

THE CONTENT AND THE PHYSICO-CHEMICAL CHARACTERISTICS OF ALGINATE EXTRACTED FROM THREE SPECIES OF BROWN ALGAE (*S. cinereum*, *H. triquetra*, and *T. conoides*)

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ABSTRACT

Three species of brown algae (*Sargassum cinereum*, *Hormophysa triquetra*, and *Turbinaria conoides*) harvested from Pari Island of the Seribu Islands, North Jakarta, in November 1992 were used for this study. The alginate content of those brown algae were 13.41, 17.04, and 15.16%, respectively. Sensory evaluation, proximate analysis, and physico-chemical test were performed on alginate extract prepared from these brown algae and on commercial alginate product. Results showed no significant difference on properties of both products. Moreover, the alginate obtained from this study fulfilled requirements established by Ekstra Farmakope Indonesia (1974) and the United States Pharmacopeia: the National Formulary (1985).

KEYWORDS: *alginate, brown algae, physico-chemical characteristic.*

INTRODUCTION

During the period of 1990-1996 Indonesia imported around 2,000 tons alginate per year which is equal to around US \$8.6 millions (Table 1). Alginate is a polysaccharide compound which can be extracted from brown algae (Phaeophyceae) (Bold & Wynne, 1985; Lewin, 1962; Stewart,

Sargassum spp., *Hormophysa* spp., and *Turbinaria* spp., was conducted. The physico-chemical characteristics of the alginate produced were compared with the commercial product and with the product requirements as stated in the Ekstra Farmakope Indonesia (1974). The results gained from this study could provide useful information for the development of science and technology in Indonesian brown algae business.

MATERIALS AND METHODS

Materials

Three species of fresh brown algae, i.e. *Sargassum cinereum*, *Hormophysa triquetra*, and *Turbinaria conoides* were collected from Pari Island waters of Seribu Islands, Jakarta Bay, in November 1992. All chemicals used in this study were classified as pure analytical grade.

Methods

Alginate was extracted by Le Gloachec-Herter method (Wheaton & Lawson, 1985; Soegiartono, 1977). Fresh algae was washed using sea water to remove dirt and then sun dried. Alginate was released from plant tissue using 1% CaCl_2 solution, and extracted with 1.5% Na_2CO_3 solution. Clarification and oxidation were then carried out by addition of 10% NaOCl solution, and the alginate was precipitated by HCl solution at pH 2.3-3.2. Alginate was purified using alcohol before drying in the oven at 105 °C. The flow diagram of the process is shown in Figure 1.

Table 1. The quantity and the value of import alginate during the period of 1990-1996.

Year	Quantity (1,000 ton)	Value (million US\$)
1990	2,069.1	7,306.2
1991	1,577.1	7,451.1
1992	1,587.8	7,399.7
1993	2,924.5	12,153.9
1994	2,311.7	8,139.2
1995	2,220.0	9,773.8
1996	1,887.2	8,320.8

1974). The species of brown algae which are generally used as a source of alginate are *Laminaria* spp., *Macrocystis* spp., and *Ascophylum* spp. (Wheaton & Lawson, 1985). The species of brown algae available in Indonesian water are *Sargassum* spp., *Dyctiota* spp., *Hormophysa* spp., and *Turbinaria* spp. (Atmadja & Sulistijo, 1985).

There is still a lack of information on the alginate content of brown algae harvested from Indonesian waters. In this study, extraction of alginate from three species of brown algae, i.e.,

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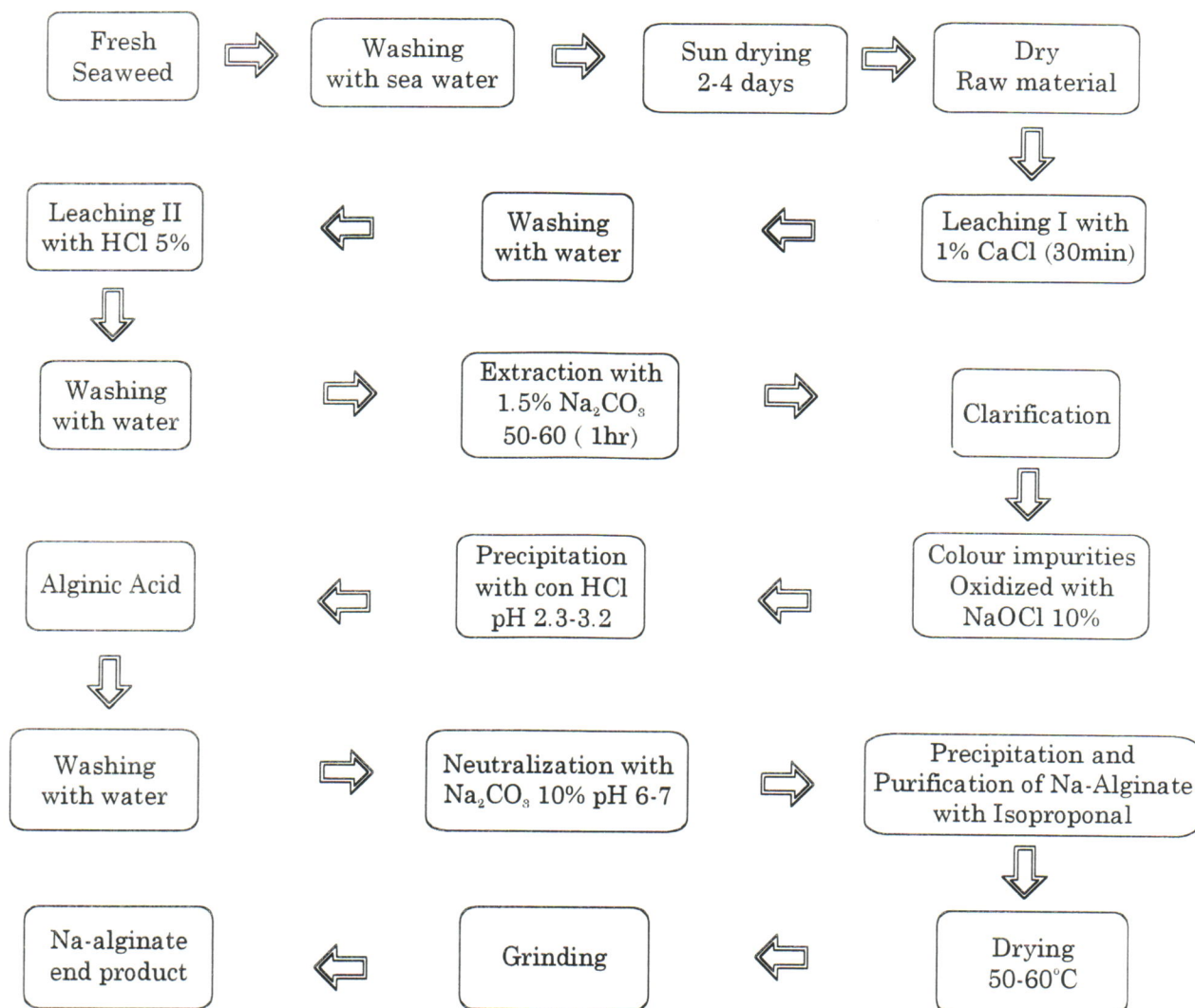


Figure 1. Flow diagram of the alginate extraction process

Proximate composition of the alginate product was analysed in triplicate by AOAC (1980) methods.

Sensory properties of the alginate including form, colour, odour and taste were evaluated by 10 panelists. The microbial load of the product was analysed according to Miwa & Low method (1992). Physico-chemical properties of alginate were determined according to the method described by "Ekstra Farmakope Indonesia" (1974) and the United States Pharmacopeia: the National Formulary (1985). Viscosity of alginate solution was determined using a viscometer.

RESULTS AND DISCUSSION

The results of proximate composition analysis of brown algae (*Phaeophyceae*) are shown in the Table 2. The content of carbohydrate (26-30%, w/

w) in the dried raw materials is relatively high and it is hoped that mostly is alginate compound. The content of ash (32-39%, w/w) is high, it means that the raw materials contain a lot of minerals as impurities. The content of protein (5.20-6.20%, w/w) is relatively high but the fat content (0.50-1.75%, w/w) is relatively low. To get high grade of alginate product, other substances or impurities contained in the dried raw materials must be eliminated or reduced as low as possible through a sequence of treatments as shown in Figure 1. The yields of alginate extracted from these three species of brown algae are shown in Table 3. The highest yield was obtained from *Hormophysa triquetra* (17.04%), followed by *Turbinaria conoides* (15.16%) and *Sargassum cinereum* (13.41%). *Sargassum* spp. from other countries had an alginate content in the range of 9-32% (Atmadja, 1991). The alginate content of

Table 2. Proximate composition of three species of dried brown algae (Phaeophyceae)

Analysis	Content (g/100g)		
	<i>S. cinereum</i>	<i>H. triquetra</i>	<i>T. conoides</i>
Moisture	16.79 ± 0.56	13.20 ± 0.63	17.33 ± 0.49
Ash	32.87 ± 0.65	38.51 ± 0.36	33.32 ± 0.38
Fat	0.81 ± 0.01	0.57 ± 0.01	1.75 ± 0.01
Protein	6.15 ± 0.05	5.20 ± 0.39	5.46 ± 0.07
Crude fiber	17.02 ± 0.02	11.92 ± 0.08	12.65 ± 0.01
Carbohydrate	26.36 ± 0.43	29.90 ± 0.88	29.49 ± 0.20

Note: all samples were analysed in triplicate. Result = mean ± SD.

Table 3. The yield of alginate extracted from three species of brown algae (Phaeophyceae)

Analysis	Content (%)		
	<i>S. cinereum</i>	<i>H. triquetra</i>	<i>T. conoides</i>
Sodium alginate	13.41 ± 0.33	17.04 ± 0.49	15.16 ± 0.96

Note: all samples were analyzed in triplicate. Result = mean ± SD.

Sargassum spp. harvested from the Indian Ocean (south coast of Java) ranged from 8.9 to 15.5% (Soegiartono, 1977).

The alginate content in the brown algae varies with species, environmental conditions, and harvesting season (Chapman, 1970; Atmadja 1991; Durairatnam & Grero, 1969). The quality of alginate is also influenced by the extraction method and the pH of extracting solvent (Durairatnam & Grero, 1969). The amount and the ratio between mannuronic and guluronic acid in the brown algae depend on algae species, season, and growth condition (Stewart, 1974).

Sodium alginate which can be extracted is affected by the concentration of extracting solution (Na_2CO_3). The optimum concentration at

which alginate compounds can be slowly dissolved from plant tissue is 1.5% Na_2CO_3 solution. If the concentration of Na_2CO_3 is too high, the alginate polymer will be degraded. McDowell (1977) stated that the addition of acid or base which brings the pH of alginate solution to below 5 or above 9 will accelerate depolymerisation of the alginate.

Based on the physical properties of alginate as shown in Table 4, the alginate product resulted from this study meets the requirements as described by "Ekstra Farmakope Indonesia" (1974) and the United States Pharmacopeia: the National Formulary (1985). It means that alginate produced in this study could be classified as a good quality product.

Moisture content of the sodium alginate, extracted from *S. cinereum*, *H. triquetra*, and *T.*

Table 4. Sensory properties of the alginate, extracted from three species of brown algae (Phaeophyceae).

Analysis	Content			Commercial alginate*	Alginate required as to the reference**)
	<i>S. cinereum</i>	<i>H. triquetra</i>	<i>T. conoides</i>		
Form	Powder	Powder	Powder	Powder	Powder
Colour	Yellowish-white	Yellowish-white	Yellowish-white	Yellowish-white	Yellowish-white
Odour	Almost odourless	Almost odourless	Almost odourless	Almost odourless	Almost odourless
Taste	Almost tasteless	Almost tasteless	Almost tasteless	Almost tasteless	Almost tasteless

Note:*) Commercial Sodium Alginate **) Reference: Ekstra Farmakope Indonesia (1974)

conoides, was 14.41, 14.75, and 14.67%, respectively (Table 5). The ash contents was 12.83, 19.17 and 22.02%, respectively. The moisture and ash contents were relatively high but the values were still in the range as required by "Ekstra Farmakope Indonesia" (1974) and the United States Pharmacopeia: the National Formulary (1985). Moisture content of alginate was less than 15% and ash content was in the range of 18-24%.

Microbial analysis of the product showed that *Salmonella* and *E. coli* were absent. It means that the process practiced in this study was able to keep the product in hygienic condition. Thus, the product can be utilized for food or pharmaceutical purposes.

To prevent degradation of the alginate polymer from high molecular weight compounds with high

viscosity into smaller molecular weight compounds with low viscosity, the extraction pH must be maintained in the range between 9.6-11 (McDowell, 1977; Soegiartono, 1977).

In this study, the alginate extraction was carried out at a temperature between 50-70°C. If a lower temperature is used, the extraction will take longer, whereas a higher temperature will degrade alginate polymer into smaller molecular weight compounds. However, Durairatnam & Grero (1969) carried out extraction process at the temperature between 80-100°C, and obtained 31% alginic acid.

Solution of the product had low viscosity. It was likely due to either the low quality of raw material used or the pH of the solution. The extraction temperature may also affect viscosity of the product.

Table 5. Physico-chemical characteristics of the sodium alginate extracted from brown algae of *S. cinereum*, *H. triquetra* and *T. conoides*

Analyses	Sc	Ht	Tc	Trade	Ref.
Moisture (%)	14.41	14.75	14.67	15.00	<15
Ash (%)	22.83	19.17	22.02	18-27	18-24
Acid insoluble ash (%)	1.09	0.97	1.09	nd	<7
Water insoluble substance (%)	0.019	0.014	0.018	0.012	<0.2
Sulfated ash (%)	2.23	2.16	2.04	nd	30-35
Viscosity (1% soln., 20°C) (Cp)	2.42	2.25	2.83	nd	-
Starch	nd	nd	nd	nd	-
Gelatine	nd	nd	nd	nd	-
5 mL Na-alginate soln. 1% (w/v) + 1 mL CaCl ₂ soln., form precipitate like gelatin.	+	+	+	+	+
10 mL Na-alginate soln. 1% (w/v) + 1 mL H ₂ SO ₄ soln., form precipitate like gelatin.	+	+	+	+	+
5 mg Na-alginate + 5 mL H ₂ O + 1 mL Nafthorecorcinol 1% in ethanol 95% and 5 mL HCl, boiled, cooled in 3 minutes until 15°C, extracted with isopropanol, give more violet colour compared to blank.	+	+	+	+	+
<i>Microbes:</i>					
<i>Salmonella</i>	Absent	Absent	Absent	Absent	Absent
<i>E. coli</i>	Absent	Absent	Absent	Absent	Absent

Note:

Sc = *Sargassum cinereum*; Ht = *Hormophysa triquetra*; Tc = *Turbinaria conoides*, nd = not determined. Trade=Commercial Sodium Alginate; Ref. = Ekstra Farmakope Indonesia (1974) and The United States Pharmacopeia: The National Formulary (1985)

CONCLUSION

1. The alginate content of three species of brown algae (*S. cinereum*, *H. triquetra*, and *T. conoides*) harvested from Pari Island, at Seribu Islands, was 13.41, 17.04, and 15.16% (wet weight) respectively, and it is relatively high.
2. Based on the sensory properties and the physico-chemical characteristics, the resulting quality of alginate products was similar to the commercial alginate product and fulfil the standard requirements set by the Ekstra Farmakope Indonesia (1974).
3. In order to get a product with the highest yield, high purity, and the best quality of sodium alginate, the species and the part of the thallus of the brown algae which will be processed also need to be selected, and the extraction temperature need to be optimized.
4. Based on the results of this research, it is promising to culture brown algae and to produce alginate in order to reduce the import of alginate which is needed by many industries in Indonesia, besides to create new job and income for coastal community.

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