Physical Properties of Agarophyte *Gracilaria* sp. (*verrucosa* type) from Seaweed Culture of Takalar, South Sulawesi

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ABSTRACT

*Agarophyte of **Gracilaria** sp. (**verrucosa** type) collected from Takalar, South Sulawesi, has been studied for its quality. The organoleptic test on the raw material indicated that its color was dull red and its water content was moderate, 23.53%. The impurity content was 46.2%, and mostly consisted of very fine water soluble materials. The agar yield of the raw material was 47.70%. Its physical properties, as indicated by geling point, gel surface strength and viscosity, were inferior than commercial agar. The data suggest that impurify content is the most important determinant of agar quality. Therefore, it is recommended to improve post harvest handling to obtain better quality.*

INTRODUCTION

Agarophytes are a group of red algae which produce phycocolloid called agar. These red algae include various species which are very common in Indonesian waters, some of them are *Gelidium latifolium, Gelidiella acerosa, Gracilaria arcuata, G. verrucosa, G. eucheomoides*, and *G. coronopifolia*. For Indonesia, agarophytes are the second important of marine phycocolloid resources, while the first is carragenophytes. About ten years ago the production of agarophytes still depended on the natural harvest, but since the last few years the agarophytes have been succesfully cultivated. For the national need, agarophytes are mostly used for producing agar powder as food material. In some places, these red algae are still used to prepare local jelly using very traditional method. At the present year, the domestic trade of these red algae indicates an increasing quantity, especially after increasing the number of processors. This mean that the prospect of culturing agarophytes will be in good condition.

Research on agar was begun before this century, in 1859 Payen has isolated agar from the red algae (cit. Kim, 1970). According to the modern research, Armisen and Galatas (1987) summarized that agar consist of two fractions, i.e. agarose and agaropectin. Both compounds form repetitive long chain polymer. The important characteristics of the compounds are that the agarose concentration is proportional to the gell-strength, and the molecular form of agar is reversible in the cooling-heating process. The other characteristic is that agar is not soluble in cold water, but forms viscous gel in hot water. Marshall et al. (1949) stated that settling point is the important characteristic of agar, where the good agar has settling point below 40°C. Instead of those characteristics there are still many other which can be used to evaluate the quality of the agar as well as chemical and physical characteristics.

This paper provides as brief information on the physical properties of agarophyte which is originated from Indonesia. I hope that this information can stimulate the development of national quality standard for the raw material of the economic macroalgae. Such specific standard is still lacking in this country. Although there was a brief guidance of the condition of the raw material (Soetrisno and Sulistijo, 1985 in Winarno, 1990), it was very simple and did not reflect the specific characteristic of each species of economic macroalgae.

MATERIAL AND METHOD

In August 1993 I had collected *Gracilaria* in seaweed culture center of Takalar (Southern of Ujung Pandang, South Sulawesi). In this district the agarophyte was cultivated in ponds and harvest taken place regularly every week. After determining the material,

I found that its morphological and histological characteristics (Figure 1) were very similar to the entity of *Gracilaria "verrucosa"* described by Abbott et al. (1985) and I agreed to give this attribute to Takalar's material. Abbott and her fellows faced difficulty to provide an exact species characteristics of *G. verrucosa* based on materials from the tropical and the subtropical regions. However, I think for the moment being that their decision in grouping the various *G. verrucosa* from broad regions into *G. "verrucosa"* (type) is quite reasonable, since there is no exact revision of this entity yet.

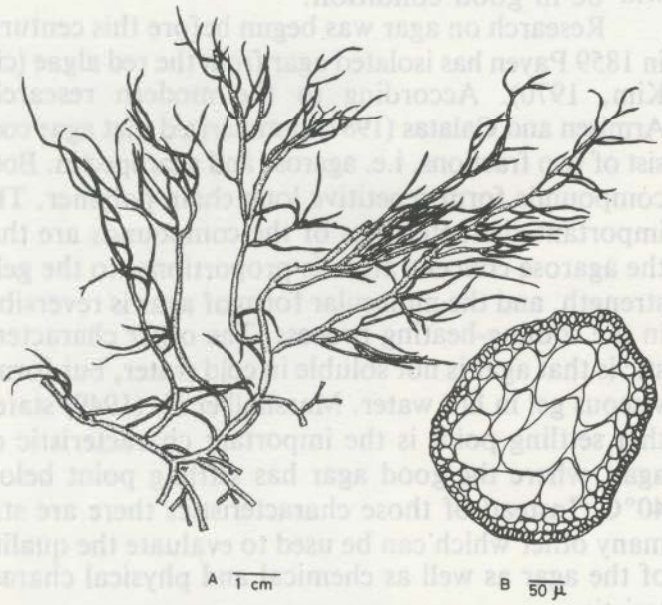

Figure 1. ***Gracilaria* sp. (*verrucosa* type) from Takalar. A. Habit of the plant. The obvious constriction at the branch base is one of its morphological characteristics. B. Transverse section of the main branch. The transition form from the cortical cells to medullar cells is rather abrupt**

Further, I conducted a simple research to analyze the agar characteristics of this material. Analysis was divided into two categories: first, the characteristics of raw material based on organoleptic test including of impurities content, color, and moisture or water content; second, the characteristics of agar itself including of agar yield, viscosity, gel surface strength, gelling point and infrared spectrum. Method of agar extraction was based on cooking-freezing-thawing procedure. Agar extraction was done by cooking 30 gram of clean oven dried materials in 4 liters aquadest at 90°C for 5 hours and at pH 5 – 6. Subsequently, the colloid was filtered with fine muslin cloth and cooled at – 24°C for 48 hours, then the frozen colloid block was thawed with running water for 3 hours. Finally, the colloid was dried in the oven until the agar sheet formet. The extracting procedure of the agar is not much different with Kim's (1970).

A solution of 2% (w/v) agar was prepared for being used to analyze its gel strength, gelling point and viscosity. The gel surface strength was measured based on piston and burden method which explained by Hatta and Hermiati (1992). The gelling point was measured at 45°C as described by Hatta and Hermiati (1992). The viscosity was measured by using LAB-LINE Viscometer model 4537-1, at 60°C. To obtain infrared spectra, a thin film of 0.5% (w/v) agar was analyzed using Shimadzu FTIR Spectrophotometer 4300.

Raw agarophyte produced in Takalar was bought by "Swallow Agar" Factory in Jakarta. This factory prepares powder agar for making many kinds of pudding and other family foods. Thus I considered that it was necessary to compare between the quality of the manufactured agar and agar of the raw material. To have another comparison, I also analyzed scientific agar of Difco Bacto-Agar. This latest agar further will be written as Difco Agar.

RESULT AND DISCUSSION

Organoleptic Characteristics

The sun dried Takalar's agarophyte had dull color, mostly dull red, but partly dull green and brown. The color of the living agarophyte was brighter than the dry. The consistency of fresh dried thalli were stiff and wiry, but the old dried materials were cartilaginous. Agarophyte (500 g) was weighted with three replicates and their impurities were sorted. The impurities could be classified into three types. First, the biological impurities consisted of epiphytic macro- (mostly *Chaetomorpha aerea*) and micro-algae (membranous bacteria covered thalli's surface) and their amount was very small, less than 0.1%. Second, the big size impurities (more than 1 mm in diameter) and mostly consisted of sand, but frequently also mollusk shells. Their amount was relatively small, i.e., ca. 6%. Both impurities were easy to be removed by picking or shaking the materials. Third, the very fine dust of mud and salt crystals. These impurities attached very tightly on the thalli and could not be removed by hard shaking, but they were soluble in

fresh water. Their amount was very high, i.e., 40.20% of the raw material weight. The water content in the raw material was 23.53%.

Impurities (approximately 46.2%) in Takalar's material had very close relationship to the water condition in the ponds and the way villagers dried the algae. The ponds of Takalar are located nearby the river mouth and formerly was the mangrove area. In such location usually the water contain very high soluble silt and mud materials which is indicated by high turbidity and brown color. In the ponds, the silt and mud precipitatae and cover the algae that live on the bottom of the ponds. Apparently, the harvested algae, were not properly washed. Most raw algae harvested in Takalar were dried on the ground. The presence of impurities leads to dull color, dusty smell, and high moisture content.

Up to the present year, the Indonesian Government has not possessed a national standard of raw seaweed. Usually the buyers pay no attention to the color and smell of algae, but they give much attention to the water content and impurities. The acceptable water content is about 30% (other kind of macroalgae may contains up to 35% water), while there is no limit for impurities. Levels of impurities are determined visually.

Agar Quality

Agar yield of Takalar's material was considered relatively high (47.70%). Reports on agar content of subtropical agarophytes were not as high as the tropical Takalar's agarophyte. Matshuhiro and Urzua (1990) reported that agar content in native *Gracilaria chilensis* from Chile extracted by similar procedures applied in this study was between 43.2 – 43.4%. Whyte et al. (1981) found that agar content in *G. "verrucosa"* (type) from Canada was influenced by reproductive stage and seasonal condition, however, its agar yield was relatively moderate, i.e., between 12.6 – 31.6%. Nelson et al. (1983) noticed that *G. verrucosa* from Taiwan produced 21 – 23.7% of agar. Nelson et al. (1983) also reported that agarophyte of *G. edulis* from Micronesia could produce up to 71% of agar. From India, Mal and Subbaramaiah (1989) found that the agar yield in the native *Gracilaria edulis* was varying between 26.6 – 32.85%. This indicates that the Takalar's agarophyte has very competitive agar content compared to other agarophytes from other regions.

The physical properties of studied agar are presented in Table 1. There are obvious differences between agar qualities of Takalar and the commercial Swallow agar. The gel surface strenght and gelling point are very important parameters of commercial agar. The pre treatment, e.g. alkaline pre treatment, might increase the yield and gel strength of the agar such as reported by Matsuhiro and Urzua (1990). The alkaline pre-treatment might also improve the quality of gelling point, such as reported by Nelson et al. (1983). They worked with *G. verrucosa* from Taiwan and applied NaOH pre-treatment on the material. They found that the gelling point of the agar was relatively high, i.e., 38 – 40°C. The high gelling point of Swallow product (between 40 – 41°C) indicates that the agar rapidly changed from colloid phase to solid phase at above the room temperature. Contrary, the agar of Takalar needs extra cooling process before become solid at temperature of 27 – 28°C (below the room temperature). The high gel surface strength (1331 gram/cm^2) of Swallow agar resulted in a firm solid phase, while the solid phase of Takalar's agar was very soft (with gel strength of 45 gram/cm^2).

Table 1. **Physical properties of agar from various sources**

Type of agar	Viscosity (cps)	Gel surface strength (gram/cm^2)	Gelling point (°C)
G *"verrucosa"* of Takalar	51	45	27 – 28
Swallow Agar	75	1331	40 – 41
Difco Agar	22	274.1	32 – 33

Difco Agar is prepared for scientific purposes, such as researches on microbiology, cell or tissue culture, and medical. Therefore, the condition of scientific agar is very different with commercial agar. Difco Agar has relatively high gelling point (32 – 33°C), it means that its solidification can take place at the room temperature. The consistency of Difco Agar block is moderate as indicated by its gel surface strength.

The infrared spectra of studied agar is presented in Figure 2 and the summary of their specific absorption is shown in Table 2. Armisen and Galatas (1987) provided three specific peaks of infrared absorption, they were: peak 890 cm^{-1} indicated

typical agar peak with unknown meaning; peak 930 and 1070 cm^{-1} both indicated 3,6-Anhydro-(L)galactose bridge vibration. In this study I observed that those peaks were shifted, especially peak

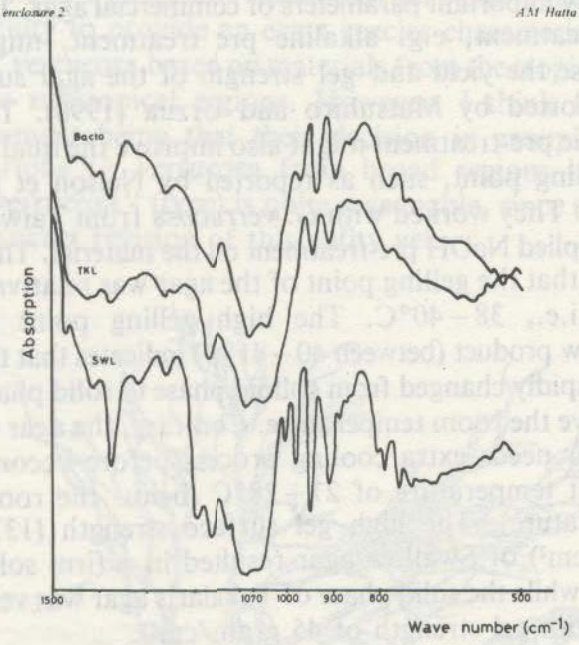

Figure 2. **Infrared spectra of studied agar. SWL = Swallow Agar product. TKL = Agar of Takalar. Bacto = Difco Bacto Agar. Explanation of the figure see in the text**

Table 2. **Characteristics of infrared absorption of various agar**

Agar Sources	Specific Infrared Absorption (cm^{-1})			Unknown Absorption (cm^{-1})	
	890–894	829–933	1075–1078	968–971	989
Takalar's agar	weak	weak	strong	absent	absent
Swallow Agar	moderate	moderate	strong	moderate	weak
Difco Agar	weak	weak	strong	very weak	absent

1070 cm^{-1}, but they still indicated specific peaks of agar. All three agar posses those specific peak of infrared absorption, however the intensity of each peak is varied. These intensity differences may be assumed that there must be different agar concentration in the product (purity). Based on the infrared spectra, the Takalar's agar has different pattern from manufactured agar (as well as Swallow and Difco). The obvious differences occur in the present of unknown peak absorption at 968–971 and 989 cm^{-1} in Swallow and Difco Agar. These peaks were not mentioned by Armisen and Galatas (1987) as specific peaks of agar. Thus, I assumed that these peaks may appear due to the influences of certain additive materials used in the processing.

CONCLUSION

In the case of agarophyte of Takalar, the post harvest handling of the raw material by the villagers should be improved. The proposed post harvest handling may consist of two steps cleaning. First, washing freshly harvested materials in running water. Second, cleaning the dry materials by shaking or striking with stick before packing or storing. This post harvest handling may increased preparation cost, but it could provide a higher quality of raw material.

The agar quality of Takalar's material discussed previously was as the quality of raw agar. The parameter set of this agar indicates that its quality must be improved by certain processing method so that its quality meets the requirement commercial agar.

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