

## Biology and agar quality of cultivated *Gracilaria* from Vietnam

Masao OHNO<sup>1</sup>, Hunh Quang NANG<sup>2</sup> and Susumu HIRASE<sup>3</sup>

<sup>1</sup> Usa Marine Biological Institute, Kochi University, Usa-cho, Tosa, Kochi 781-11, Japan

<sup>2</sup> Nha Trang Institute of Material Science, Center for Production of Seaweeds, 2-Hung, Nha Trang, Vietnam

<sup>3</sup> Research Laboratory, Tioto Co., LTD. 1-26 Higashi, Shiruiki-Shinmachi, Nagata-ku, Kobe 653, Japan

**Abstract:** There are more than 1000 ha of commercial *Gracilaria* cultivation grounds in Vietnam. Almost all of the cultivated materials are *G. tenuistipitata* var. *liui* and *G. heteroclada*, which are mainly grown and produced in ponds. In 1993-94, a survey of *Gracilaria* pond cultivation was conducted in Vietnam. Fronds of 30-50 cm initial length were cultivated throughout the year in these brackish ponds (30 x 50 m in area) of 30-60 cm depth, with ranges in temperature and salinity of 23-30 °C and 10-25 ppt, respectively.

Agar of good quality were obtained from materials which were quickly dried. Best agar quality obtained in this survey have the following values: agar yield of 18-25%, gel strength of 813-1011 g/cm<sup>2</sup> (1% gel) and sol viscosity of 10.1-20.0 cP (treatment at 70 °C, 1%).

**Key words:** agar, seaweed cultivation, *Gracilaria*, Vietnam

### INTRODUCTION

There are approximately 13 species of *Gracilaria* in Vietnam (Nguyen 1992), two of which are being cultivated in ponds, namely: *G. tenuistipitata* var. *liui* Chang et Xia and *G. heteroclada* Zhang et Xia. The former is cultivated in many ponds of Hue and other parts of northern Vietnam, while the latter, in the ponds of central Vietnam. During the present survey, wild materials of *G. heteroclada* were transplanted into shrimp culture ponds. *Gracilaria* pond cultivation has been operated experimentally since 1963. In 1974-77, a Vietnam-German (referring to the former German Democratic Republic) cooperation program was undertaken on *Gracilaria* cultivation, with the view of ensuring raw materials for the Vietnamese agar industry. Production of *Gracilaria* in the ponds at Hue reached 1.5-3.0 tons dry wt./ha/yr. (FAO, 1991). Vietnamese *Gracilaria* products were exported mainly to Soviet Union and China during 1988-1991. There are approximately 22,000 ha of shallow lagoonal regions in Vietnam, many of which are used as *Gracilaria* cultivation grounds since 1980. In addition to exported dry raw materials, some quantity has recently been used to produce agar for domestic consumption (FAO, 1991).

### MATERIALS AND METHODS

The survey was carried out at five cultivation sites in Vietnam, namely: Hai Phong, Sam Son, Hue, Dong Xuan and Ninh Hai from February to March, 1994 (Fig. 1). Strains, of *G. heteroclada* from the lagoons of Dong Xua were transplanted into shrimp culture ponds in Ninh Hai in 1993. Lengths of fronds of more than 30 individuals, were measured at each survey site, and about 5 kg fresh weight of *Gracilaria* were collected at each pond. These materials were sun-dried and then transported to Kochi University in Japan.

Water temperature and salinity of each pond were measured at the surface layer by a thermometer and salinometer, respectively. For agar extraction, samples of 40 g dry wt. were

alkali treated in a 2l solution of 6 % NaOH at 70-80 °C for 3 h, and washed in running tap water for 30 min. Afterwards the materials were acid treated in a 2l solution of 0.11-0.18 % H<sub>2</sub>SO<sub>4</sub> solution for 1 h, and washed again in running tap water for another 2 h. The samples were then boiled for 1 h with 1.5 l of distilled water (pH 7-8) using a Bunsen burner in a 2l Erlenmeyer flask equipped with a reflux condenser. The agar extract were dehydrated by freezing and pressing. Properties of a 1 % agar solution were finally measured to determine gel strength, gelling and melting temperatures, viscosity and pH.

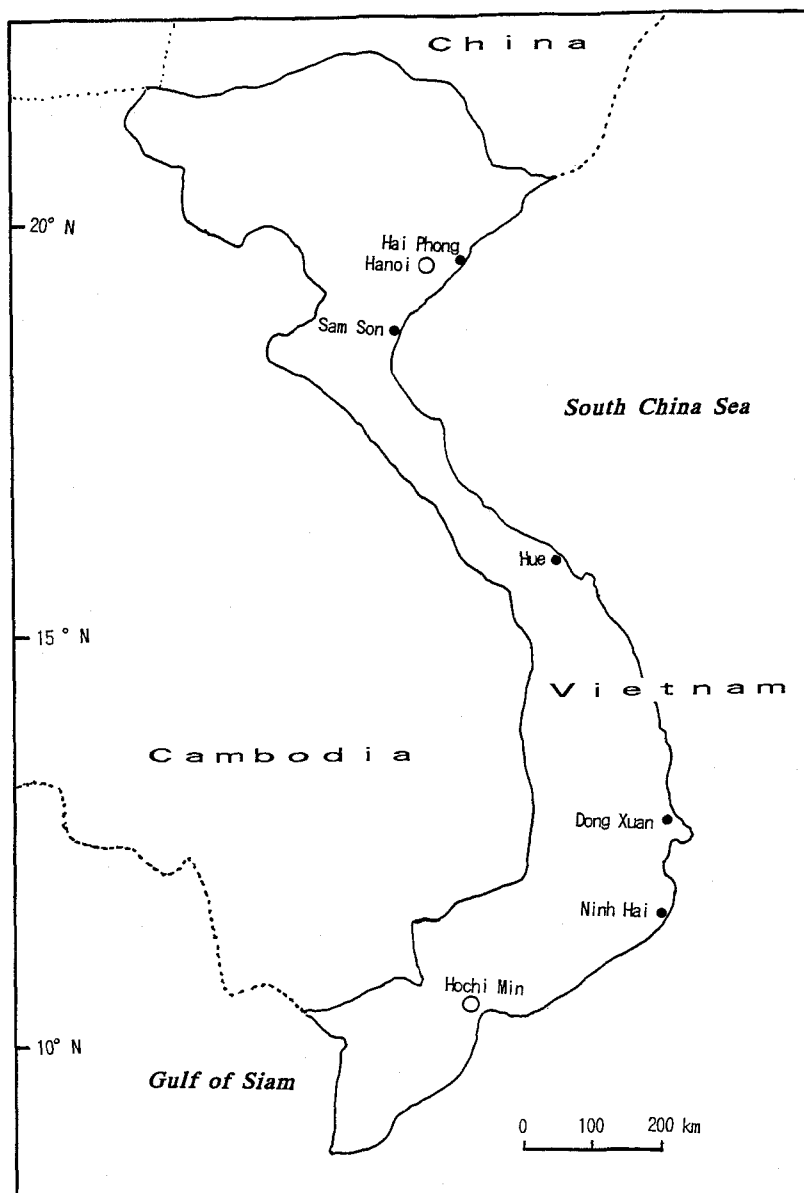
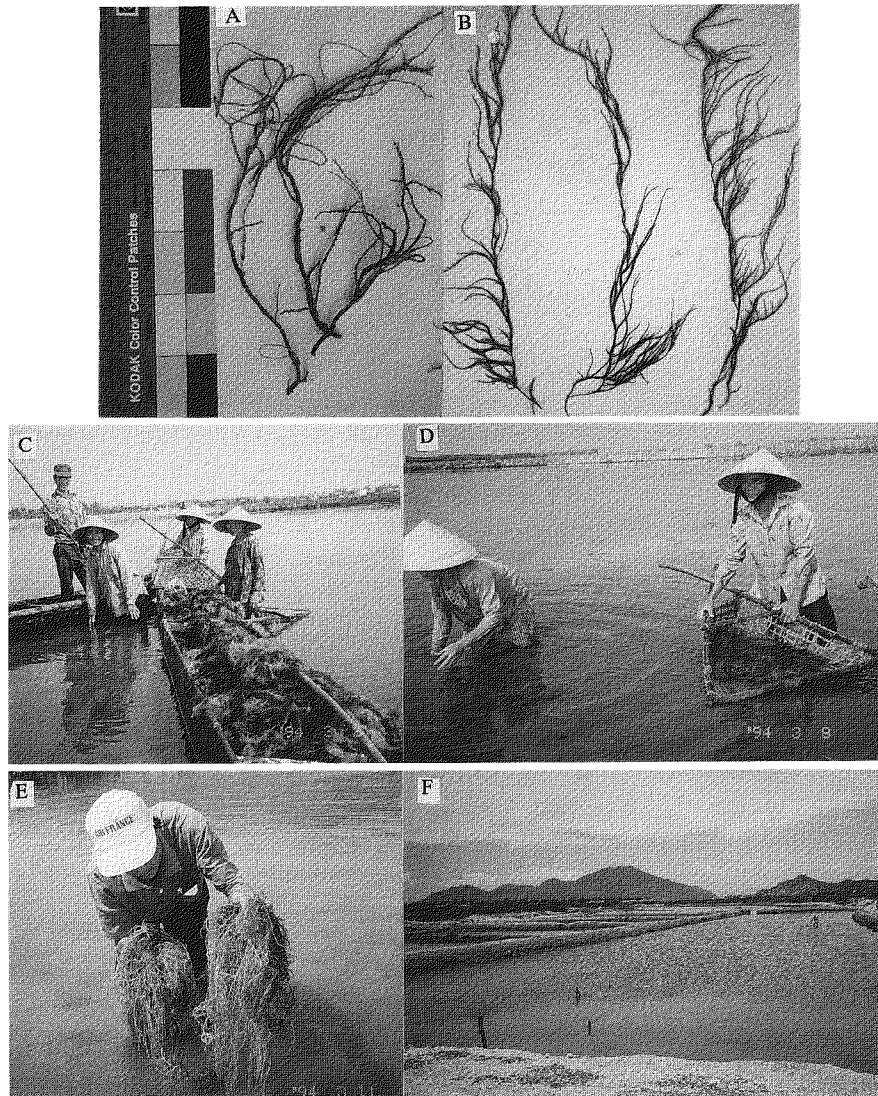


Fig. 1. Survey location of *Gracilaria* cultivation ponds in Vietnam.

## RESULTS

*Environmental conditions in the Gracilaria cultivation ponds*

*Gracilaria* grows in the sub-tidal bottoms, usually with a small tidal range (0.3–0.5 m). The pond bottom substrates are usually composed of sandy and muddy-sand. The largest *Gracilaria* cultivation ponds (more than 500 ha) are in Hue (Fig. 2A, C and D). The *Gracilaria* cultivation ponds in Ninh Hai are converted shrimp culture ponds (Fig. 2B, E and F).



**Fig. 2.** Procedure of *Gracilaria* cultivation in Vietnam.

- A : Habit of *Gracilaria heteroclada* Zhang et Xia.
- B : Habit of *Gracilaria tenuistipitata* var. *liui* Chang et Xia.
- C : Pond (lagoon) cultivation of *Gracilaria* at Hue.
- D : Collecting the materials of *G. tenuistipitata* var. *liui* in a Hue pond.
- E : Collecting the materials of *G. heteroclada* in Ninh Hai pond.
- F : Experimental pond cultivation of *Gracilaria* at Ninh Hai.

**Table 1.** Water temperature and salinity of *Gracilaria* cultivation ponds in Viet Nam

Place	Date	Water temperature (°C)	Salinity (ppt)
Hai Phong	28, Feb. '94	17.0	29.46
Sam Son	4, Mar. '94	18.5	29.20
Hue	9, Mar. '94	28.0	29.22
Dong Xuan	12, Mar. '94	28.5	33.25
Ninh Hai	13, Mar. '94	29.0	33.50

The environmental conditions at the *Gracilaria* cultivation ponds in Hai Phong, Sam Son and Hue are shown in Table 1. The water temperature and salinity in the cultivation ponds in Hai Phong and Sam Son in northern Vietnam ranged from 17.0-18.5 C and 29.2-29.46 ppt, respectively. In the Hue ponds in central Vietnam, water temperature of 28.0 C and salinity of 29.22 ppt were recorded. The water temperature and salinity in the ponds at Dong Xuan and Ninh Hai, southern Vietnam were relatively high ranging from 28.5-29 C and 33.25-33.50 ppt, respectively. These results show that *Gracilaria* cultivation in Vietnam can be carried out in a wider region from temperate to the tropical waters.

#### Characteristics of cultured *Gracilaria* species

In Hai Phong, Sam Son and Hue, the cultivated strain consisted of *G. tenuistipitata* var. *liui* (Fig. 1A, B). The fronds of this species have dark red color, delicate, having alternate branching arrangement of one to two orders, with lengths of 15-30 cm (Table 2). The species cultivated in the ponds at Dong Xuan and Ninh Hai consisted of *G. heteroclada* (Table 2, Fig. 2B, E and F) characterized by a mixed branch pattern of either alternate or irregular. The branches, which are often spinous in the upper portion of the main axes, are comparatively thick and long, reaching 30-60 cm, and are normally pale green in color. This species grows in waters of high temperature and salinity. *G. heteroclada* transplanted from the ponds at Dong Xuan into the ponds at Ninh Hai had grown into long sizes of healthy fronds. *G. tenuistipitata* var. *liui* and *G. heteroclada* can be grown in these ponds throughout the year.

**Table 2.** Biological data of cultivated *Gracilaria* in Vietnam

Place	Habitat	Species	Character of fronds		
			length	thallus	color
Hai Phong	temperate waters	<i>G. tenuistipitata</i> var. <i>liui</i>	30-40 cm	long & delicate	dark red
	lower salinity				
Sam Son	warm waters	<i>G. tenuistipitata</i> var. <i>liui</i>	15-25 cm	delicate	dark red
	lower salinity				
Hue	warm waters	<i>G. tenuistipitata</i> var. <i>liui</i>	20-30 cm	delicate	dark red
	lower salinity				
Dong Xuan	tropical waters saline	<i>G. heteroclada</i>	30-60 cm	thick	pale green
Ninh Hai	tropical waters saline	<i>G. heteroclada</i>	50-60 cm	thick	pale green

*Physical properties of agars from Vietnamese Gracilaria*

The yield of agar and its gel strength, gelling and melting temperatures, viscosity and pH from each source in Vietnam are shown in Table 3. Agar yield ranged from 16.0-18.9% from *G. tenuistipitata* var. *liui* harvested from Hai Phon ponds but those from the ponds in Sam Son and Hue showed low values of between 10.0 and 13.0%. The agar yield of *G. heteroclada* from Dong Xuan ranged from 10.9-11.9% while at Ninh Hai it ranged from 20.8-21.0%. These results show that the agar yields from Vietnamese *Gracilaria* vary mainly according to cultivation conditions and by the drying methods of samples.

**Table 3.** Yield and properties of agar from cultivated *Gracilaria* collected in Vietnam

Sample	Alkali treatment			Acid Treatment pH	Yield %	gel Strength g/cm <sup>2</sup>	Properties of agar			pH
	%	°C	hr				gelling temp. °C	melting temp. °C	Visco-sity of sol. cp	
Hai Phon	6	70	3	2.5	16.8	809	41.0	95.5	20.0	8.4
<i>G. tenuistipitata</i> var. <i>liui</i>	"	"	"	2.1	18.9	678	40.6	91.1	11.7	8.3
"	"	80	"	2.5	16.0	1011	41.6	93.7	19.8	8.4
"	"	"	"	2.1	18.3	813	41.7	89.6	18.0	8.2
Sam Son	"	70	"	2.5	17.1	282	41.6	87.0	16.6	8.3
<i>G. tenuistipitata</i> var. <i>liui</i>	"	"	"	2.1	17.8	324	41.3	85.6	11.4	8.2
"	"	80	"	2.5	16.9	608	40.2	86.1	14.3	8.2
"	"	"	"	2.1	17.5	305	40.6	82.3	9.9	8.1
Hue	"	70	"	2.5	12.4	601	40.8	99.2	17.6	8.1
<i>G. tenuistipitata</i> var. <i>liui</i>	"	"	"	2.1	13.0	377	40.8	96.3	14.9	8.0
"	"	80	"	2.5	10.7	721	42.3	99.6	17.0	8.2
(good dry)	"	"	"	2.1	10.6	748	42.2	96.8	12.6	8.0
Hue	"	70	"	2.5	12.2	306	42.6	93.9	16.5	8.0
<i>G. tenuistipitata</i> var. <i>liui</i>	"	"	"	2.1	12.5	303	41.7	92.3	9.8	8.1
"	"	80	"	2.5	10.0	634	42.6	96.1	10.1	8.1
(insufficient dry)	"	"	"	2.1	10.8	603	42.0	93.6	8.9	8.1
Dong Xuan	"	70	"	2.5	10.2	774	39.2	91.6	13.8	8.4
<i>G. heteroclada</i>	"	"	"	2.1	11.6	511	39.0	88.8	12.3	8.1
"	"	80	"	2.5	11.9	357	40.5	87.5	10.7	8.2
"	"	"	"	2.1	10.7	296	40.1	86.3	7.7	8.2
Ninh Hai	"	70	"	2.5	21.0	563	38.0	65.9	15.1	8.4
<i>G. heteroclada</i>	"	"	"	2.1	21.2	487	38.0	64.7	9.8	8.1
"	"	80	"	2.5	21.3	467	39.0	62.5	13.7	8.2
"	"	"	"	2.1	20.8	369	39.3	56.1	9.1	8.0

The physical properties of agar from each source improved significantly after alkali treatment. The agar yield from *G. tenuistipitata* var. *liui* have a higher gel strength after alkali treatment at 80 °C and acid treatment at pH 2.5. The agar from the Hai Phon materials showed the highest gel strength of 1011 g/cm<sup>2</sup> while those from Sam Son and Hue after alkali treatment showed lower gel strengths of 608 and 748 g/cm<sup>2</sup>, respectively. The gel strength of agars from *G. heteroclada* showed highest values of 774 g/cm<sup>2</sup> at Dong Xuan and 563 g/cm<sup>2</sup> at Ninh Hua after alkali treatment at 70 °C and acid treatment of pH 2.5.

Gelling temperatures of agar extracted from *G. tenuistipitata* varied from 40.2–42.7 °C, while that of *G. heteroclada* varied from 38.0–40.5 °C. On the other hand, the melting temperatures of agar from *G. tenuistipitata* var. *liui* varied from 82.3–99.6 °C, while those from *G. heteroclada* ranged from 56.1–91.6 °C. The viscosity of the sgar in both *G. tenuistipitata* and *G. heteroclada* showed comparatively lower values between 7.7 and 20.0 cP at all the extract sol. The pH of the agar extracted from all sources did not vary much (8.0–8.4).

## DISCUSSION

The commercial cultivation of *Gracilaria* in Vietnam has been operated in ponds for more than 10 years now, but there are only very few scientific reports on this cultivation. Three species of cultivated *Gracilaria* have been reported by FAO (1991), namely: *G. tenuistipitata* var. *liui*, *G. verrucosa* and *G. blodgettii*. The materials collected in this survey were the species *G. tenuistipitata* var. *liui* from the culture ponds, and *G. heteroclada* from the lagoons of areas surveyed. Yamamoto *et al.* (1994) has reported on the life cycle and taxonomic status of *G. heteroclada* from the materials collected at Dong Xuan lagoon. The common species of *Gracilaria* cultivated in ponds of Vietnam are *G. tenuistipitata* var. *liui*. *Gracilaria heteroclada* has not been used for pond cultivation. In this study, an experimental cultivation of *G. heteroclada* in central Vietnam was operated in a newly converted shrimp culture pond. This species has the desired frond characteristics (*i. e.* thick and long) preferred by agar producers for commercialization compared with those of *G. tenuistipitata*.

*Gracilaria* materials which are imported into Japan usually give an agar yield of 14–25% which at 1.5% concentration forms a gel with strength of 600–800 g/cm<sup>2</sup> and gelling temperature of 39–44 °C (Orosco *et al.* 1992). The yield from Hue and Dong Xuan materials did not show values higher than 14%, but the yield of other materials from Vietnam ranged from 16.0–21.8%. The gel strength values of 563–1011 g/cm<sup>2</sup> of Vietnamese *Gracilaria* was lower than those of the species from Japan. Japanese species, such as *G. chorda*, showed gel strength of a 1.5% agar as high as 1139 g/cm<sup>2</sup> (Orosco *et al.* 1992). *Gracilaria lemaneiformis*, also from Japan, showed gel strength of 1455 g/cm<sup>2</sup> from 1.5% agar. Species of *Gracilaria* from Taiwan, Philippines and Thailand showed gel strengths of 660 ± 45 g/cm<sup>2</sup>, 622.4 ± 4 g/cm<sup>2</sup> and 716 ± 14 g/cm<sup>2</sup>, respectively (Tam and Edwards 1982, Orosco *et al.* 1992).

Viscosities of sol from Vietnamese materials had higher values of 7.7–2.0 cP comparing with 7–9 cP of those of Japanese *Gracilaria* (Orosco *et al.* 1992). Agars with lower viscosity is an advantage, because the extract can be filtered smoothly.

From the data gathered in this study, it may be concluded that *Gracilaria* from Vietnam could be a good source of high quality agar by strain selection and good drying method.

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