Preliminary Characterization of Seaweed Agar Sheet Products: Case Study of Local Small and Medium Enterprise in Java Island

Jasmadi¹, H Novianty¹, A R Sefrienda¹, S Permadi¹, I T Suryaningtyas¹, B Kumayanjati¹, D E D Setyono¹, C D Poeloengasih¹*

¹Research Division for Natural Product Technology, Indonesian Institute of Sciences (LIPI), Yogyakarta, 55861, Indonesia

*crescentianadewi@gmail.com

Abstract. Micro, Small, and Medium Enterprises (MSMEs) in Indonesia have grown quite rapidly and play an important role in modern economies. Many innovative products have been developed; however, the monitoring of product quality is rare. The aim of this study was to perform a comparative evaluation of the characteristics of agar sheet products from local MSMEs in Java Island, Indonesia. Moisture content, acid-insoluble ash content, total mould count, heavy metals (Pb, Zn, and As, Cu, Sn, Hg) and gel strength of three different agar sheet products were evaluated. Moreover, evaluation of its commercial packaging was carried out according to the regulation of the National Agency of Drug and Food Control (NADFC). The results reveal that the moisture content of agar sheets ranged from 17.48 % to 21.64 %, the acid-insoluble ash contents were lower than the maximum limit by Indonesian National Standard (INS), whereas according to the sensory inspection, the presence of mould was not found. Heavy metals were found at low levels, below the maximum allowable limit by INS. However, all agar sheets have poor gel strength (approximately 32.24 g/cm² – 77.49 g/cm²).

The result of packaging evaluation showed that neither packaging design, nor packaging label of all agar sheet products were excellent. The packaging label was prepared inappropriately according to NADFC. In conclusion, these agar characteristics and packaging quality were lack the minimum standard required. Therefore, product enhancements, such as processing and packaging innovations can be introduced to meet the minimum standard and improve the quality.

1. Introduction

Micro, Small, and Medium Enterprises (MSMEs) in Indonesia have grown quite rapidly and play an important role in modern economies. So far, approximately 97 % of total employees in Indonesia have been situated in MSMEs [1]. MSMEs also contributed to the Gross Domestic Product (GDP) of Indonesia by 60.3%. On the other hand, providing good quality products by MSMEs is essential, where product competitiveness and public awareness of food products have been increasing recently. The challenge for small enterprises is providing their good quality products.

Nowadays, there are massive number of MSMEs products including marine-derived products, for instance agar seaweed products. Agar is biopolymer extracted from red seaweeds (Gellidium sp. or Gracilaria sp.) generally used as gelling agents in the food industry, biotechnology and cosmetics [2].
Agar is a polysaccharide consisting mainly of a succession of agarobiose units, α-1,3 linked D-galactose and β-1,4 linked 3,6-anhydro-4-O-β-D-galactopyranosyl-L-galactose [2, 3] or consisting of agarose and agarpectin which can be extracted with alkali treatment [3]. Seaweed agar sheet product is among the fishery products that have become more popular in society, especially the product of MSMEs. The massive amount of seaweed production (Gracilaria sp. and Gelidium sp.) enables people to take part in producing higher value-added seaweed products as an alternative to getting more economical advantages. Although there have been some more advanced seaweed products (such as, agar powder) that are produced by big established companies, the market opportunity for agar sheet product remains profitable for MSMEs. Moreover, seaweed agar sheet can be produced relatively easily by small enterprises or home industry. So far, there is lack information about the quality of agar sheet products that are produced by MSMEs. Whether the quality is good or not, it has not known clearly.

On the other hand, many studies about seaweed product developing have been conducted, such as nori made from Ulva sp. [4], agar powder [5], noodles [6], and Yogurt and quark [7]. However, there are a few studies about the monitoring of agar sheet quality product in the commercial products that are produced by Micro, Small, and Medium Enterprises. Therefore, study on characterization of seaweed agar sheet products that are produced by Local Small and Medium Enterprise MSMEs is required. This study was to perform a comparative evaluation of the characteristics of agar sheet products from local MSMEs in Java Island, Indonesia.

2. Methodology

2.1. Materials

The products were purchased in September – November 2020 by online market place from three different agar sheet products. The products were stored in room temperature before further analysis.

2.2. Characterization of minerals and heavy metals

The minerals of agar sheets was determined using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES, 720, Agilent, Tokyo, Japan) according to a method by AOAC 2011.14 (2011). In the meantime, the heavy metals of agar sheet, namely arsenic (As), lead (Pb), mercury (Hg), copper (Cu), zinc (Zn), and Stannum (Sn) was conducted as explained by AOAC 2015.01 (2015) and AOAC 2011.19 (2014) using an Inductive Coupled Plasma Mass Spectrometry (ICP-MS) (ICP-MS, 7900, Agilent, Tokyo, Japan).

2.3. Moisture, Ash, acid undissolved ash, and mould

Moisture was determined gravimetrically according to SNI 01-2891 (Standard Nasional Indonesia, 1992), 1-2 g sample in a weighing bottle. The sample was dried in an electrical oven (Memmert, Germany) at 105°C for 24 hours and then the sample was stored in the desiccator for 30 minutes before weighing. The moisture was calculated as the percentage of lost weight after drying (gr) divided by the weight of sample before drying (gr).

Ash determined, where (1-2g) samples were placed in a porcelain crucible (Wo). Before the burning process in a furnace, the porcelain crucibles are placed on a hot plate on an electric stove for preheating. The samples were then burnt in a furnace for 5-6 hours at 550°C. As the samples returned to room temperature, their weight stabilized in the electrical oven 110°C over night. The samples were placed in a desiccator for 1-2 hours before being weighed as Wt. The ash was calculated by using the following formula: Ash (%) = ((Wt-Wo)/Wo)x100%. Meanwhile, the acid undissolved ash and mould of samples were carried out according to SNI 01-4105-1996. Gel strength and Water activity

Gel strength measurement was performed using a universal testing machine (UTM, Zwick Z0.5, German). The agar gel sample was prepared (1.5% w/v in water) and kept at 4°C for 12 h prior to testing. The sample was centrally positioned below the cylindrical probe (Ø = 12.7 mm) and measurement was performed at a test speed of 10 mm/min. The measurements were made triplicate.
The water activity of agar sheet was determined using a water activity meter (Pawkit, Decagone, Greece). The homogenous sample was placed in the sample cup. The sample must be completely covering the bottom of the cup and not more than half full. The sample cup was inserted into the chamber to secure the cup inside the instrument, and then the start button was pressed to begin the water activity measurement. Record the displayed value. The measurements were made triplicate.

3. Results and Discussion
Many fishery products have been introduced to the community along the coastline of Indonesia. Seaweed agar sheet is among these products that have become more popular in society. The huge amount of seaweed production (Gracilaria sp. and Gelidium sp.) enables people to take part in producing higher value-added seaweed products as an alternative to getting more economical advantages. Although there have been some more advanced seaweed products (agar powder) that are produced by big established companies, the market opportunity for agar sheets remains profitable for Micro, Small, and Medium Enterprises. This is the reason why seaweed agar sheet products need to improve to meet the standard minimum requirements and market.

3.1. Physical and chemical characterization
Three different samples of seaweed agar sheet products have been examined in a laboratory. Physical and chemical characteristics were determined and compared to the minimum requirements according to Indonesian National Standard 01-4105-1996 [8]. The results showed that the moisture and gel strength. The moisture content varied from 17.48 % to 21.64 %, with the lowest found in products made in Yogyakarta. Furthermore, the gel strength for these different three agar sheets were 32.24 g/cm², 57.75 g/cm², and 77.49 g/cm² of agar sheets that were produced in Garut, Sukabumi, and Yogyakarta respectively. The low-level quality of the three products can be influenced by several factors. The moisture content was higher than required in SNI (15 %), it is liner with Kuraesin [9], where the moisture varied from 19.15 % to 20.34 %. It might be associated with the drying process or storage system before packaging. According to Kuraesin [9], the sun drying allows the surface of the agar sheet dry easily but not the inside. As a hygroscopic material, the moisture of agar sheet could increase when it is in improper storage condition, such as in a higher humidity room. Micro, Small, and Medium Enterprises sometimes lack product handling knowledge which causes product quality deterioration. The gel strength levels, on the other hand, were less than 150 g/cm² (SNI) and other studies ranged from 201,67 g/cm² to 360 g/cm² [9, 10]. The gel strength of a product could be attributed to its sulphate content; the higher the sulphate level, the lower the gel strength. Moreover, the gel strength is also determined by the amount of 3,6-anhydrogalactosia content in the product. The results of Sasuga, Yamanashi [11] showed that alkali pre-treatment can elevate the conversion of L-galactose sulphate to 3,6-anhydrogalactose, reduce sulphate content, and alter the gel strength.

| Parameters                | Yogyakarta | Sukabumi | Garut | SNI 01-4105-1996 |
|---------------------------|------------|----------|-------|-----------------|
| Moisture (% w/w)          | 19.71      | 17.48    | 21.64 | 15              |
| Ash (%)                   | 32.69      | 29.84    | 32.93 | -               |
| Acid undissolved ash (%)  | 0.36       | -        | -     | 0.5             |
| Fibre                     | 34.19      | 66.64    | 61.13 | -               |
| Natrium (mg/100 g)        | 468.92     | 208.81   | 355.33| -               |
| Calcium (mg/100 g)        | 1,890.75   | 883.2    | 1,195.2| -               |
| Aw                        | 0.61       | 0.68     | 0.71  | -               |
| Gel Strength (g/cm²) Min  | 77.49      | 58.75    | 32.24 | 150             |
| Appearance                | NA         | NA       | NA    | 7               |
| Mould                     | ND         | ND       | ND    | ND              |

Heavy metals have become a hot issue, where they are associated with high-risk constituents for human health. Macro algae is also known as an absorbent of heavy metals, as an example, according
to Khaled, Hessein [12] Pb was found in Gelidium crinale and Gracilaria verrucosa, 18.63 µg/g and 41.16 µg/g dry weight respectively. Moreover, heavy metals (Cd, Cu, Zn, Fe, and Ni) were also found in macro algae. Therefore, it is important to know how much heavy metals are allowed in food. It is apparent from Table 2 that, interestingly, the six types of heavy metals (Pb, Cu, Zn, Sn, Hg, and As) were lower than the maximum limit that is allowed by the SNI. Some heavy metals were not detected in the three seaweed agar sheet products, namely Cu, Sn, and Hg. The highest concentration of As was found in a product from Garut, at 0.91 mg/kg. Seaweed is a marine product that spends its whole life in seawater, making it vulnerable to seawater pollution. It is important to be wise in collecting seaweed as the raw materials for agar sheet products. Raw materials screening is essential because seaweed is influenced by the environment and water quality. Banach, Hil [13] stated that seaweed that is cultivated near industrialized or anthropogenic activities has seaweed as ingredient list, and halal logo) were still unclear. In the meantime, the product from Garut had the most lack of label information compared to other products. All in all, the product packaging labels on the three products were still inadequate and need to be further improved at least in accordance with National Agency of Drug and Food Control Number 2019-2019, food packaging is a material that is used as a container that either directs or indirectly contacts the food [15]. Furthermore, as mentioned in BPPOM [16], every person who produces a food product that will be traded in this country must provide a label on their product packaging. At least there are eleven components that should be included in the packaging labels of food products in Indonesia. Labels are essential for every commercial product.

This current study found that every agar sheet product packaging had some labels provided by their manufacturers (Table 3). Surprisingly, all of the manufacturers (Yogyakarta, Sukabumi, and Garut) did not provide the labels properly. Some labels were absent and some lacked information. The agar sheet product from Sukabumi has provided more complete than the others, even though some labels (serving information, ingredient list, and halal logo) were still unclear. In the meantime, the product from Garut had the most lack of label information compared to other products. All in all, the product packaging labels on the three products were still inadequate and need to be further improved at least in accordance with National Agency of Drug and Food Control Number 31-2018. The awareness of MSMEs about packaging standards is needed to encourage considering that the competitive environment and packaging strongly influence consumers’ decisions [17]. Moreover, packaging could also increase sales, market share, and promotional costs [18, 19]. Inappropriate packaging provided by Micro, Small, and Medium Enterprises thus far is most likely the result of inadequate priority to product packaging, particularly for lower-budget enterprises.

### Table 2. Heavy metals of agar sheets from different three products

| Heavy metals                  | Origin  | SNI 01-4105-1996 (max. mg/kg) |
|-------------------------------|---------|------------------------------|
|                               | Yogyakarta | Sukabumi | Garut |
| Pb (mg/kg)                    | 0.11     | 0.68   | 0.35  | 2.0  |
| Cu (mg/kg), limit of detection | ND      | ND     | ND    | 20.0 |
| Zn (mg/kg)                    | 5.4      | 4.58   | 0.5   | 100.0|
| Sn (mg/kg), 0.0025            | ND      | ND     | ND    | 40.0 |
| Hg (mg/kg), limit of detection| ND      | ND     | ND    | 0.5  |
| As (mg/kg)                    | 0.4      | 0.74   | 0.91  | 1.0  |

ND: Not Detected

### 3.2. Packaging identification

Packaging is essential to build brand equity, in addition to self-service, consumer affluence, company and brand image, and innovation opportunities [14]. According to the rules of the National Agency of Drug and Food Control Number 2019-2019, food packaging is a material that is used as a container that either directs or indirectly contacts the food [15]. Furthermore, as mentioned in BPPOM [16], every person who produces a food product that will be traded in this country must provide a label on their product packaging. At least there are eleven components that should be included in the packaging labels of food products in Indonesia. Labels are essential for every commercial product.

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### Table 3. Product labels evaluation on the three agar sheet products

| No | Product labels | Yogyakarta | Sukabumi | Garut |
|----|----------------|------------|----------|-------|
| 1  | Product         | √          | √        | √     |
3.3. Evaluation

In order to produce good quality agar sheet products for Micro, Small, and Medium Enterprises requires some evaluation. The moisture of the product that is higher than required can be modified by drying the product directly under sunlight for about 2-3 days, depending on the sunlight intensity. In some places, the daily sunlight intensity is not the same, it depends on location, season, and time. Sometimes, it needs to use extra drying such as a drying chamber when the maximum sunlight intensity is not achieved. Besides sunlight, the agar sheet thickness influences the drying process in order to get optimum drying. Furthermore, the handling procedure of the agar sheet product right after the drying process requires good practice, for instance, the agar sheets should be packed in the packaging right after the drying process or the agar sheets can be stored in the proper chamber as soon as possible to avoid the negative effect of higher humidity.

Higher ash content in the agar sheets could be caused by sanitation procedures and the use of inappropriate filter screens. Applying good sanitation from the first production step of agar sheets is essential. Washing treatment of raw materials should be conducted properly, that is sometimes required to ensure a good water source, water treatment before use can be an alternative. In addition, bigger filter screen mesh can lead to passing unused materials that influence the agar sheet product. Thus, determining the proper screen filter mesh could help reduce the number of unused materials in the product.

Technically, in order to get higher gel strength, the agar sheets should use selected good raw materials (seaweed). Moreover, the gel strength of the agar sheets is influenced by sulphate content, where the more sulphate content, the less gel strength. The gel strength could be enhanced by optimizing in alkali treatment before the boiling (extraction) process. It would reduce the sulphate content and increase the content of 3,6-anhydrogalactosa that relates to the gel strength.

Standardized packaging, on the other hand, is also important either for the agar quality to remain in good condition or for market interest. By evaluating the packaging labels in this study, the packaging labels need to be renewed in accordance with the requirements of the National Agency of Drug and Food Control. To do that, manufacturers should be aware of good packaging for commercial products. Having good cooperation with local government is also a good step in order to obtain assistance not only with knowledge of product improvement but also with administration management that is required by the manufacturers.
Table 4. Product evaluation of the seaweed agar sheets

| No | Component | Suspected processing | Suspected | Evaluations |
|----|-----------|----------------------|-----------|-------------|
| 1  | Moisture  | Drying              | Sun drying, inappropriate handling before packaging | Packaging right after drying |
|    |           |                     |           |             |
| 2  | Ash       | Filtering           | Inappropriate filter membrane, Sanitation | Using proper mesh size screen, Considering the hygiene procedure every single step production |
|    |           |                     |           |             |
| 3  | Gel strength | Treatment of alkaline | Alkali treatment | Optimizing of alkali treatment, Combining different of red macroalgae |
|    |           |                     |           |             |
| 4  | Packaging |                     | Unstandardized raw materials (seaweed) | Standardization of raw materials |
|    |           |                     | Unstandardized packaging | Enhancing of packaging labels, Enhancing of packaging materials according to the minimum standard |

4. Conclusion
In general, the physical and chemical characteristics of the different seaweed agar sheet products were fairly good, even though they need to be improved, for instance, gel strength and moisture. The products (from Yogyakarta, Sukabumi, and Garut) had a moisture content of 19.71 %, 17.48 %, and 21.64 %, respectively; the gel strengths were 77.49 g/cm², 58.75 g/cm², and 32.24 g/cm², respectively. There was no finding of mould, Cu, Sn, or Hg, while other heavy metals concentrations (Pb, Zn, and As) were found to be less than the maximum allowed by INS. The packaging labels of the three agar sheet products were still under minimum requirements; therefore, it is important to upgrade.

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