22	23.362	10.08	9-Octadecenoic Acid, Methyl Ester	96
9	15.179	5.17	tert-butoxy-5-trimethylsilyloxy-pentane	75
16	20.733	4.38	Pentadecanoic acid, 14-methyl-, methyl ester	80
19	21.425	3.77	l-(+)-Ascorbic acid 2,6-dihexadecanoate	92
15	19.169	3.23	2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-6-Hydroxy-4,4,7a-Trimethyl	85
10	16.392	2.77	1,4-Anhydrohexitol	86
8	8.467	2.55	1-Pentene, 2,4,4-trimethyl-	80
18	21.2	2.52	1-Dimethyldecahydronaphthalene	81
25	28.464	2.27	STIGMAST-5-EN-3-OL, (3.BETA.,24S)	84
14	18.837	2.23	9-OCTADECENOIC ACID (Z)-	71
12	16.71	2.17	PROPRANOIC ACID, 2-METHYL-, 1-(1,1-DIMETHYLETHYL)-2-METHYL-1,3-PROPANEDIYL EST	89
21	23.269	1.97	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	94

Discussion

Macroalgae, especially brown algae, has high carbohydrate content, such as fucoidan, laminaran, cellulose, and alginate (Dawczynski et al., 2007; Mabeau and Fleurence, 1993). The chemical composition of macroalgae varies considering several factors, such as habitat, geographical distribution, season, and concentration of nutrients in its environment, particularly in species and genus (Fleurence, 1999; Goecke et al., 2010; Mansilla and Ávila, 2011). These factors will influence the minerals provided that can be absorbed by *Padina* sp.

(Goecke et al., 2012; Rupérez, 2002). This study presents that *Padina* sp. from Takalar contained Ca (7.61%), K (1.5%), and Fe (0.26%) which is in line with a study conducted by Manteu et al. (2018). The highest minerals in the brown algae of *Padina* sp. from Pohuwato waters, Gorontalo, Indonesia were Ca (10.22%), k (1.48%), and Fe (0.125%).

The minerals found in *Padina* sp significantly affect the chemical composition of this *Padina* sp., especially ash and fiber levels. High ash content in food indicates that

the mineral settles in a material high, as well as as a form of adaptation to conditions marine environment that contains various minerals with high concentrations (Fleurence, 1999). Compared to terrestrial food sources, microalgae contained more trace elements and minerals (MacArtain et al., 2007). *Padina* sp. species are an important source of calcium carbonate and organic matter in the shallow waters of tropical and subtropical areas (Wefer, 1980).

The content found in *Padina* sp. from Puntondo coast differed from the previously reported of *Padina* sp. *Padina* sp. collected from Gorontalo, Indonesia (Manteu et al., 2018) which had lower content of ash (30.53%), fat (0.52%), protein (4.78%), and fiber (3.81%). The other study reported by Goecke et al. (2012) presents *Padina fernandeziana* collected from Chile had a greater ash content of 53.79%, with a protein composition of 6.54%, and a lower water content of 7.33%. Meanwhile, the brown algae from Kupang bay contained water content (11.21%), ash content (34.58%), protein (13.39%), and fat (2.66%).

The ash (mineral) content of marine macroalgae is commonly range from 8 to 40%, depending on the type of water. High ash content in algae is related to the way of the absorption of nutrient minerals, as well as a form of adaptation to environmental conditions in marine waters that contain various minerals with high concentrations. In addition, Fleurence (1999) stated that the highest protein content was obtained in winter and spring while the lowest was recorded during summer. However, in this present study, *Padina* sp. from Puntondo coast had sufficient protein levels for nutritional intake. Accordi Wu (2016), protein intake for human is about 0.8-3.5 g per kg body weight per day. Protein is important to note since it has a function as a building block, a regulator, a burning agent. As a protein-building substance, it forms various new tissues for growth, replaces damaged tissue, and reproduces.

This present study exhibits the carbohydrate content of *Padina* sp. from Puntondo coast (8.06%) (Indonesia) was higher than the previous study reported by Manteu et al. (2018) and Salosso et al. (2020) from Gorontalo, Indonesia (41.88%), and Kupang, Indonesia (38.15%), respectively. It was also higher than the carbohydrate content of brown algae (30.48%) from Chile, *Padina fernandeziana* from Southeast India (14.73%) (Goecke et al., 2012). Carbohydrates which comprise monosaccharides, oligosaccharides, and polysaccharides, are considered as the critical source of energy. It has been shown that polysaccharides and oligomers contained in algae possess a broad range of biological properties, including antioxidant, anticoagulant, anti-inflammatory, anti-arthritis, immunomodulatory, and immunostimulant properties. It also has potential to be a hepatoprotective,

neuroprotective, chemopreventive, anti-diabetic, and anti-obesity medication. The pharmacology effects of the algae carbohydrates are essentially determined by subject changes in the composition of the sugar backbone, the degree of sulfation, and molecular weight. Aside, the level of carbohydrate is affected by the growth environment, age, and collection season, and the geographical location. Also, the differences in the chemical composition of carbohydrates are suspected to be associated with their biological activities (Lee et al., 2017).

The other substance that is essential for human body and can be found in *Padina* sp. from Puntondo coast is fat. Interestingly, in this study, saponin was not found. The absence of this compound was shown by the absence of foam. In contrast, Haryani et al. (2019) reported that the brown algae of *Padina australis* from Lampung (Sumatera), Indonesia, contains saponin.

Moreover, the substances contained in algae that is usually investigated is the phytochemical composition. The phytochemical composition of algae is also influenced by the habitat conditions and the type of algae. Manteu et al. (2018) reported that *Padina* in Gorontalo (Sulawesi) contained alkaloids, flavonoids, saponin, and tannin. Salosso et al. (2020) reported *Padina australis* in Kupang (East Timor) had alkaloids, flavonoids, saponin, and tannin. The different results can be caused by the different methods and solvents used to extract the compounds (Harborne, 1998).

In this study, the analysis of toxicity of *Padina* sp. was carried out by examining the LC₅₀. A compound can be toxic if in a short time, it can kill 50% of *A. salina* larvae. The result shows that the LC₅₀ of the extract was 6344.54 ppm. Thus, it was non-toxic over *A. salina* larvae. The value higher than 1,000 ppm implies the safety of using *Padina* sp. from Puntondo as a functional food. This toxicity value of *Padina* sp. can be different as reported by Haryani et al. (2019) which the LC₅₀ was 177.83 ppm. The low toxicity of *Padina* sp. was supposed to be caused by the absence of saponin. Saponin is a glycoside which is a mixture of simple carbohydrates and aglycones found in various plants. Saponins can destroy blood grains or hemolysis. Hence, it is toxic to cold-blooded animals (Prihatna, 2001).

Based on the FTIR spectrum, methanol extract of *Padina* sp. contained alkaloids, flavonoid, and steroids. This positively correlated with the phytochemical results obtained. Meanwhile, the results of GC-MS confirmed the presence of terpenoid, alkaloid, steroid, and fatty acid which were showed in FTIR spectrum. Phenolic or polyphenolic compounds contained in this sample are alkaloid groups, cyanate acid derivatives, coumarin, tocopherol, and functional acids that can serve as antioxidant compounds (Marimuthu and Gurumoorthi, 2013).

However, this study focused on the investigation and characterization of the chemical compounds in *Padina* sp. from Puntondo coast, Takalar, Indonesia by using AAS, FTIR, GC-MS, and phytochemical assay. Thus, the results can be acknowledged as a reference to utilize *Padina* sp. as a functional food.

Conclusion

Padina sp. from Puntondo coast comprises rich nutrients (protein, carbohydrates, and minerals) and has bioactive components such as alkaloids, flavonoids, steroids, tannins, and unsaturated fatty acids that can be used to be a functional food. Based on the results, further studies are necessary to advance *Padina* sp. from Puntondo coast as a raw material source for the food and pharmaceutical industry.

Author contributions

All authors designed the study; N.H.S., F.F. conducted the experimental work; N.H.S., F.F., and Y.M.S. analyzed the data; K.K., N.H.S., and S.M.T.C. wrote the manuscript. All authors read and revised the final manuscript.

Conflicts of interest

All the authors declared that this is no conflict of interest in the study.

Acknowledgements

Thanks to Ministry of Education and Culture, Directorate of Higher Education, which funded this research through PTUPT Grant with contract number 1516/UN4.22/PT.01.03/2020.

References

- Association of Official Analytical Chemist (AOAC). (2005). Official method of analysis. 18th edition. Arlington, VA, USA.
- Chew Y.L., Lim Y.Y., Omar M., Khoo K.S. (2008). Antioxidant activity of three edible seaweeds from two areas in South East Asia. *LWT- Food Science and Technology*. 41: 1067-1072. [DOI: 10.1016/j.lwt.2007.06.013]
- Dawczynski C., Schubert R., Jahreis, G. (2007). Amino acids, fatty acids, and dietary fibre in edible seaweed products. *Food Chemistry*. 103: 891-899. [DOI: 10.1016/j.foodchem.2006.09.041]
- Fleurence J. (1999). Seaweed proteins: biochemical, nutritional aspects and potential uses. *Trends in Food Science and Technology*. 10: 25-28. [DOI: 10.1016/S0924-2244(99)00015-1]
- Goecke F., Escobar M., Collantes G. (2012). Chemical composition of *Padina fernandeziana* (Phaeophyceae, Dictyotales) from Juan Fernandez Archipelago. Chile. *Rev Latinoam Biotechnol Amb Algal*. 3: 95-104.
- Goecke F., Hernández V., Bittner M., González M., Becerra J., Silva M. (2010). Fatty acid composition of three species of *Codium* (Bryopsidales, Chlorophyta) in Chile. *Revista de Biología Marina y Oceanografía*. 45: 325-330. [DOI: 10.4067/S0718-19572010000200014]
- Harborne J.B. (1998). Textbook of phytochemical methods. A guide to modern techniques of plant analysis. 5th Edition. Chapman and Hall Ltd, London. pp: 21-72.
- Haryani T.S., Lohitasari B., Triastinurmatiningsih. (2019). Toxicity and compound identification of *Padina australis* extract. *International Journal of Recent Technology and Engineering*. 8: 79-82. [DOI: 10.35940/ijrte.B1016.0782S719]
- Kadi A. (2004). Potensi rumput laut dibebepara perairan pantai Indonesia. *Oseana*. 29: 25-36
- Kim M.S., Kim J.Y., Choi W.H., Lee S.S. (2008). Effects of seaweed supplementation on blood glucose concentration, lipid profile, and antioxidant enzyme activities in patients with type 2 diabetes mellitus. *Nutrition Research and Practice*. 2: 62-67. [DOI: 10.4162/nrp.2008.2.2.62]
- Lanyon J. (1986). Guide to the identification of seagrasses in the great barrier reef region. *Great Barrier Reef Marine Park Authority*. Queensland.
- Lee S.Y., Cho J.M., Chang Y.K., Oh Y.-K. (2017). Cell disruption and lipid extraction for microalgal biorefineries: a review. *Bioresource Technology*. 244: 1317-1328. [DOI: 10.1016/j.biortech.2017.06.038]
- Mabeau S., Fleurence J. (1993). Seaweed in food products: biochemical and nutritional aspects. *Trends in Food Science and Technology*. 4: 103-107. [DOI: 10.1016/0924-2244(93)90091-N]
- MacArtain P., Gill C.I.R., Brooks M., Campbell R., Rowland I.R. (2007). Nutritional value of edible seaweeds. *Nutrition Reviews*. 65: 535-543. [DOI: 10.1301/nr.2007.dec.535-543]
- Mansilla A., Ávila M. (2011). Using *Macrocystis pyrifera* (L.) C. Agardh from southern Chile as a source of applied biological compounds. *Brazilian Journal of Pharmacognosy*. 21: 262-267. [DOI: 10.1590/S0102-695X2011005000072]
- Manteu S.H., Nurjanah N., Nurhayati T. (2018). Characteristics of brown seaweeds *Sargassum polycystum* and *Padina minor* from Pohuwato water, Gorontalo. *Jurnal Pengolahan Hasil Perikanan Indonesia*. 21: 396-405. [DOI: 10.17844/jphpi.v21i3.24709]
- Marimuthu M., Gurumoorthi P. (2013). Phytochemical screening and FT-IR studies on wild and common South Indian legumes. *Asian Journal of Pharmaceutical and Clinical Research*. 6: 139-142.
- Meyer B.N., Ferrigni N.R., Putnam J.E., Jacobsen L.B., Nichols D.E., McLaughlin J.L. (1982). Brine shrimp: a convenient general bioassay for active plant constituents. *Planta Medica*. 45: 31-34. [DOI: 10.1055/s-2007-971236]
- Paul J.P., Yuvaraj P. (2013). Phytochemical analysis of *Padina distromatica* hauck. *Indo American Journal of Pharmaceutical Research*. 3.
- Pesang M.D., Ngginak J., Kase A.G.O., Bisilissin C.L.B. (2020). Komposisi pigmen pada *Ulva* sp., *Padina australis* dan *Hypnea* sp. dari Pantai Tablolong Provinsi Nusa Tenggara Timur. *Jurnal Kelautan Tropis*. 23: 225-233. [DOI: 10.14710/jkt.v23i2.5912]
- Prihatna K. (2001). Saponin untuk pembasmi hama udang. Penelitian perkebunan gambung. Bandung.
- Qin Y. (2020). Chapter 29 - health benefits of bioactive seaweed substances. *Handbook of Algal Science, Technology and Medicine*. 2020: 455-466. [DOI: 10.1016/B978-0-12-818305-2.00029-2]
- Renhoran M., Noviendri D., Setyaningsih I., Uju. (2017). Extraction and purification of fucoxanthin from *Sargassum* sp. as anti-acne. *Jurnal Pengolahan Hasil Perikanan Indonesia*. 20: 370-379. [DOI: 10.17844/jphpi.v20i2.18105]
- Rupérez P. (2002). Mineral content of edible marine seaweeds. *Food Chemistry*. 79: 23-26. [DOI: 10.1016/S0308-8146(02)00171-1]
- Salosso Y., Aisiah S., Toruan L.N.L., Pasaribu W. (2020). Nutrient content, active compound, and antibacterial activity of *Padina*

- australis* against *Aeromonas hydrophila*. *Pharmacognosy Journal*. 12: 771-776. [DOI: 10.5530/pj.2020.12.110]
- Sanger G., Widjanarko S.B., Kusnadi J., Berhimpon S. (2013). Antioxidant activity of metanol extract of seaweeds obtained from North Sulawesi. *Food Science and Quality Management*. 19: 63-70.
- Santoso J., Podungge F., Sumaryanto H. (2013). Chemical composition and antioxidant activity of tropical brown algae *Padina australis* from Pramuka Island, district of Seribu Island, Indonesia. *Jurnal Ilmu dan Teknologi Kelautan Tropis*. 5: 287-297. [DOI: 10.28930/jitkt.v5i2.7558]
- Shannon E., Abu-Ghannam N. (2016). Antibacterial derivatives of marine algae: an overview of pharmacological mechanisms and applications. *Marine Drugs*. 14: 81. [DOI: 10.3390/md14040081]
- Wefer G. (1980). Carbonate production by algae *Halimeda*, *Penicillus* and *Padina*. *Nature*. 285: 323-324. [DOI: 10.1038/285323a0]
- Wells M.L., Potin P., Craigie J.S., Raven J.A., Merchant S.S., Helliwell K.E., Smith A.G., Camire M.E., Brawley S.H. (2017). Algae as nutritional and functional food sources: revisiting our understanding. *Journal of Applied Phycology*. 29: 949-982. [DOI: 10.1007/s10811-016-0974-5]
- Wouthuyzen S., Abrar M., Lorwens J.D. (2015). Pengungkapan kejadian pemutihan karang tahun 2010 di perairan Indonesia melalui analisis suhu permukaan laut coral bleaching incidents of 2010 in Indonesian waters revealed through analysis of sea surface temperature. *Oseanologi dan Limnologi di Indonesia*. 1: 305-327.
- Wu G. (2016). Dietary protein intake and human health. *Food and Function*. 7: 1251-1265. [DOI: 10.1039/C5FO01530H]

Chemical Composition, Phytochemical Constituent, and Toxicity of Methanol Extract of Brown Algae (*Padina* sp.) from Puntondo Coast, Takalar (Indonesia)

ORIGINALITY REPORT

12%

SIMILARITY INDEX

10%

INTERNET SOURCES

6%

PUBLICATIONS

1%

STUDENT PAPERS

PRIMARY SOURCES

1	journal.ipb.ac.id Internet Source	2%
2	www.solabiaa.org Internet Source	1%
3	www.doria.fi Internet Source	1%
4	www.frontiersin.org Internet Source	1%
5	"Handbook of Marine Macroalgae", Wiley, 2011 Publication	1%
6	S Widyastuti, D Evawati. " Proximate characteristics of nano calcium in Blood Cockle () shell from four different locations ", IOP Conference Series: Earth and Environmental Science, 2019 Publication	<1%
7	vuir.vu.edu.au	

<1 %

8

www.scielo.br

Internet Source

<1 %

9

core.ac.uk

Internet Source

<1 %

10

Irmawati, Asmi Citra Malina, Aidah A.A. Husain, Andi Rezky Annisa, Ince Ayu Khaerana Kadriah, Alimuddin Alimuddin. "Genetic variation in the Asian seabass (*Lates calcarifer* Bloch, 1790) from Wallacea Region estimated using random amplified polymorphic DNA (RAPD) markers", IOP Conference Series: Earth and Environmental Science, 2021

Publication

<1 %

11

www.migal.org.il

Internet Source

<1 %

12

Khadijah, N H Soekamto, Firdaus, Y M Syah. "Total Content of Phenol and Antioxidant Activity from crude extract Methanol of brown algae (*Padina* sp) collected from Kayoa Island, North Maluku", Journal of Physics: Conference Series, 2021

Publication

<1 %

13

f1000research.com

Internet Source

<1 %

- 14 Jerzy Jonczak, Agnieszka Parzych. <1 %
"Bioaccumulation of macronutrients in herbaceous plants of the Sławno glaciolacustrine plain, northern Poland", Acta fytotechnica et zootechnica, 2018
Publication
-
- 15 Submitted to Universiti Malaysia Pahang <1 %
Student Paper
-
- 16 Wang, Tao, Rosa Jonsdottir, Gudrun Olafsdottir, and Hordur G. Kristinsson. <1 %
"Antioxidant properties of marine macroalgae", Antioxidants and Functional Components in Aquatic Foods, 2014.
Publication
-
- 17 www.journal-aquaticscience.com <1 %
Internet Source
-
- 18 Galland-Irmouli, A.V.. "Nutritional value of proteins from edible seaweed *Palmaria palmata* (dulse)", The Journal of Nutritional Biochemistry, 199906 <1 %
Publication
-
- 19 files.aiscience.org <1 %
Internet Source
-
- 20 Www.intechopen.com <1 %
Internet Source
-

21 Alfonsina Marthina Tapotubun, Theodora E.A.A. Matrutty, Johan Riry, Elizabeth Juleny Tapotubun et al. "Seaweed Caulerpa sp position as functional food", IOP Conference Series: Earth and Environmental Science, 2020
Publication

22 J Santoso, K Khasanah, K Tarman, I K Sumandiarsa. "Antioxidant activities of acetone extract of Sargassum polycystum from different parts of Thallus", IOP Conference Series: Earth and Environmental Science, 2022
Publication

23 repository.unhas.ac.id
Internet Source

24 www.bodybuilding.com
Internet Source

25 Franklin R Kemenangan, Gaspar D Manu, Fransine B Manginsela. "Growth Of Brown Algae, Padina australis, In The Coastal waters of Serei Village, West Likupang District, North Minahasa Regency", JURNAL ILMIAH PLATAX, 2017
Publication

26 H B Setyorini, A Puspitasari. "Fat, water and ash content in Chlorophyceae, Rhodophyceae and Phaeophyceae macroalgae at Sepanjang

Beach, Yogyakarta, Indonesia", IOP Conference Series: Earth and Environmental Science, 2021

Publication

27	biodiversitas.mipa.uns.ac.id Internet Source	<1 %
28	cyberleninka.org Internet Source	<1 %
29	file.zums.ac.ir Internet Source	<1 %
30	hdl.handle.net Internet Source	<1 %
31	jjbs.hu.edu.jo Internet Source	<1 %
32	link.springer.com Internet Source	<1 %
33	pt.scribd.com Internet Source	<1 %

Exclude quotes On

Exclude matches < 5 words

Exclude bibliography On