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Phycocolloid contents in certain economically important seaweeds of Kerala coast, India

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Original Article

Abstract

Agar, alginic acid and carrageenan are the major phycocolloids obtained from seaweeds that are stored in their cell walls. The phycocolloids extracted from seaweed species of commercial importance collected quarterly from nine locations along the Kerala coast formed the basis of this communication. Agarophytes harvested for extraction of agar were represented by seven species and out of them, highest yield (% dry weight) of agar was obtained from *Gelidium pusillum* and the lowest from *Gracilaria foliifera*. Alginophytes *Sargassum duplicatum* collected from Mullur as well as *Sargassum tenerrimum* from Thikkodi registered algin yield though comparable to *Sargassum wightii*, their biomass availability was seasonal and limited. Carrageenan yielding seaweeds are represented by nine species and the highest yield of carrageenan was recorded by *Gracilariopsis lemaneiformis* (38.13 %) occurring in the bay waters of Dhalavapuram and Kannur stations followed by *Hypnea valentiae* (35.28%) occurring in seven stations. The present investigation highlighted the occurrence of considerable wet biomass of *Gracilaria corticata, G. foliifera, Gelidium pusillum* for agar production, *Laurencia paniculata, Hypnea valentiae, H. musciformis* and *Gracilariopsis lemaneiformis* for carrageenan production and *Sargassum wightii, Padina gymnospora* and *P. tetrastromatica* for algin production and their colloid yields from 9 intertidal areas along the Kerala coast.

Keywords: *Agar, algin, carrageenan, extraction methods, polysaccharide yield, seaweed industry, phycopreneurs*

Introduction

Agar, alginic acid and carrageenan are the major phycocolloids obtained from seaweeds and are stored in their cell walls. Seaweeds comprise marine Thallophytes which are grouped under three major classes namely Chlorophyceae (green algae), Phaeophyceae (brown algae) and Rhodophyceae (red algae) based on their morphology and pigmentation of their thallus as well as cell wall polysaccharides (phycocolloids). World seaweed production in 2016 was 30.1 million t wet weight with first sale value estimated at 11.7 billion USD (FAO, 2018) and through mariculture it is expected to increase to 35 million t by the year 2025. India is endowed with a coastline of 8,118 km, an exclusive economic zone (EEZ) of 2.02 million sq km and a continental shelf area of 468000sq km spread across 9 maritime states and seven union territories. The seaweed wealth of India is estimated at 260876 t wet weight (Kaladharan and Reeta, 2003) comprising 896 species; 228 species from

Chlorophyceae, 210 species from Phaeophyceae, 455 species from Rhodophyceae and three species from Xanthophyceae (Umamaheswara Rao, 2011). Rich vegetation of seaweeds can be found in southern coast of Tamil Nadu, Okha and Gulf of Kachchh in Gujarat, Lakshadweep and Andaman -Nicobar archipelagoes. Density and harvestable wet biomass of seaweed resources and their availability for exploitation for phycocolloid extraction along the Kerala coast in relation to water quality were studied by Baby Ushakiran *et al.* (2017).

Agar is the major constituent of the cell wall polysaccharide of certain red seaweed (Rhodophyceae) especially the members of families Gelidiaceae, Gelidiellaceae and Gracilariaceae. "Agar-Agar" is the Malay word for a gelling substance extracted from *Eucheuma* sp., now known to be carrageenan. The term agar is now generally applied to the algal galactan, which have agarose, the disaccharide agarobiose as their repeating units (Duckworth and Yaphe, 1971). The world demand for agar has increased rapidly in recent years and currently the supply of agar containing seaweeds have greatly reduced. It is estimated that the current production of agar in the world is about 7500-10,000 t/ year and India's share is hardly 130 t /year (Devaraj *et al.*, 1999).

Algin or alginic acid is a membrane mucilage obtained from some brown seaweeds (Phaeophyceae) species like *Laminaria, Macrocystis, Turbinaria* and *Sargassum* and is a major constituent of all alginates such as calcium alginate and sodium alginate. Carrageenan is a sulphated galactan obtained from red seaweeds belonging to Gigartinaceae, Soliriaceae and Hypneaceae such as *Hypnea valentiae*, *Eucheuma cottonii*, *Chondrus crispus, Kappaphycus alvarezii* etc. In food industry, carrageenan finds its use in bakery, dairy, confectionery and culinary purposes in the preparation of whipped creams, ice desserts, cheese etc. Carrageenan improves the quality of wheat flour in *spaghetti* and *parota* making. The food sector accounts for nearly 70% of world market for carrageenan (Kaladharan and Kaliaperumal, 1999).

Kerala has a coastline of 690 km and the seaweeds grow abundantly along the coast wherever hard, rocky or coral substrata are available for attachment. Chennubhotl*a et al.* (1988) conducted resource assessment survey along the Kerala coast and brought out the details of availability of commercially important resources for the first time. Occurrence of *Porphyra kanyakumariensis* was reported from the southern Kerala coast by Chennubhotla *et al.* (1990). *Gracilariopsis lemaneiformis,* a long thalloid agar yielding red alga has been reported from certain backwaters of Dhalavapuram, (Quilon), Kadalundi (Kozhikode) and Mopla Bay (Kannur) along the Kerala coast (Kaladharan, 2005). Nettar and Panikkar (2009) described two new species from the Family Ralfsiaceae, *Hapalospongidion thirumullavaramensis* and *Pseudolithoderma thangass*eriensis, collected from the Quilon coast of Kerala. The taxonomy of four species of *Feldmannia* collected from different parts of Kerala such as *F. collumellaris*, *F. irregularis* and two new species: *F. sahnienii* and *F. renienii* was also reported *by* Nettar and Panikkar (2009a). Nettar and Panikkar 2009b) reported five species of *Hincksia* collected from different parts of Kerala and these include, *H. clavata* (Krishnamurthy and Baluswami) Silva, *H. rallsiae* (Vickers) Silva, *H. sandriana* (Zanardini) Silva, *H. mitchelliae* (Harvey) Silva and *H. turbinariae* (Jaasund) Silva. Among these, *H. rallsiae* is a new report to the Indian seaweed flora.

Although lot of investigations are available on the occurrence and distribution of many seaweed resources from the Kerala coast, very limited information is available on the polysaccharide content in different seaweed species which serve as raw material for the phycocolloid industry. This study was undertaken and communicated as its outcome might help the entrepreneurs of seaweed based industries (phycopreneurs) on various seaweed resources that can be used as alternate raw materials and their phycocolloid yielding potential along the Kerala coast.

Material and methods

Nine study sites as listed in Table 1 were selected along the Kerala coast and the geographical locations of the study sites were marked with the help of hand held geographical positioning system (GPS mp 76 CSX, Garmin model) for subsequent sampling. Seaweeds were collected from the above sites at quarterly intervals for one year period during low tide as recorded in the Indian Tide Table. The seaweeds collected from each sites were cleaned with seawater to remove sand and other debris and brought to the laboratory separately for further analysis. Seaweeds were dried separately by species on net-screen under sunlight. These dried seaweeds were soaked in water overnight and dried on the next day. The process was repeated until the seaweed samples were bleached and the dry seaweed species were stored airtight until analysis.

Table 1. Study sites and their geo locations

Sl. No.	Study sites	Geo locations (Latitude &Longitude)
1	Mullur	8° 22' 044" N& 77° 00'201" E
2	Dhalavapuram	8° 56' 519" N& 76° 33'081" E
3	Thirumallavaram	8° 54' 427" N& 76° 38'213" E
4	Manassery	9° 55' 278" N& 76° 15'011" E
5	Chettikulam	11° 19' 824" N& 75° 44'185" E
6	Thikkodi	11° 28' 461" N& 75° 37'288" E
7	Dharmadom	11° 46' 355" N& 75° 27'246" E
8	Kannur	11° 51' 156" N& 75° 22'429" E
9	Bekal	12° 23' 438" N& 75° 02'078" E

Extraction and estimation of agar

Agar was extracted by boiling dry seaweed sample and filtering the hot extract according to the procedure of Thomas and Krishnamurthy (1976). Cleaned, bleached and dried *Gracilaria corticata* samples weighing 10 g were cut into small pieces and soaked in 500 ml of fresh water for 24 hours. The soaked seaweeds were ground to get a pulp using mortar and pestle. The pulp in a final volume of 500 ml water was boiled in a vessel for an hour without spilling the extract. Then the hot seaweed extract was filtered using 2 layers of cloth. The residue was discarded and cooled in a tray at room temperature. The gel formed while cooling was sundried on a net screen to get agar strips. The agar strips were weighed to calculate yield of agar as given below.

$$\text{Percentage of yield of dry agar} = \frac{(\text{Dry weight of agar obtained (in gm)} \times 100)}{\text{Dry weight of seaweed used (in gm))}}$$

Similarly, agar was extracted and estimated from other four species of agarophytes.

Extraction and estimation of alginic acid

Alginic acid or algin extraction from brown seaweeds was performed according to the method of Cameron *et al.* (1948). Cleaned, bleached and dried seaweed *Sargassum wightii* weighing 10g was pulverized and then taken in 500 ml beaker and soaked in acidified (0.3% HCl) water for 6 hours. Then the seaweed was washed with excess water and filtered. The pulverized seaweed was digested with 2% Sodium carbonate solution at room temperature overnight, with occasional stirring. The digested seaweed mixture was diluted with one litre distilled water was filtered using muslin cloth. Crude sodium alginate containing filtrate was treated with 5% HCl and the pH was adjusted to 2.5. A precipitate formed was filtered. This precipitate was bleached with 2% Sodium hypochlorite solution, washed with water and neutralized the alginic acid granules with sodium bicarbonate and dried. The dry alginic acid was weighed to assess the yield. Percentage of yield of dry alginate was calculated as done in agar extraction. Similarly alginic acid was extracted from other six species of alginophytes collected.

Extraction and estimation of carrageenan

Extraction of carrageenan was carried out according to the method of Craigie and Leigh (1978). 10 g of cleaned, bleached, dried and pulverized *Hypnea musciformis* was taken in a beaker. It was soaked in one litre of 2% potassium hydroxide solution for 6 hours. Then the seaweed sample was washed with excess water and boiled in 500 ml of distilled water after adjusting the pH to 7.0. The hot extract was filtered through muslin cloth and the viscous filtrate was cooled at room temperature. The filtrate was mixed with twice its volume of ethanol while stirring until a coagulate was formed. Filtered and dried the coagulated carrageenan in the sun. Powdered the dry carrageenan and then weighed to assess the yield as that done for agar and algin. Similarly carrageenan was extracted from other species of carrageenophytes collected from Kerala coast.

Results and discussion

Nearly 40 seaweed based industrial units are functioning in India of which 80% are located in Tamil Nadu and it is estimated that annually 40,000 t of red and brown seaweeds are processed by these units for producing 130 t of agar and 540 t of Algin (Kaladharan and Kaliaperumal,1999). Seaweed research in India once confined to mere reporting of seaweed flora of certain coastal regions took shape of utilization research during the Second World War. This shift in focus of seaweed research especially on the identification of new raw materials for agar, their biomass, their value addition and postharvest technology etc was due to restrictions in the import of agar from Japan who held monopoly on agar, was involved in the war. The yield of phycocolloids extracted from seaweed species of commercial importance from the nine locations along the Kerala coast, quarterly were averaged and is presented in three tables.

Agar and agarophytes of Kerala coast

Agar yielding seaweeds or the agarophytes harvested for extraction of agar from the Kerala coast were represented by seven species and the major resources were *Gracilaria corticata, G. foliifera, Gelidiopsis variabilis* and *Gelidium pusillum* and a

Table 2. Agar yielding seaweeds and their agar content (% dry weight) from Kerala coast

Seaweed species	Mullur	Dhalawa puram	Thirumallavaram	Manassery	Chettikulam	Thikkodi	Dharmadam	Kannur	Bekal	Mean of 9 Stn
Gracilaria corticata	31.25± 3.02	NA	32.25± 1.43	NA	32.25± 1.39	30.67± 0.54	34± 0.47	34.5± 0.35	38± 0.71	33.27
Gracilaria foliifera	22.9± 0.78	NA	26.5± 1.77	NA	24.33± 0.98	26± 0.37	29.5 ±0.43	NA	29± 0.71	26.37
Gelidiopsis variabilis	39 ± 1.41	NA	33± 1.63	NA	29.33± 0.54	37.67± 1.19	NA	NA	NA	34.79
Gelidium pusillum	49± 1.70	NA	38.63± 5.72	NA	52.33± 1.19	49.5± 0.83	50.5 ±1.82	49.5± 0.43	48± 0.47	48.21
Pterocladia sp.	NA	NA	NA	NA	24.5± 1.06	25± 0.04	NA	NA	NA	24.75

species of *Pterocladia* (Table 2). Out of them, highest yield (% dry weight) of agar was obtained from *G. pusillum* and the lowest from *G. foliifera* although *G. corticata* from Bekal coast registered, a yield of 38% agar. Agar yield determined from *G. pusillum* showed maximum values from Chettikulam samples (52.33 ± 1.19%) and in the samples from Dharmadom (50.5 ± 1.82 %. Although *G. corticata* exhibited higher density and quantity of harvestable biomass as well as higher frequency of occurrence (Table 2) from Mullur, Thirumallavaram, Chettikulam and Kannur (Baby Ushakiran *et al*., 2017) agar yield from this species varied from 30.67% for Thikkodi samples to 38% for samples from Bekal. *Pterocladia* sp. though available scarcely in Chettikulam and Thikkodi coasts, its agar yield registered 24.75% of its dry weight. *G. foliifera* was also a raw material whose mean agar yield was maximum from Dharmadom coast (29.5%).

Easy availability of both wild and cultivated species of *Gracilaria* has led to its becoming the principal source of agar worldwide (Critchley, 1997). Approximately 60% of the world's present production of agar is derived from *Gracilaria* spp. (Durairatnam, 1987). Although *Gelidium* spp. is the most preferred agarophyte due to the higher yield and quality of its agar, it has become unavailable to industries because of depleting wild stock due to over exploitation and slow growth rate. Many studies have found that agar content in *Gracilaria* species is negatively correlated with nitrogen levels in seawater (Hoyle, 1978; De Boer, 1979; Bird, 1988; Oyieke, 1993). However, positive correlation in the yield of agar from *Gracilaria edulis* with nitrogen levels of seawater has been observed by Veeragurunathan and Anand (2012). *Gracilaria edulis* growing in natural beds of Tamil Nadu coast is known to yield maximum agar during July-September (Veeragurunathan and Anand, 2012; Karthikeyan and Eswaran, 2010). However, a different opinion in this regard exists (Chennubhotla *et al.,* 1986).

Agar yield from *G. corticata* obtained through the present study was lower (30.67- 38%) than the earlier observations (Chennubhotla *et al*., 1977; Kaliaperumal *et al*.,1992) and lower than agar yield from *G. edulis* (Chenubhotla *et al*.,1986; Balakrishnan *et al*., 2009; Veeragurunathan and Anand, 2012) from Tamil Nadu coast. The yield of agar obtained from *G. pusillum* is comparable with the earlier observations from the Visakhapatnam coast by Kaliaperumal and Umamaheswara Rao (1981). However, they obtained 35% agar from *Pterocladia heteroplatos* which is higher than the yield from *Pterocladia* sp., from Kerala coast. Although *G. pusillum* and *Gelidiopsis variabilis* yielded agar higher than *G. corticata, G. foliifera* and *Pterocladia* sp., their harvestable biomass production per unit area along the Kerala coast was very less and their thallus are crustose in form. Yield and quality of agar can be modified or optimized by adjusting the pH while extraction (Kaliaperumal and Umamaheswara Rao, 1981; Rao and Kaladharan, 2003).

Alginophytes and their algin content

Alginophytes available from Kerala coast are represented by seven species belonging to four genera (Table 3). The mean yield of alginic acid (% dry weight) was highest (35.42%) for *S. wightii* collected from Mullur (34.25%), Thirumallavaram (36.67%), Thikkodi (35.75%) and Bekal (35.17%) coasts followed by *S. tenerrimum* (34.67 ± 2.83 %) collected from Thikkodi coast. *Stoechospermum marginatum* available in Thirumallavaram and Thikkodi rocky coasts showed a mean yield of 26%. *Sargassum duplicatum* also yielded 22 ± 0.83% alginic acid but was obtained only from Mullur coast (Table 3).

Species of *Sargassum, Turbinaria* and *Padina* are regarded as major sources of alginic acid production in India (Kalimuthu *et al*., 1991; Kaladharan and Kaliaperumal, 1999). *S. wightii* and *Padina tetrastromatica* are regarded as the major source for the production of alginic acid in Kerala (Sobha *et al.,* 2009). Through the present study, it was established that Kerala coast supports *S. wightii* (44-50.67%), *P. tetrastromatica* (10- 19%) and *S. marginatum* (30%) as source of algin production in Kerala. Variation in the yield of alginic acid from *S. wightii* collected from localities within the southwest coast of Kerala coast is evident from earlier report (Sobha *et al*., 2009) which can justify the observed variation in the mean yield of alginic acid from Mullur, Thirumallavaram and Thikkodi for the seven

Table 3. Alginophytes and their alginate content (% dry weight) from Kerala coast

Seaweed species	Mullur	Dhalawa puram	Thirumalla varam	Manassery	Chettikulam	Thikkodi	Dharmadam	Kannur	Bekal	Mean of 9 stn
Sargassum wightii	34.25± 1.43	NA	36.67± 1.96	NA	NA	35.75± 1.75	NA NA	35.17± 1.4	35.42	
S. duplicatum	22.0±0.83	NA	NA	NA	NA	NA	NA	NA	NA	22
S. tennerrimum	NA	NA	NA	NA	NA	36.67± 2.83	NA	NA	NA	36.67
Dictyota dichotoma	18.0± 1.04	NA	18.0± 1.37	NA	19.33± 2.83	13.0± 0.71	12.5± 0.83	NA	NA	16.17
Stoechospermum marginatum	NA	NA	22.0± 1.04	NA	NA	30.0± 0.92	NA	NA	NA	26
Padina gymnospora	16.25± 2.07	NA	10.0± 0.94	NA	11.33± 0.54	11.5± 0.87	10.0± 0.79	NA	NA	11.82
Padina tetrastroamtica	12.0± 0.62	NA	19.0± 0.71	NA	NA	10.0± 0.04	NA	NA	NA	13.67

species of alginophytes. Similar intraspecific variation in alginic acid in the case of *Sargassum tenerrimum* is reported from Palk Bay (Varrier and Pillai, 1951) and from Gujarat coast (Kappanna *et al.*, 1962).

Considerable variation in the yield of alginic acid in different locations might be due to the variation in substratum on which they were growing or the growth stages of thallus at the time of harvest (Umamaheswara Rao,1969; Chauhan,1970; Chennubhotla *et al.*,1982). The present observation also strongly supports the earlier finding that among all the alginophytes, *S. wightii* contained highest level of alginic acid (Solimabi and Naqvi, 1975; Chennubhotla *et al.*, 1977; Kaliaperumal *et al.*, 1989). Alginophytes *S. duplicatum* collected from Mullur as well as *S. tenerrimum* obtained from Thikkodi registered algin yield though comparable to *S. wightii*, their biomass availability was seasonal and limited. The yield of algin observed from *S. duplicatum* from Mullur is higher than the earlier observation from Lakshadweep (Kaliaperumal *et al.*, 1989) and lower than the observation of Istini *et al.* (1994) from Tosa Bay, Japan. Another species *P. tetrastromatica* registered, maximum in the mean yield of 19% from Thirumallavaram coast which is higher than the yield reported by Kaliaperumal *et al.* (1992) from Thiruchendur coast and comparable with that of Sobha *et al.* (2009) from Thankaserry and Vizhinjam coasts.

The yield of alginic acid from *S. marginatum* in the present study is higher than the levels reported from Mandapam (23.8%, Kalimuthu *et al.*, 1980) and from Idinthakarai and Manapad coasts (21-25.7%, Kaliaperumal *et al.*, 1992). October to March season has been recommended for commercial exploitation of alginophytes *Cystoseira trinodis* and *Hormophysa triquetra* from the Palk Bay and Gulf of Mannar area based on the maximum alginic acid yield (Kaliaperumal *et al.*, 1989).

Carrageenophytes and carrageenan content from Kerala coast

Carrageenan yielding seaweeds of Kerala coast are represented by nine species and the highest yield of carrageenan (% dry weight) was recorded by *G. lemaneiformis* (38.13 %) occurring in the bay waters of Dhalavapuram and Kannur stations followed by *H. valentiae* (35.28 %) occurring in seven stations. *H. musciformis* observed from five stations along the Kerala coast also contained fairly good quantity of carrageenan (Table 4). Among the species of *Grateloupia*, *G. lithophila* registered higher yield of carrageenan (20.83%) than *G. filicina* (18.59%). Mullur station had maximum number of carrageenan yielding species including *Acanthophora spicifera* (19.5 ± 0.35%), *Asperagopsis taxiformis* (17.5 ± 0.25%) and *Laurencia paniculata* (16 ±0.82%). *Chondrus* sp. available in Thikkodi station registered 22±0.54% carrageenan (Table 4).

Carrageenan is one of the commercially important polysaccharides of sulfated galactan group found in cell walls of certain red seaweeds. Globally there are 25 large processing plants of carrageenan and less than 10 small factories (Hurtado and Agbayani, 2000). Information available on carrageenan and carrageenophytes from Indian coasts is scarce compared to the wealth of information available from India on agar and alginic acid and their raw materials. On an average India imports 100 t of carrageenan every year (Umamaheswara Rao, 2011).

Kerala coast support considerable biomass of *Grateloupia lithophila* and *Grateloupia filicina* and their carrageenan content also was found encouraging (16-23%). *G. lithophila* from Kovalam (Chennai) is known to show seasonal variation in carrageenan yield from 28- 38.5%, maximum during June and Minimum during December (Rajasulochana, 2005). The yield

Table 4. Carrageenan yielding seaweeds and their carrageenan content (% dry weight) from Kerala coast

Seaweed species	Mullur	Dhalawa puram	Thirumalla varam	Manassery	Chetti kulam	Thikkodi	Dharmadam	Kannur	Bekal	Mean of 9 stn
Acanthophora spicifera	19.5± 0.35	NA	NA	NA	20± 0.54	NA	16± 0.47	NA	20.25± 0.24	18.94
Asperagopsis taxiformis	17.5± 0.25	NA	NA	NA		NA	NA	NA	NA	17.5
Grateloupia filicina	18± 0.08	NA	16± 0.13	17.25± 0.65	16.66± 0.54	NA	16± 0.82	15.67± 0.84	NA	16.59
G. lithophila	NA	NA	23± 0.13	19.5± 1.09	20± 0.65	NA	20.67 ± 0.54	23.51± 0.35	18.33± 0.85	20.83
Hypnea valentiae	34.5± 1.35	NA	35± 0. 08	NA	35± 1.19	33.3± 1.36	34 ± 0.82	36.5 1.06	38.67± 1.09	35.28
H. musciformis	32.5± 1.77	26± 0.27	34± 2.82	NA	NA	35.67± 0.98	NA	NA	37.5± 1.03	33.13
Chondrus sp.		NA	NA	NA	NA	22± 0.54	NA	NA	NA	22
Gracilariopsis lemaneiformis	NA	39.25± 0.96	NA	NA	NA	NA	NA	37 ± 2.49	NA	38.13
Laurencia paniculata	16± 0.82	NA	NA	NA	NA	NA	NA	NA	NA	16

of carrageenan obtained from *Acanthophora spicifera* is in conformity with the results reported by Angelin *et al.* (2004). A new resource of carrageenan yielding *G. lemaneiformis* was earlier reported from Kannur, Kadalundi and Dhalavapuram and the density ranged from 300-900 gm/m^2 in Mopla Bay, Kannur and 150-600 gm/ m^2 in Dhalavapuram during the peak growth season of October to January. The standing crop in both the estuarine areas of about 20 hectares was estimated to be 12-15 t wet wt./yr and the polysaccharide content in this species ranged from 18 to 26% dry weight (Kaladharan, 2005). Outside the Kerala coast, this species has been reported from Pamban, Mandapam and Visakhapatnam by Umamaheswara Rao and Kalimuthu, 1972).

In recent years a carrageenophyte *Kappaphycus alvarezii* has been introduced in our waters from the Philippines mainly to cultivate and export the raw material or value added products and they are known to yield 50-59% of carrageenan (Siddhanta, 2005; Mishra *et al.,* 2006). However, Istini *et al.* (1994) obtained carrageenan yield between 21.8–35.47% from *K. alvarezii* harvested from the Philippines. Carrageenan yield from *Solieria robusta* available in Okha coast (Gujarat) which is closely related to *Eucheuma* is 22% dry weight (Doshi *et al*., 1990). Based on the data analysed on the commercial exploitation of seaweeds from the natural seaweed beds of Tamil Nadu for the period 1990 to 2003, large scale exploitation of seaweeds for industrial purposes has become necessary to be restricted only during the peak growth period of the algae from July-August and October–January (Kaliaperumal *et al*., 2004) allowing the seaweeds to multiply through spores.

There are nearly 40 agar and algin industries located in the coastal parts of Tamil Nadu and Kerala states and to cope up with the ever increasing demand for raw materials, there exist extensive and indiscriminate exploitation by seaweed collectors resulting in the depletion of natural stock of commercial seaweeds. Hence alternate sources, hither to unconventional species should be tried and their phycocolloid yield should be evaluated. The present investigation has highlighted the occurrence of considerable wet biomass of *G. corticata, G. foliifera, G. pusillum* for agar production, *L. paniculata, H. valentiae, H. musciformis* and *G. lemaneiformis* for carrageenan production and *S. wightii, P. gymnospora* and *P. tetrastromatica* for algin production and their colloid yields from 9 intertidal regions along the Kerala coast.

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