

Nutrient Composition of Dried Seaweed *Gracilaria gracilis*

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Abstract

The nutrient composition of dried red seaweed *Gracilaria gracilis* collected from Barru waters, South Sulawesi including proximate, dietary fiber, minerals, fatty acid and amino acid profile has been investigated. The objective of this study was to evaluate the various nutritional parameters of *G. gracilis* for utilization in human nutrition. Results show that the content of moisture (19.045), protein (10.86%), ash (6.78%), fat (0.18%), carbohydrate (63.13%) and dietary fiber (27.48%) basis on the dry weight. The content of calcium (429.11 mg.100 g⁻¹), sodium (290.89 mg.100 g⁻¹), phosphor (57.01 mg.100 g⁻¹), iron (15.20 mg.100 g⁻¹) and potassium (1380.42 mg.100 g⁻¹). Leucine was the major essential amino acid found to be 9374.22 mg.kg⁻¹, while glutamic acid was the major non-essential amino acid found to be 10848.98 mg.kg⁻¹. Palmitic acid was the major saturated fatty acid found to be 0.08%, while oleic acid was the major unsaturated fatty acid found to be 0.05%. The nutrient composition of *G. gracilis* was discussed in this study and suggested that the seaweed species have potentially be used as raw material or ingredient of a healthy food for human.

Keywords: Barru waters, nutrition, healthy food, red seaweed

Introduction

Seaweeds have been utilized globally for different purposes (Nazni and Deepa, 2015). Currently, seaweeds are consumed as part of modern diet in the western countries. Changing of food patterns increase in Asia-style food and people become more comfortable consuming edible seaweeds, particularly *Porphyra* and *Undaria* spp. that are commonly found in Korea and Japanese dishes (Smith *et al.*, 2010). Especially in China, *Gracilaria* originally were utilized as food and as binding material in the preparation of lime for painting walls. The use of seaweed as food spreads to several Asian countries, until the content of agar was discovered by the western countries and the Japanese (Santelices, 2014).

Seaweeds (fresh or dried form) are extensively consumed, especially by people living in the coastal region. Seaweeds are generally suitable for making cool, concoctions or gelatinous dishes. The nutrient composition of seaweeds varies and are affected by geographical area, species, temperature, of water and season of the year (Jensen, 1993).

However, there are no published data on the nutrient composition of the dried red seaweed *G. gracilis* from Barru waters, South Sulawesi. This paper presents data on the various nutrient

composition of *G. gracilis*, including proximate, dietary fiber, minerals, fatty acid and amino acid profile. The potential of *G. gracilis* as a source of healthy food nutrients is discussed.

Materials and Methods

The red seaweed *G. gracilis* was collected from Barru waters, South Sulawesi during low tide. The seaweed was picked by hand and cleaned immediately using sea water to remove debris, sand, epiphytes and other unnecessary matter and transported to the laboratory. The sample was sorted and thoroughly cleaned by rinsing distilled water. The sample was dried under the sun for 6 days and then ground in a blender. The powdered samples were kept in the dark container and stored in the room temperature for future analysis.

Proximate analysis

The moisture content was determined by drying 2 g *G. gracilis* in an oven at 105°C for 3 hours. The dried sample was put into a desiccator and weighed (AOAC, 1990). The ash content was determined by heating 2 *G. gracilis* in a muffle furnace at 550°C for 4 hours. The sample was put into a desiccator and weighed immediately (AOAC, 1990).

The fat content was determined by loosely wrapping 2 g *G. gracilis* with a filter paper and then put into the thimble which was fitted to a clean round bottom flask containing 120 ml of petroleum ether. The sample was heated and allowed to a reflux for 5 hours. The thimble with the spent sample was kept and weighed (AOAC, 2000). The protein content was determined by calculating from the elemental N using the nitrogen-protein factor of 6.25 (AOAC, 2000). The carbohydrate content was determined by difference: 100 - (moisture + ash + protein + fat) %. The dietary fiber content was determined by putting 2 *G. gracilis* and 1 g asbestos into 200 ml H₂SO₄ 1.25% and boiled for 30 min. The solution was filtered by Buchner funnel and the residue was put into 200 ml boiled NaOH for 30 min and then filtered. The residue was washed twice with alcohol and continued with petroleum ether. The residue was put in a clean crucible and dried in an oven and weighed (AOAC, 1990).

Mineral analysis

Mineral (calcium, sodium, iron, and potassium) content was determined by the standard AOAC method (2000). While the phosphor content was determined by the spectrophotometric method.

Fatty acid analysis

The fatty acid profile was determined by using gas chromatography (Perkin Elmer Clarus 580 GC). The apparatus condition: Flow rate (18.0 cm per second with column length 100 m); column (Supleco SPTM 2560 100 m 0.25 mm 0.2 µm), carrier gas (N₂), injector temperature (225°C), detector FID (240°C) and split (1:100).

Sample preparation for fat extraction (AOAC, 2000): A 5 g *G. gracilis* was added 4 ml isopropanol and 6 ml n-hexane. The solution was centrifuged for 3 minutes at 9000 RPM. The clear upper solution was moved into a Hach tube and was dried in a water bath. About 0.03–0.04 g fat extract was added 1.5 ml KOH methanol 0.5M and 1.5 ml BF₃ 20% in methanol. The solution was heated in a water bath at 100°C for 20 min. A 3 ml saturated NaCl and 0.2ml n-hexane was added to the mixture and then vortexed for 2 min. The mixture was allowed to stand at room temperature for 10 min. The n-hexane methyl ester layer was transferred into 10 ml volumetric flask, diluted with n-hexane and injected to gas chromatography.

Amino acid analysis

The amino acid profile was determined by using Ultra Performance Liquid Chromatography (UPLC). The apparatus condition: Detector (FDA,

wavelength 260 nm), column (Accq.Tag Ultra C18 1.7 µm (2.1x100 mm), Waters), temperature (49°C), flow rate (0.5 ml per min), mobile phase (Gradient composition system) and injection volume (1 µl).

Sample preparation: A 0.1 g *G. gracilis* was added 5 ml HCl 6N. The mixture was hydrolyzed for 22 h at 110°C. The hydrolyzed mixture was transferred into a 50 ml volumetric flask and diluted to volume with aquadest. The solution was filtered with a 0.45 µm filter. A 500 µl of the filtrate was added 40 µl AABA and 460 µl aquabidest. A 10 µl of the solution was added 70 µl AccQ Fluor Borate and 20 µl reagent fluor A. The solution was incubated for 10 min at 55°C and then transferred into the UPLC system.

Standard solution preparation: A 40 µl standard solution was mixed with amino acid. A 40 µl internal standard AABA and 920 µl aquabidest was added and then homogenized. A 20 µl standard solution was pipetted and 70 µl AccQ Fluor Borate was added. A 20 µl reagent fluor A was added and then vortexed for 1 min. The solution was incubated for 10 minutes at 55°C and injected into the UPLC system.

Results and Discussion

Nutrient composition of seaweeds was different and affected by geographical area, species and environmental growth condition (Benjama and Mashiyom, 2012). Metabolic activity of seaweeds is the fundamental one, but it is controlled by temperature and concentration of essential nutrients of the surrounding waters (Nazni and Deepa, 2015). The moisture, protein, ash, fat, carbohydrate and dietary fiber content of *G. gracilis* collected from Barru waters, South Sulawesi were shown in Table 1. The moisture content examined in this study was 19.4% dry weight. This result was relatively low if compared with the quality standard of commercial seaweeds sold in Indonesia set by the National Standardization Agency of Indonesia where

Table 1. Proximate composition of dried seaweed *Gracilaria gracilis*

No	Parameter	Result (%)
1	Moisture	19.04
2	Ash	6.78
3	Fat	0.19
4	Protein	10.86
5	Carbohydrate	63.13
6	Dietary fibre	27.48

Gracilaria sp. was 25% dry weight. This result was higher than the other species of *Gracilaria* reported in the previous study such as *G. verrucosa* (10.17%) (Nazni and Deepa, 2015) and *G. cervicornis* (14.33%) (Marinho-Sorano et al., 2007).

The moisture content is an important criterion in determining the quality and shelf-life of processed seaweed meals where high moisture may hasten the growth of microorganisms. In addition, by drying and storage of seaweeds are likely to affect the moisture content of the seaweed examined (Rohani-Ghadikolaie et al., 2012).

The ash content of *G. gracilis* examined in this study was 6.78%. This result was lower than other species of *Gracilaria* such as *G. changgi* (22.70%) (Norziah and Ching, 2000), *G. salicornia* (38.91%) (Tabarsa et al., 2012), *G. cervicornis* (7.72%) (Marinho-Soriano et al., 2006), *G. verrucosa* (30.72%) (Nazni and Deepa, 2015), *G. domingensis* (30.72%) and *G. bindiae* (22.5%) (Gressler et al., 2010), *G. arcuate* (16.51%) and *G. salicornia* (29.10%) (Mwalugha et al., 2015) and *G. cornea* (29.06%) (Robledo and Freile-Pelegrin, 1997).

The protein content of *G. gracilis* examined in this study was 10.86%. This result was higher than other species of *Gracilaria* such as *G. salicornia* (9.55%) (Mwalugha et al., 2015), *G. salicornia* (9.58%) (Tabarsa et al., 2012), *G. cornea* (5.47%) (Robledo and Freile-Pelegrin, 1997), *G. changgi* (6.90%) (Norziah and Ching, 2000), but lower than *G. verrucosa* (18.7%) (Nazni and Deepa, 2015), *G. cervicornis* (22.96%) (Marinho-Soriano et al., 2006) and *G. arcuate* (13/79%) (Mwalugha et al., 2015). The protein content in red and green seaweeds are generally higher (ranging from 10 to 30%) compare to brown seaweeds (ranging from 5 to 15%) (Burtin, 2003).

The fat content examined in this study was 0.19%. This result lower than other species of *Gracilaria* such as *G. arcuate* (1.07%) and *G. salicornia* (1.47%) (Mwalugha et al., 2015) and *G. salicornia* (2.00%) (Tabarsa et al., 2012).

Carbohydrate was the major component of the proximate composition in *G. gracilis* examined in this study. The carbohydrate content was 63.13%. This result was higher than other species of *Gracilaria* such as reported by Nazni and Deepa (2015) for *G. verrucosa* was 33.67%, Robledo and Freile-Pelegrin (1997) for *G. cornea* was 36.29% and Marinho-Soriano et al. (2006) for *G. cervicornis* was 63.12%. Carbohydrate is also the most important component of metabolism, mainly in supplies the

energy needed for respiration and other metabolic processes (Khairy and El-Sharay, 2013).

The dietary fiber content of *G. gracilis* examined in this study was 27.48%. This result was higher than other species of *Gracilaria* reported by Mwalugha et al. (2015) for *G. arcuate* (10.90%) and *G. salicornia* (12.52%), Tabarsa et al. (2012) for *G. salicornia* (10.4%), McDermid et al. (2005) for *G. parvispora* (26.4%) and *G. tikvahae* (28.4%), Norziah and Ching (2000) for *G. changgi* (24.79%), Marinho-Soriano et al. (2006) for *G. cervicornis* (5.65%) Nazni and Deepa (2015) for *G. verrucosa* (8.35%) and Robledo and Freile-Felegrin (1997) for *G. cornea* (29.08%), but lower than reported by McDermid et al. (2005) for *G. salicornia* (35.8%).

The mineral composition of *G. gracilis* examined in this study was shown in Table 2. Potassium was the major component in *G. gracilis*. Potassium content was 1380.42 mg.100g⁻¹. The content of other mineral examined in this study, including calcium (429.11 mg.100g⁻¹), sodium (290.89 mg.100g⁻¹), iron (15.20 mg.100g⁻¹) and phosphor (57.01 mg.100g⁻¹). Rohani-Ghadikolaie et al. (2012) reported that the concentration and composition of mineral in seaweeds are affected by location and species where seaweeds are able to selectively absorb minerals from the surrounding seawater and accumulated them in their thalli.

The fatty acid profile was shown in Table 3. The total percentage of identifying saturated fatty acids were 0.12% and unsaturated fatty acids were 0.07%. For individual fatty acids, palmitic acid (C 16:0) was the major saturated fatty acids while lauric acid (C 12:0) and myristic acid (C 14:0) were the same value.

Whereas unsaturated fatty acids, including oleic acid (C 18:1) and linoleic acid (C 19:2) were 0.05% and 0.02% respectively. In the previous study, Francavilla et al. (2013) were also reported that palmitic acid and arachidonic acid were the most abundant in *G. gracilis*, but arachidonic acid was not detected in this study.

Table 2. Mineral content in dried seaweed *Gracilaria gracilis*

No	Parameter	Result (mg.100 g ⁻¹)
1	Sodium	290.89
2	Calcium	429.11
3	Potassium	1380.42
4	Phosphorus	57.01
5	Iron	15.20

The amino acid profile was shown in Table 4. All essential amino acids were found in *G. gracilis* except tryptophan. Tryptophan could not be detected after acid hydrolysis of the protein sample. The major essential amino acid was leucine (9374.22 mg.kg⁻¹). The other essential amino acids including threonine (7336.78 mg.kg⁻¹), histidine (923.29 mg.kg⁻¹), lysine (3549.05 mg.kg⁻¹), phenylalanine (7518.04 mg.kg⁻¹), isoleucine (5826.37 mg.kg⁻¹), valine (6379.71 mg.kg⁻¹) and methionine (677.51 mg.kg⁻¹).

The major non-essential amino acid in *G. gracilis* was glutamic acid (10848.98 mg.100g⁻¹). The other non-essential amino acids, including tyrosine (2152.47%), proline (4871.92 mg.kg⁻¹),

glycine (7673.82 mg.kg⁻¹), aspartic acid (10134.37 mg.kg⁻¹), alanine (7011 mg.kg⁻¹), arginine (6847.05 mg.kg⁻¹), cysteine (61.38 mg.kg⁻¹) and serine (7583.72 mg.kg⁻¹).

Glutamic acid was abundantly occurring amino acid examined in this study. In the previous study also reported that it was the most abundantly in several seaweeds such as *Caulerpa lentilifera* and *Ulva reticulata* (Ratana-arpom and Chirapart, 2006), *Durvillaea antarctica* (Ortiz et al., 2006), *Porphyra* sp., *Undaria pinnatifida*, *Laminaria* sp., and *Hizikia fusiforme* (Dawczynski et al., 2007) and *Acanthophora delilei* and *Codium lyngaria* (Qasim, 1991).

Table 3. Fatty acid composition of dried seaweed *Gracilaria gracilis*

No	Fatty acid composition	Result (%)
1	C12:0 (Lauric acid)	0.02
2	C14:0 (Myristic acid)	0.02
3	C16:0 (Palmitic acid)	0.08
4	C18:1 W9C (Oleic acid)	0.05
5	Omega 6	0.02
6	Omega 9	0.05
7	Unsaturated fat	0.07
8	Saturated fat	0.12
9	MUFA	0.05
10	PUFA	0.02

Table 4. Amino acid composition of dried seaweed *Gracilaria gracilis*

No	Parameter	Result (mg.kg ⁻¹)
1	Histidine	923.29
2	Threonine	7336.78
3	Proline	4871.92
4	Tyrosine	2152.47
5	Leucine	9374.22
6	Aspartic acid	10134.37
7	Lysine	3549.05
8	Glycine	7673.82
9	Arginine	6947.05
10	Alanine	7011.00
11	Valine	6379.71
12	Isoleucine	5826.37
13	Phenylalanine	7518.04
14	Glutamic acid	10848.96
15	Serine	7583.72
16	Methionine	677.51
17	Cysteine	61.38
18	Tryptophan	Not detected

Conclusion

Based on the nutritional composition of *Gracilaria gracilis* it is suggested that this seaweed species can potentially be used as a raw material or healthy food ingredient for the human diet.

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