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ISSN: 2347-467X, Vol. 06, No. (3) 2018, Pg. 664-671 Current Research in Nutrition and Food Science Journal Website:www.foodandnutritionjouswrnal.org Chemical Evaluation of a Nori-Like Product (Geluring) Made from the Mixture of Gelidium Sp. and Ulva Lactuca Seaweeds ERNIATI1, FRANSISKA RUNGKAT ZAKARIA2*, ENDANG PRANGDIMURTI2, DEDE ROBIATUL ADAWIYAH2, BAMBANG PONTJO PRIOSOERYANTO3 and NURUL HUDA4 1Department of Marine Science, Faculty of Agricultural, Malikussaleh University, Aceh Province, Indonesia. 2Department of Food Science and Technology, Faculty of Agricultural Engineering, Bogor Agricultural University, Bogor, Indonesia.

3Department of Clinic, Reproduction and Pathology, Faculty of Veterinary Medicine, Bogor Agricultural University, Bogor, Indonesia. 4Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, 88400, Kota Kinabalu, Sabah, Malaysia.

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 ± 0.26%), P2 (29.42 ± 0.66%), and P3 (29.83 ± 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. __
Article History Received: 23 April 2018 Accepted: 8 August 2018 Keywords Bioactive compound; Dietary fiber; Functional food; Nori-like product; Red seaweed.

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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 r e d s e awe e d Po r p hy ra , a n d i t i s c o m m o n l y 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 Por phyra marcossi 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 polysacchar ide, 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 oC 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 oC for 2 hours. P2: Seasoned gelur ing 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 oC (Sanyo SK-8600 FM, Jepang) for 2 minutes.

The P1, P2 and P3 gelur ing sheets w ere vacuum sealed in plastic packaging and stored at 4 oC 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 chlor ide color imetr ic 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 Proximate composition Sample _ Moisture (%) _ Protein (%) _ Fat (%) _ Ash (%) _ Carbohydrate (%) _ _ P1 _ 11.60 ± 0.01b _ 9.41 ± 0.01a _ 3.55±0.01c _ 13.49 ± 0.06b _ 61.94 ± 0.07c _ _P2 _11.62 ± 0.02b _9.66 ± 0.11a _3.51±0.01c _14.56 ± 0.01c _60.65 ± 0.09b _ _P3 _11.04 ± 0.01a _9.89 ± 0.09a _4.25±0.01d _14.53 ± 0.01c _60.29 ± 0.08b _ _U. lactuca _12.43 ± 0.01c _10.26 ± 0.02b _0.96±0.02a _15.35 ± 0.03d _62.01 ± 0.06d _ _Gelidium sp _14.40 ± 0.01d _13.44 ± 0.01c _2.17±0.01b _10.97 ± 0.02a _59.01 ± 0.05a _ _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 us 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 that 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 ± 0.26b _ 1.12 ± 0.01b _ 1.01 ± 0.01b _ 58.33 ± 1.33b _ _P2 _29.44 ± 0.66b _1.38 ± 0.03c _1.11 ± 0.02c _61.23 ± 0.55c _ _P3 _29.82 ± 0.11b _0.93 ± 0.01a _0.81 ± 0.02a _49.93 ± 1.45a _ _Gelidium sp _20.12 ± 0.33a _6.33 ± 0.09e _4.03 ± 0.07e _74.33 ± 0.52e _ _U. lactuca _50.21 ± 0.45c _5.91 ± 0.07d _2.21 ± 0.17d _68.23 ± 1.92d _ _ 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 repor ted 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. Priecina 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 oC but increased to 49% at 40 oC. 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.

Acknowledgement The authors would like to thank the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia for providing financial support for this research.

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