UTILIZATION AND FARMING OF SEAWEEDS IN INDONESIA

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ABSTRACT

A great variety of seaweeds grow abundantly along the 81 000-km coastline of the 13 000 islands comprising the Indonesian archipelago. However, it is only recently that the economic importance of seaweeds has really been appreciated.

At present, seaweeds collected in Indonesia are mainly used for food supplement, domestic agar manufacture, and for export. Because of the increasing demands for the carrageenan-containing seaweed, mass cultures have been undertaken in both experimental and production sites established in many parts of the country. These efforts are expected to increase the annual volume of exports from 2 000 to 6 000 mt.

The paper reviews the state and problems of seaweed utilization, development, and farming efforts in Indonesia.

INTRODUCTION

The Indonesian archipelago is situated between the Asian and the Australian continents and between the Pacific and the Indian Oceans. Geographically, it is located between 94°-141°E and 6°N-11°S. Roughly, it consists of 13 667 islands with more than 81 000 km of coastline. Marine waters constituting two-thirds of the country's territory are an ample resource for maritime opportunities. Hence, a considerable amount of scientific survey and research on the marine environment had been undertaken.

Early marine research in Indonesia started when Amboina was a headquarter for the Dutch East Indies Company. However, modern marine research stemmed from the Siboga Expedition of 1899-1900 (Tydeman 1903) which focused on the marine flora and fauna and their biogeography. Physical oceanography was brought to the fore in the 1930's by the Snellius

(Riehl 1952) and the Dana Expeditions and more recently by the world-renowned Albatross and Galathea Expeditions in 1948 and 1951, respectively.

The earliest report on seaweeds in Indonesian waters probably was that of Rumphius (1750). Through the untiring effort of Weber van Bosse during the Siboga Expedition, phycology flourished in Indonesia. Unfortunately, however, it is only recently that the economic potential of seaweeds has been appreciated. This paper describes the state of research on algae and their significance in Indonesia.

SEAWEED PRODUCTION

A number of surveys indicate that the distribution and density of marine algae in different areas vary according to the type of bottom, season, hydrographic conditions, and species composition at a given time. Table 1 presents the great variations in standing crop from one region to another and from one species to another. It is, thus, imperative to consider these differences in the utilization of seaweed resources.

Table 1. Variations in standing crops of seaweed in Indonesia and other countries

Location	Species	Standing crop (tons/ha)
INDONESIA		
Wawarada Bay	*Eucheuma spinosum*	4-18**
Moluccas and East Nusa Tenggara	*E. spinosum*	0.6-3.4**
Seribu Islands	*E. spinosum*	0.11**
Tenjung Benoa	*E. serra*	0.46**
	Gracilaria lichenoides	0.96**
	Hypnea spp.	1.52**
	Ulva spp.	1.63**
Southeast Moluccas	*E. spinosum*	2.27**
Central Moluccas	*E. edule*	5.02**
	Gracilaria spp.	2.13**
OTHERS		
Philippines	*E. spinosum*	9**
La Jolla, California	*Laminaria* sp.	62.5-100**
Scotland	*Laminaria cloustonii*	19.5-45**
Hanauma Bay, Hawaii	*Sargassum obtusifolium*	5.7-10.2*
	S. echinocarpum	4.7-6.5**
Kaneohe Bay, Hawaii	*Dictyosphaeria cavernosa*	0.07-7.27*

* Dry weight; ** Wet weight.

The identification of factors responsible for such variations must then be one major area for seaweed research. Fortunately, this has been recognized in Indonesia recently. For example, Soegiarto (1963) observed that the standing crop of seaweeds in Wawarada Bay, Sumbawa, ranged from 4 to 18 tons wet weight per hectare and about half (52.6%) of the mixed populations consisted of *Eucheuma spinosum*. In 1974, a large-scale survey was carried out to determine the location and production potentials of the seaweed *Eucheuma* in the Moluccas and the East Nusa Tenggara (Lesser Sunda) waters (Mubarak 1974). Based on this survey, it was estimated that production *of Eucheuma* from the Moluccas is about 1 750 mt/yr and from the East Nusa Tenggara 200 mt/yr. It seems that these estimates were rather low since figures from the Directorate General of Fisheries showed that the Moluccas produced 2 277 mt in 1973, 2 636 mt in 1974 and 7 160 mt in 1975 (Table 2). This discrepancy only indicates that further surveys and research are needed in order to arrive at reasonable estimates on seaweed production in each region. Other surveys were carried out by Sulustijo and Atmadja (1980) in the Seribu Islands, Jakarta Bay; Sulustijo and Yusuf in Southeast Moluccas; and Sahupala et al. (1977) in Central Moluccas.

UTILIZATION OF SEAWEEDS

At present, the seaweeds collected in Indonesia are mainly used for food, agar extraction, and export.

Table 2. Seaweed production from selected coastal waters of Indonesia*

Place	Production (metric tons)		
	1973	1974	1975
Bengkulu, West Sumatra	5	5	3
South Sumatra	39	13	645
Riau Archipelago (Strait of Malacca)	**	**	195
Northcoast of East Java	56	234	**
Yogyakarta, Southcoast of Java	**	**	9
Bali	60	74	61
Lesser Sunda Islands (Nusa Tenggara)	329	154	150
Southeast Celebes	387	126	203
Moluccas	2 277	2 636	7 160
West Irian	3	990	**

*Source: The Indonesian Directorate General of Fisheries.
**No available data.

Food

The widespread use of seaweeds as human food in Indonesia was recorded as early as 1292 when the first European ships sailed through Indonesian waters. For centuries, the islanders utilized marine algae as food supplement, especially as "sayur" or vegetable (Zaneveld 1955). However, algal consumption was limited to fishermen and normally these edible species did not reach local markets. But some species used in making sweetened jellies were transported farther inland.

Hogue (1922) mentioned some twenty-one species of useful seaweeds in Indonesia. The list was later expanded by Zaneveld (1955) to include also the economically important algae of the Southeast Asian waters. This fact indicates that Indonesians eat seaweeds in various forms: raw as salads, boiled as vegetable, mixed with various spices, pickled, cooked with coconut milk, for soup thickening, pudding, and sweetened jellies. Some species even serve as medicine.

The organic composition of seaweeds varies from one division to another and from one species to another. For any one species, it can also vary geographically, according to depth, and even from one part of a thallus to another. Therefore, it is hardly surprising that the published data on their organic contents are highly variable.

Table 3 shows the chemical analyses of six red algae collected from Sumbawa Island (Nusa Tenggara). Generally, proteins are present in small quantities and are hardly assimilated by human beings. However, animals may utilize certain proteins better. This is probably one of the reasons for using some seaweeds for stock feed instead of for human consumption.

Carbohydrates, occurring mainly as cell wall and intracellular storage materials, constitute the bulk of algal organic matter. However, the high carbohydrate content is of low value as a source of energy since most of these substances are hardly digested in man. It has been suggested, however, that people who eat seaweeds from childhood may acquire a specialized bacterial flora in the intestines to help digest these algal carbohydrates. Thus, islanders might obtain more food value from seaweeds than others and, possibly also, animals not used to a diet which includes algae.

Even if all the carbohydrates and proteins in seaweeds were fully digestible, these could not significantly supplement the nutrients derived from present food or dietary sources. Rather, the nutritive value of seaweeds is based on their mineral and vitamin contents. Biochemists have definitely established the presence of carotene, and vitamins B_1, B_2, B_{12}, C, D, and E in marine algae. Again, the vitamin concentration varies from one species to another. Intraspecific differences also occur geographically and even with depth.

Table 3. Proximate analysis of some Indonesian seaweeds (*After* Soegiarto 1968)

Proximate analysis (% dry weight)	*Eucheuma spinosum*	*Eucheuma* sp.	*Gracilaria* sp.	*Gracilaria confervoides*	*Gelidiopsis* sp.	*Hypnea* sp.
Moisture	27.50	16.99	19.01	24.91	12.95	25.15
Protein	5.40	2.48	4.17	3.14	9.98	1.59
Carbohydrates	33.22	63.19	42.59	37.52	54.43	32.25
Fats	8.62	4.30	9.54	5.52	11.09	5.81
Crude fiber	3.01	-	10.51	9.14	-	11.43
Ash	22.25	23.04	14.18	15.77	11.75	23.77

Organic Substances

Seaweeds are important sources of chemical substances for industrial or medical purposes, ranking them among the important resources of the sea. The agar industry in Indonesia is of recent development. Incidentally, the term 'agar' is of Indonesian origin. An attempt to manufacture agar commercially was first reported in 1910. Hofstede(1921a, b, 1923) surveyed the agar content of various seaweeds to determine the possibility of establishing large-scale agar production in Indonesia. But due to rather crude and inadequate analytical methods, he concluded that (1) among the edible seaweeds in Indonesia, only a few contain agar, (2) the agar-containing seaweeds are not abundant, and (3) the seaweeds exported in large quantities do not contain agar. Later, the use of improved methods of analysis, however, showed that the seaweeds occurring in Indonesia contain sufficient agar to justify large-scale agar manufacture for export, an opinion shared also by Zaneveld (1955).

The Indonesian government had been giving full support to the establishment of agar factories. Between 1947 and 1952, the Laboratory for Chemical Research in Bogor analyzed the agar content of practically all species of commercial seaweeds collected from Indonesian waters. This work later showed that *Eucheuma* spp. did not contain agar but another substance known as the iota-carrageen in extract from *E. spinosum* which is becoming more important as an additive in various industrial products, especially in America and Europe.

The first large-scale agar factory in Indonesia was set up in 1930 in Kudus along the north coast of Central Java. More factories were soon established in other cities. Unfortunately, the industry suffered a severe setback during the Second World War. But the high price of agar and full government support after the war stimulated the emergence of smaller factories in Jakarta, Surabaya, Padang, Bandung, and other cities. Table 4 shows the present locations of agar factories in Java.

At present, *Gracilaria lichenoides* is the most important raw material for agar manufacture in Indonesia (Table 4). Two other species also commonly used by the industry are *Gracilaria blodgettii* and *Gelidium latifolium*. On the other hand, *Gracilaria confervoides* is not used in agar processing in Indonesia but is exported from Ujungpandang (Macassar) in rather great quantities. There is, however, a need to improve the quality of the agar product For example, by using a combination of *G. latifolium* and *G. lichenoides,* an agar of better quality can be obtained. Research in this field is badly needed.

Export

For many years, Indonesian export of seaweeds has been an important

Table 4. Some agar factories in Java (*After* Soegiarto et al., 1975)

Name	No. of workers	Species used	Raw materials needed (kg/month)	Production (kg/month)
Universal Surabaya	4	*Gracilaria* spp.	710	42
Sinar Kencana Wonocolo, Surabaya	32	*Gracilaria* spp. and *Gelidium* spp.	13 000	800
Sriti Surabaya	-	-	250	15
Sari Jaya Surabaya	-	-	2278	166
Oen Brothers Surabaya	7	*Gracilaria* spp. and *Gelidium* spp.	417	25
Sumber Laut Surabaya	7	*Gracilaria* spp. and *Gelidium* spp.	1000	60
Hasalin Jakarta	60	*Gracilaria* spp. and *Gelidium* spp.	20 000- 30 000	2000- 3000
Djawa Jakarta	25	*Gracilaria* spp.	15 000	1500

economic activity. Early records show that for over a century, seaweeds had been exported to China. Before the Second World War, the volume of export was more than 1000 mt/yr but it decreased immediately after the war. In the last few years, the demand has increased considerably. With attractive export regulations on soft products, including many marine resources, the volume of seaweed export reached an all-time high of 5 923 mt in 1966 (Table 5) but it later declined due to changes in export regulations, the government's tight money policy, and the decrease in seaweed price.

Table 5. Annual export of seaweeds (dry weight, metric tons) from major Indonesian ports in 1960-1976

Year	Tanjung Priok, Jakarta	Surabaya	Ujungpandang (Macassar)	Ambon	Others
1960	104.50	197.87	305.20	-	20.00
1961	286.05	72.61	562.99		
1962	76.50	40.76	300.99		-
1963	146.00	-	-	-	12.00
1964	147.00	-	110.00	-	28.00
1965	335.00	-	770.00	-	27.00
1966	329.00	137.00	5 246.00	-	211.00
1967	244.70	335.00	265.80	-	72.70
1968	380.80	182.70	1 571.40	89.00	170.80
1969	136.00	227.50	1 040.30	490.20	289.30
1970	888.30	5.50	1 076.50	1 373.20	463.90
1971	45.90	24.30	1 125.80	2 283.50	254.00
1972	80.20	137.40	1 480.40	1 804.50	219.40
1973	52.60	64.20	1 587.10	1 296.60	250.70
1974	8.60	53.20	1 446.20	1 605.60	187.70
1975	9.50	23.00	764.70	745.70	59.70
1976	10.00	43.20	1 313.60	505.50	115.70

Source: The Indonesian Directorate General of Fisheries.

By far, Ujungpandang has been the major market and shipping harbor for seaweeds harvested mainly from the south coast of Celebes and the adjacent islands. In recent years, harvests from Nusa Tenggara (Sumbawa, Flores, Sumba) and the Moluccas region have also been transported to Ujungpandang. The seaweed production from the Moluccas now is rather substantial (over 2 000 mt in 1971) to make Ambon another center of seaweed trade.

Between 1920 and 1930, Indonesian seaweeds exported almost exclusively to China consisted chiefly of *E. spinosum*. The export statistics for 1930-1940 also indicates that 20-30% of the exported seaweeds landed in Japan and consisted mainly of *G. blodgettii, G. lichenoides, G. amansii* and *G. rigidum*. Singapore and Hong Kong are important transitory ports of seaweed exports destined for European, American, or even Japanese markets. However, in the last few years, direct exportation has increased steadily.

SEAWEED FARMING

One of the problems of the seaweed export industry is the lack of a constant supply of seaweeds of good quality. Shipments containing some low-grade seaweeds are unacceptable in the international market and are usually sold at low prices. Steps are being taken to remedy this problem.

Some commercial seaweed buyers are sponsoring programs on the cultivation of *E. spinosum* in tropical Southeast Asian countries such as Singapore, Philippines, and Indonesia. Successful field cultivation will ensure yields of predictable quantity and quality and possibly also reduce transport costs. So far, the results have been very encouraging and the Philippine experience has become a model of such efforts (Doty 1973).

Indonesian seaweed culture in the laboratory started as early as 1966 (Soerjodinoto 1968, Soegiarto 1968, Ismail 1971) but the study progressed only slowly due, in part, to political and economic instability in the country during that time. In 1972 the study was resumed with strong government support, especially by the Indonesian National Institute of Oceanology (NIO) and the Marine Fisheries Research Institute (MFRI). In the last few years, a number of seaweed farms have been set up by NIO at Pari Islands, Jakarta Bay (Soegiarto et al. 1975) and the Tanjung Benoa, Bali (Sulistijo and Atmadja 1980); by MFRI and Copenhagen Pectin Company in Samaringa Islands, Central Celebes (Mubarak 1975); by fishermen in North Tanimbar Island and in Maumere (Mubarak 1974); by MFRI and Marine Colloids in Riau (Mubarak 1976); by Directorate General Cooperative and USAID in Aru Islands, Moluccas (Mubarak 1978); by fishermen in cooperation with the Moluccas Government and NIO Ambon Station in Geser, Ceram Island, Moluccas; and by fishermen with the assistance of Copenhagen Pectin Company in Terora-Tanjung Benoa, Bali (Sulustijo and Atmadja 1980).

The *E. spinosum* farm in Terora-Tanjung Benoa, Bali, so far has produced the best results, with a monthly production of 15-20 mt dry weight in 1979. However, due to the decreased prices, the monthly production declined to around 10 mt after one year. Furthermore, experimental results have shown that the growth rate on floating rafts is slightly better than that of the bottom method. For example, in the farms in Tanjung Benoa, Bali, the average growth rate was 4-5%/day on the floating rafts and less than 3%/day in the bottom method.

CONCLUSIONS

The economic value of seaweeds in Indonesia is not yet fully appreciated. The full potential of the country's seaweed resources remains to be tapped.

More extensive surveys and research are urgently needed to determine the potential production and the factors which govern the productivity of the economically important species.

Only a few species have so far been investigated for their nutritional value and chemical composition which considerably vary from one species to another and with geographical distribution and seasonal changes.

The expansion and upgrading of agar factories in Indonesia will depend on government protection against imported products, capital investments, improved management, continuous supplies of good quality raw materials, and the application of more modern technology.

Seaweed exports can be increased through attractive export regulations and bonuses in combination with strict quality control.

Seaweed farming should be encouraged to increase production, control the quantity and the quality of seaweeds, and reduce interinsular transport costs and risks. Technically, seaweed farming is easy and does not require much capital investment. It will also provide new job opportunities for fishermen.

Appropriate marketing and pricing systems should be developed in order to protect the seaweed farmers from unscrupulous dealers or buyers.

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