



Chemical Evaluation of a Nori-Like Product (*Geluring*) Made from the Mixture of *Gelidium* Sp. and *Ulva Lactuca* Seaweeds

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Abstract

Dry sheet food products or nori-like products can be produced from the mixture of *Gelidium* sp. and *Ulva lactuca* seaweeds, which is called *geluring*. Making *geluring* involves heat application that may influence the chemical composition of the product. The goal of this study was to evaluate the chemical characteristics of *geluring* by measuring proximate composition; dietary fiber, total phenolic, and flavonoid contents; and antioxidant activity (by DPPH analysis) of *geluring* and compare the values to those of the raw materials. Three types of *geluring* were prepared following commercial nori preparation procedures with some modifications: P1 (unseasoned), P2 (seasoned), and P3 (seasoned and roasted). The proximate composition of *geluring* products and raw materials differed significantly ($P < 0.05$). *Geluring* fiber contents were not significantly different ($P > 0.05$) among P1 ($29.19 \pm 0.26\%$), P2 ($29.42 \pm 0.66\%$), and P3 ($29.83 \pm 0.11\%$), but these values differed significantly ($P < 0.05$) from those of the raw materials. The total phenolic content, flavonoid content, and DPPH activity of P2 *geluring* were 1.38 mg GAE/g, 1.11 mg QE/g, and 61.23%, respectively, which were significantly ($P < 0.05$) higher than those of P1 and P3 but lower than those of the raw materials. These results suggest that *geluring* processing might negatively impact the chemical composition of the products, but they still have high antioxidant activity and dietary fiber content and thus have potential for utilization as a functional food product.



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Introduction

One of the food products that can be developed from seaweed is a thin dried sheet product, or "nori". Nori is produced by processing of the red seaweed *Porphyra*, and it is commonly consumed by the people of Japan, Korea, and China. Nori can be directly consumed as a snack or used as an edible wrapper (e.g., with sushi).¹⁻² In Indonesia, nori products are mostly imported from other countries, as its consumption is still limited, especially among the middle and upper classes.

Due to increasing demand for nori, researchers are assessing the possibility of producing nori-like products using other seaweeds. For example, Loupatty³ explored the potential of *Porphyra marcosi* as a raw material for the production of a nori-like product. Other types of seaweed, such as the red seaweed *Gelidium* sp. and the green seaweed *Ulva lactuca* (*U. lactuca*), could also be used. This nori-like product made from the mixture of *Gelidium* sp. and *U. lactuca* seaweeds is a new product that we named "geluring". *Geluring* can be produced by modifying the commercial method of nori production.

Gelidium sp. and *U. lactuca* grow well in the coastal water of Indonesia, especially near coral reefs.⁴⁻⁵ These seaweeds, which contain bioactive compounds such as sulfate polysaccharide, phenolics, flavonoids, and chlorophylls,⁶⁻⁷ have the potential to be used as raw materials to produce healthy and/or functional foods. *Ulva lactuca* has high chlorophyll content (21.27 mg/g)⁶ and dietary fiber content.⁸ To date, this species has not been utilized optimally in Indonesia.

The goal of this study was to evaluate the chemical characteristics (proximate composition, dietary fiber, total phenolic, and flavonoid contents; and antioxidant activity) of *geluring* prepared from the mixture of *Gelidium* sp. and *U. lactuca*. Three types of *geluring* were studied [P1 (unseasoned), P2 (seasoned), and P3 (seasoned and roasted)], and results were compared with those of the raw materials.

Materials and Methods

Geluring Processing

Dry *Gelidium* sp. and *U. lactuca* were obtained from a local collector from Sayang Heulang Beach,

Pameumpuk, Garut, West Java, Indonesia. The nori-like product was processed according to the method of Zakaria *et al.*,⁹ with modifications including soaking in vinegar and heat treatment on the preparation of the pulp.

Dried seaweeds were washed and soaked with water (ratio 1:2) for 24 hours for *Gelidium* sp. and 6 hours for *U. lactuca*. Samples then were soaked in 2% vinegar (ratio 1:1) for 30 minutes. The soaked seaweeds were washed with water, drained, cut into small pieces, and blended with water (ratio 1:1) using a commercial blender (Philips HR 2116). The pulp of *U. lactuca* was prepared by adding water (ratio 1:1) and cooking at 90–100 °C for 30 minutes. For *Gelidium* sp., the pulp was prepared by adding water (ratio 1:9) and cooking at 90–100 °C for 2 hours. The three *geluring* products prepared during the study were:

- P1: Unseasoned *geluring* was produced by mixing *Gelidium* sp. pulp and *U. lactuca* pulp (ratio 3:1 (256 g)) in a 12 x 38 cm mold and drying the mixture in an oven (Cascade Tex, USA) at 50 °C for 2 hours.
- P2: Seasoned *geluring* was produced by the same process used to make P1, but seasoning made from 0.1% salt, 0.1% garlic powder, and 0.1 % pepper powder was added to the mixture.
- P3: Seasoned and roasted *geluring* was produced by the same process used to make P2, but the produced dry sheet was smeared with coconut oil and roasted at 100 °C (Sanyo SK-8600 FM, Jepang) for 2 minutes.

The P1, P2 and P3 *geluring* sheets were vacuum sealed in plastic packaging and stored at 4 °C in prior to analysis for not more than 3 months.

Proximate Composition

The proximate composition (moisture, protein, fat, ash, and carbohydrate) of *geluring* products and raw materials was determined according to AOAC10 methods. Carbohydrate analysis was conducted by different.

Dietary Fiber Content

Dietary fiber content was measured following the AOAC¹⁰ method.

Total Phenolic Content

Total phenolic content was measured using Folin-Ciocateu reagent (Sigma) with gallic acid as the standard (Sigma) based on the method described by Hodzic.¹¹ Solution absorbance was measured using a UV spectrophotometer (Shimadzu UV-1800, USA) at 725 nm wavelength.

Flavonoid Content

Flavonoid content was measured using the aluminum chloride colorimetric method, with absorbance measured using a spectrophotometer¹² (Shimadzu UV-1800, USA). Quercetin (Sigma) was used as the standard.

Antioxidant Activity Measured by the 1,1-diphenyl - 2-picryl-hydrazyl (DPPH) Assay

Analysis of antioxidant activity was conducted using the DPPH method.¹³ Extraction of *geluring* products was performed by macerating the *geluring* product for 24 hours using water solvent at a concentration of 20 mg/ml. For analysis, 2 ml of each sample extract were reacted with 2 ml of 0.1 mM DPPH reagent (Sigma) and then placed in a dark room for 10 minutes. The solution absorbance was measured using a UV spectrophotometer (Shimadzu UV-1800, USA) at 517 nm wavelength.

Statistical Analysis

The design of the experiment was completely randomized. Analysis of variance followed by Duncan's multiple range test were used to compare

proximate composition, fiber content, total phenolic content, total flavonoid content, and antioxidant DPPH activity data among the treatments. $P < 0.05$ was considered to be statistically significant.

Results and Discussion

Proximate Composition

Table 1 shows the moisture, protein, fat, ash, and carbohydrate content of the *geluring* products. The moisture, protein, and fat content did not differ significantly ($P > 0.05$) between P1 and P2, but they did differ significantly ($P < 0.05$) from P3. The ash and carbohydrate content of P2 and P3 did not differ significantly ($P > 0.05$), but they did differ significantly ($P < 0.05$) from P1. In general, proximate composition of *geluring* products was significantly different ($P < 0.05$) from that of its raw materials. P3 *geluring* was high in fat content due to the addition of coconut oil prior to the roasting process. The fat content of coconut oil according is 85-95%.¹⁴

Geluring produced in this study had higher moisture, ash, and carbohydrate contents but lower protein and fat contents compared to commercial nori made from *Porphyra* seaweed.¹⁵ The difference in proximate composition between *geluring* products and commercial nori likely is due to the use of different seaweed types. Taboada *et al.*,¹⁶ and Polat and Ozogul¹⁷ reported that the proximate content of seaweed is affected by the type, harvest age, harvest period, post-harvest handling, and conditions of the sea environment.

Table 1: Proximate composition of *geluring* products (P1, P2, P3) and raw materials

Sample	Proximate composition				
	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
P1	11.60 ± 0.01 ^b	9.41 ± 0.01 ^a	3.55±0.01 ^c	13.49 ± 0.06 ^b	61.94 ± 0.07 ^c
P2	11.62 ± 0.02 ^b	9.66 ± 0.11 ^a	3.51±0.01 ^c	14.56 ± 0.01 ^c	60.65 ± 0.09 ^b
P3	11.04 ± 0.01 ^a	9.89 ± 0.09 ^a	4.25±0.01 ^d	14.53 ± 0.01 ^c	60.29 ± 0.08 ^b
<i>U. lactuca</i>	12.43 ± 0.01 ^c	10.26 ± 0.02 ^b	0.96±0.02 ^a	15.35 ± 0.03 ^d	62.01 ± 0.06 ^d
<i>Gelidium sp</i>	14.40 ± 0.01 ^d	13.44 ± 0.01 ^c	2.17±0.01 ^b	10.97 ± 0.02 ^a	59.01 ± 0.05 ^a

Values are expressed as mean ± SD (n=3); different letters within columns indicate significant differences ($p < 0.05$).

Dietary Fiber Content

The fiber content of *geluring* products ranged from 29.19 to 29.82% (Table 2). No significant difference ($P > 0.05$) in fiber content was detected among the *geluring* products, but they did differ significantly ($P < 0.05$) from the raw materials. Dietary fiber content of *geluring* was higher than that of the raw material *Gelidium* sp., and the addition of *U. lactuca* pulp during *geluring* preparation also successfully increased the dietary fiber content of the *geluring* product. *Ulva lactuca* is a green seaweed that is rich in dietary fiber.¹⁸ The dietary fiber content of *U. lactuca* used in this study was 50.21%, which was lower than the content (53–54.9%) reported by Yaich *et al.*,⁸ but higher than the content (28.4%) reported by Rasyid.¹⁹ *Gelidium* sp. in this study had dietary fiber content of about 20.12%, which was lower than the dietary fiber content of *Gelidium pusillum* (24.74%).⁷ The process of making *geluring* including soaking with acid, blending of seaweed, pulping and drying of the sheet may influence the fiber functionality of the *geluring* product compared to that of the raw material. Treatment with acid was reported to improve the swelling properties of dietary fiber,²⁰ mechanical treatments such as stirring reportedly caused changes in the chemical structure of the fibers that can free hydroxyl groups in the fiber molecules making them readily bind to water.²¹ Likewise, heat processing is reported to alter the ratio of soluble and insoluble fiber and fiber surfaces.²²

Geluring in this study had a higher dietary fiber content than commercial nori, which is about

23.1%.¹⁶ This difference is due to the difference in the dietary fiber content of the raw material. Dietary fiber content of *Porphyra* sp. is about 48%.²³ Although the dietary fiber content of the *geluring* products in this study was higher than that of commercial nori, the values were lower than that of the nori-like product prepared from the mixture of *U. lactuca* and *Euchema cottoni* (36.76%).⁹

Total Phenolic Content

Total phenolic content of the *geluring* products ranged from 0.93 to 1.38 mg GAE/g, and values differed significantly ($P < 0.01$) among all *geluring* products and the raw materials (Table 2). P2 had higher total phenolic content compared to P1 and P3. The high total phenolic content of P2 was due to the addition of 0.1% garlic and 0.1% pepper. Kamath *et al.*,²⁴ and Lachowicz *et al.*,²⁵ reported that the total phenolic content of garlic is 0.065 mg and that of pepper is 1.76 mg GAE/g. Although P3 also contained pepper and garlic, the product was roasted at 100 °C, which could have destroyed some of the phenol substances. Amorim *et al.*,²⁶ reported that the heating process at high temperatures, such as roasting process could lower the phenolic content in seaweed.

The total phenolic contents of the *geluring* samples in this study were lower than those of the raw materials. Total phenolic contents of *Gelidium* sp. and *U. lactuca* were 6.33 mg and 5.91 mg GAE/g, respectively, which is lower than the value for *Porphyra* (18.2 mg GAE/g), which is the raw material for commercial nori.²⁷ The *geluring* processing

Table 2: Dietary fiber, total phenolic content, flavonoid content, and DPPH antioxidant activity of *geluring* products (P1, P2, P3) and raw materials

Sample	Dietary fiber content (%)	Total phenolic content	Flavonoid content (mg GAE/g)	DPPH antioxidant activity (%) (mg QE/g)
P1	29.19 ± 0.26 ^b	1.12 ± 0.01 ^b	1.01 ± 0.01 ^b	58.33 ± 1.33 ^b
P2	29.44 ± 0.66 ^b	1.38 ± 0.03 ^c	1.11 ± 0.02 ^c	61.23 ± 0.55 ^c
P3	29.82 ± 0.11 ^b	0.93 ± 0.01 ^a	0.81 ± 0.02 ^a	49.93 ± 1.45 ^a
<i>Gelidium</i> sp	20.12 ± 0.33 ^a	6.33 ± 0.09 ^e	4.03 ± 0.07 ^e	74.33 ± 0.52 ^e
<i>U. lactuca</i>	50.21 ± 0.45 ^c	5.91 ± 0.07 ^d	2.21 ± 0.17 ^d	68.23 ± 1.92 ^d

Values are expressed as mean ± SD (n=3); different letters within columns indicate significant differences ($p < 0.05$).

procedure includes cooking and drying, which could reduce the phenolic content. Xu and Chang²⁸ reported a 40–50% loss in the total phenolic content of legumes due to the boiling process. Cox *et al.*,²⁹ found that *Himanthalia elongata* seaweed steamed for 45 min lost around 32.06% of its total phenolic content. Watchtel-Galor *et al.*,³⁰ reported that steaming and microwaving caused loss in total phenolic content of broccoli, choysum, and cabbage. The thermal process can change the phenolic structure of phenol substances, causing the content to lessen.³¹⁻³³ The thermal process can also denature enzymes that are important for breakdown of nutrients and phytochemicals.³³

Flavonoid Content

Flavonoids are phenolic compounds that are found commonly in seaweeds.³⁴⁻³⁵ Flavonoid content of the *geluring* products in this study ranged from 0.81 to 1.11 mg QE/g (Table 2). Significant differences ($P < 0.05$) in the flavonoid content were detected among all *geluring* samples and raw materials. The flavonoid content of P2 was significantly higher than those of P1 and P3. The presence of garlic and pepper in P2 likely increased the flavonoid content. Priccina and Karlina³⁶ reported that the flavonoid content of garlic is 8.9 mg QE/g.

The flavonoid content of nori products is affected by the flavonoid content of the seaweed raw material. The flavonoid contents in the *geluring* samples were lower than those of the raw materials. The processing procedure used affects the content, activity, and bioavailability of bioactive compounds such as flavonoids.²⁸⁻³⁰ Gupta *et al.*,³⁷ reported that the flavonoid content of *H. elongata* decreased to 30% due to drying at 25 °C but increased to 49% at 40 °C. Cox *et al.*,²⁹ found that boiling of *H. elongata* significantly reduced the flavonoid content within a range of 88.86 to 90.18%.

Antioxidant Activity

The antioxidant activity of the different *geluring* samples and raw materials all differed significantly from each other (Table 2). P2 had significantly higher

antioxidant activity than P1 and P3. The addition of 0.1% garlic and 0.1% pepper likely accounts for the higher antioxidant activity in P2. Garlic and pepper contain bioactive components such as phenolics, which have antioxidant activity.³⁸⁻⁴⁰ The lower antioxidant activity of P3 compared to P2 likely was caused by roasting of P3, which would destroy bioactive components in garlic and pepper. Antioxidant stability also is affected by temperature.⁴¹ Exposure to roasting temperature causes antioxidant compounds to become less stable due to chemical and physical degradation.⁴²⁻⁴⁴

The antioxidant activities of P1 and P2 were higher than those of commercial nori, which is about 51%.¹⁵ The antioxidant activities of all *geluring* products were lower than those of the raw materials (Table 2). The cooking and drying process could have decreased the antioxidant activity. Hwang and Do Thi⁴⁴ and Susanto *et al.*,⁴⁵ reported that processing of seaweed by drying, steaming, and boiling can reduce antioxidant activity. Although high temperature is used in the process of making *gelurings*, the product still has the antioxidant activity to inhibit DPPH radical compound. These results are similar to those reported by Pina *et al.*,⁴⁶ that boiled and evaporated seaweed still has a high activity in inhibiting DPPH radical compound.

Conclusions

Geluring products made from the mixture of *Gelidium* sp. and *U. lactuca* had high carbohydrate and dietary fiber content and low fat content, contained bioactive components such as phenols and flavonoids, and exhibited antioxidant activity. These results show that *geluring* has potential for use as a functional food. However, further research is necessary to determine the benefits of *geluring* products and to identify biological functions of its components.

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