PART-I

REVIEW ON AGAR AND VALUE ADDITION OF INDIAN AGAROPHYTES

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I.1 INTRODUCTION

A Japanese innkeeper discovered agar serendipitously in the mid seventeenth century. He threw away the surplus seaweed soup, which transformed into a gel by the night’s freezing cold. In 1882, Koch was the first to use agar in microbiology. Agar was traditionally used in Europe for preparing jams and jellies. The term ‘agar-agar’ is of Malaysian origin and used to be referred to extracts from *Eucheuma*, which is a source of carrageenan, not agar. By the early 1900s, agar became the gelling agent of choice instead of gelatin. Agar was found more suitable because it remained solid at the temperatures required for growth of human pathogens and was resistant to breakdown by bacterial enzymes.

Agar is a phycocolloid, a water soluble polysaccharide, extracted from a group of red marine algae (Class Rhodophyceae) including *Gelidium, Pterocladia, Gracilaria* and *Gelidiella* spp.. These marine algae are widely distributed throughout the world in temperate and tropical regions. Agar is a polymer of galactose, having molecular weight in the order of $10^5$ daltons, with repeating units of 1,3-linked β-D-galactose and 1,4-linked α-L-3,6-anhydrogalactose (Figure I.1).

Agar production by modern industrial freezing techniques was initiated in 1921 in California, U. S. A. by a Japanese person named Matsuoka. Now the biggest agar factory in the U. S. A. is the American Agar Company in San Diego, California. In Japan, some two-thirds of the agar makers still rely on the natural winter weather to produce strip agar and square agar. The rest have modern equipped factories using the mechanical freeze-thaw process. In China, the agar factories in the North make agar in winter relying on the natural freezing conditions. In other seasons they use diffusion and press techniques to produce agar powder.

In India, the agar factories are situated mainly in the southern region and they use the mechanical freezing process in all seasons because the natural winter freezing process is not possible in India.

I.2 SOURCE

Agar is obtained from various genera and species of the red-purple seaweeds, belonging to the class Rhodophyceae, where it occurs as a structural polysaccharide in the cell walls and probably also performs a function in ion exchange and dialysis processes. Distribution of important agarophytes is shown in Table I.1 [1].
### TABLE I.1 World distribution of agarophytes

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gelidiella aethereum</td>
<td>Japan, India, China</td>
</tr>
<tr>
<td>Gelidium amansii</td>
<td>Japan, China</td>
</tr>
<tr>
<td>Gelidium cartilagineum</td>
<td>U. S. A., Mexico, South Africa</td>
</tr>
<tr>
<td>Gelidium corneum</td>
<td>South Africa, Portugal, Spain, Morocco</td>
</tr>
<tr>
<td>Gelidium litulum</td>
<td>Japan</td>
</tr>
<tr>
<td>Gelidium lingulatum</td>
<td>Chile</td>
</tr>
<tr>
<td>Gelidium pacificum</td>
<td>Japan</td>
</tr>
<tr>
<td>Gelidium pristoides</td>
<td>South Africa</td>
</tr>
<tr>
<td>Gelidium sesquipedale</td>
<td>Portugal, Morocco</td>
</tr>
<tr>
<td>Gracilaria spp.</td>
<td>South Africa, Philippines, Chile, China, Taiwan, India, U. S. A.</td>
</tr>
<tr>
<td>Pterocladia capilacea</td>
<td>Egypt, Japan, New Zealand</td>
</tr>
<tr>
<td>Pterocladia lucida</td>
<td>New Zealand</td>
</tr>
<tr>
<td>Ahnfeltia plicata</td>
<td>U. S. S. R.</td>
</tr>
</tbody>
</table>

### I.3 SEAWEED RESOURCES OF INDIA

India has a long coastline extending to 5700 km and the seaweeds are confined mostly to narrow littoral and sublittoral belts of the marine environment. On the coastline we have about 8.5 million hectares of coastal expanse in the form of sheltered bays and lagoons, which are ideal for mariculture activities. Seaweeds are one of the commercially important living marine resources. These grow abundantly along the Tamil Nadu and Gujarat coasts, and in Lakshadeep, Andaman and Nicobar Island. There are also rich seaweed beds around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Pulicat in Tamil Nadu and Chilka in Orissa. Out of the ca. 700 species of marine algae in different parts of the Indian coast, nearly 7 agarophytes are commercially important and can be utilized as raw material for production of agar for food, manure and pharmaceuticals. Estimated quantities of agarophytes that are occurring naturally in India have been reported: 29 tonnes from Gujarat coast, 1.048 ITom from Tamil Nadu coast and 961-2074 tonnes from Laksadweep Islands \(^2\).
Reports are available in the literature on the distribution, resource assessment utilization and cultivation of seaweeds of the Indian coast [3-9]. The commonly available agarophytes in India are *Gelidiella acerosa*, *Gracilaria dura*, *Gracilaria crassa* and *Gracilaria edulis*.

Standing crop of seaweeds in different maritime states [4] of Indian region is as follows: in Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa and Lakshadweep state is 20509, 20000, 2000, Negligible, 1000, 22044, 7500, 5 and 19345 tones wet wt. of seaweeds respectively. The natural biomasses of *Gelidiella acerosa* during 1979-1983 (100-550 tones dry wt.) and *Gracilaria edulis* during 1981-1991 (117-982 tonnes dry wt.) from Tamil Nadu coast have been reported [10].

1.4 SEAWEED FARMING IN INDIA

In India seaweed farming is in a very formative and experimental stage [10]. The overexploitation of certain natural seaweed resources from specific localities, especially *Gelidiella acerosa* from the Tamil Nadu coast, has resulted in depletion and shortage of raw material. This situation has encouraged development of seaweed resources through cultivation. Additionally, conservation and judicious harvest strategies for sustainable production and utilization of marine algae are now advocated. As a consequence, The CSMCRI initiated programmes on seaweed cultivation have developed technical expertise for the large-scale cultivation of edible, pharmaceutically important green seaweed and economically important brown and red seaweeds [10]. *Gelidiella acerosa* and *Gracilaria dura* have been cultivated in large scale in the sea using artificial substrata as well as other techniques [11]. It has been observed that agars extracted from the cultivated lot have qualities comparable to those obtained from the natural habitat and Sigma (A0576) agarose [12]. Farmed seaweeds are expected to ensure quality and quantity of biomass as well as production of agars having reproducible quality, contrary to the uncertainties associated with naturally occurring seaweeds.

1.5 HARVESTING SEAWEEDS AND ITS EFFECT ON THE STANDING CROP

In India, the collection of seaweeds or agarophytes was made by hand picking during the low water, sometimes necessitating diving in shallow water (one to two meter). The plants were
pulled out from their attachments, some coming completely. Therefore, some guide lines for harvesting of seaweeds should be adopted:

(1) Harvesting should be restricted to seasons of maximum vegetative growth of the seaweed concerned,

(2) The alga should be cut at the base to leave fragments for the regeneration of the plants,

(3) Pulling out of the plants should be avoided, and

(4) Batch harvesting should be adopted.

1.6 VARIABILITY

The agar content of seaweeds varies greatly. The agar content mostly depends on specific seaweed and environmental/seasonal changes (i.e. concentration of carbon dioxide, oxygen tension, temperature of water and intensity of solar radiation). Gelation (i.e. gelling and melting) temperatures and gel strength of the agars by different extraction methods from different seaweeds show variation and some parameters are species specific. Moreover, we have found that variation of process parameters appears to be one of the most important factors in the variability of the products. For example, *Gracilaria dura*, in India and elsewhere in the world, has not been known as a source of good quality agar. We have prepared agarose directly from *Gracilaria dura* and *Gelidiella acerosa* of Indian waters using an improved extraction process \[^{[11,12]}\].

1.7 WORLD MARKET OF AGAR

Major agar producing countries are Japan, Spain, Chile, Mexico, China, and Korea. World production per annum: 110,000 dry tons, a total of USD100-200 million. Agar producing seaweeds are *Ahnfeltia*, *Gelidium*, *Gelidiella*, *Gracilaria*, *Pterocladia* species. Agar is produced mainly from *Gelidium* and *Pterocladia*. *Gelidium* occurs in Indian waters sparsely, with no report of *Pterocladia* occurring. The major applications bacteriological and microbiological (ca.5% of the total sale) and the remaining find use in food industry as standard thickener. The cheapest food grade agar is ca.USD50.00 per kg. The bacteriological variety is the most expensive costing up to USD25,000 per kg. The market of agar has an estimated growth of 5-10% per annum \[^{[13]}\].
1.8 SEAWEED INDUSTRY IN INDIA

The seaweed industry in India is chiefly a cottage industry and is based mainly on the natural stock of agar yielding red seaweeds, such as *Gelidiella acerosa* and *Gracilaria edulis*. Production of total dry agarophytes in 2000 was approximately 880-1100 tons and India produces 110-132 tons of dry agars annually. Furthermore, many agar and algin extracting industries have been established in different places in maritime states of Tamil Nadu, Andhra Pradesh, Kerala, Karnataka and Gujarat [14]. Production of 100-160 tonnes/year agar in India from 800-1300 tonnes of seaweeds *Gelidiella acerosa* and *Gracilaria* species has been reported in an FAO document [1].

1.9 AGAR EXTRACTION

Extraction of agar from seaweeds involves the following steps:

(i) Washing and cleaning of seaweed with water;
(ii) pretreatment of seaweeds with acid or alkali depending on the nature of the agarophyte followed by removal of acid or alkali;
(iii) pressure extraction of the seaweed;
(iv) filtration of the hot extractive;
(v) clarification of the hot extractive;
(vi) gelling of the agar extractive at ambient temperature;
(vii) freeze-thawing of the agar gel for purification;
(viii) isolation of the agar after thawing the frozen gel;
(ix) drying and pulverizing the agar by conventional methods;
(x) optionally spray drying the agar.

There exist many reports on the various extraction conditions of agar from the seaweed. During our work, it was recognized that whichever process is followed the process water requirement in the extraction of agar is usually very high since agar is a gelling material in fairly low concentrations, forming viscous matter during the filtration process thereby substantially slowing down the process causing great difficulties. During the course of the work it was found that extraction of agar requires large volume of process water. Therefore, it is necessary to keep the concentration of agar at an optimized low to ensure easy and quick filtration of the hot extractive. This problem was circumvented using a non-ionic surfactant.
(Brij 35) along with the agar extractive, which lowers the viscosity of agar sol. The surfactant additive was easily removed during the subsequent freeze-thaw cycles. It has been demonstrated that using non-ionic surfactant during agar extraction the quantity of process water can be curtailed by about 50% [15].

Another crucial step in the agar extraction process is pretreatment of seaweed which involves choice of acid, alkali as well as temperature and duration of treatment in the pretreatment steps. It has been realized that an optimized condition keeping all the factors in view can produce superior quality agarose even from seaweed which has not been reported to produce good agar [11, 12]. An eco-friendly method [11, 12], was developed during present dissertation work for producing agarose in 20-22% yield with gel strength 2200 g cm\(^{-2}\) in 1.0% gel at 20°C; gelling point 35±1°C; melting point 98±1°C from Gracilaria dura occurring in the west and south east coast of India (Tables 1.2 & 1.3). This process was also useful for other agarophyte species, because superior quality agarose has also been prepared during this study from the Indian Gelidiella acerosa occurring from the natural and artificial sources of west and south east coast of India in 14-16% yield having gel strength 2400 g cm\(^{-2}\) in 1.5% gel at 20°C; gelling point 41±1°C; melting point 85±1°C (Tables 1.3).

To our knowledge, this is the first example of producing agarose having such high gel strength and low gelling point from Indian Gracilaria species [11]. The highest known gel strength of agar (ca. 1600 g cm\(^{-2}\) in 1.5% gel) that has been reported from Gracilaria spp. in the public domain is from Gracilaria cornea occurring in Mexican waters [16].

**1.10 VALUE ADDITION OF INDIAN AGAROPHYTES**

There are many literature reports on the extraction of agar from Indian agarophytes. These reports describe extraction of agar from Gelidiella acerosa and Gracilaria spp. collected from the natural habitat on the Indian coasts. Review of literature reveals that the quality of agar that was extracted was not very good as these agars have gel strength in the range <100 g/cm\(^2\) to 300 g/cm\(^2\) [12, 17-30], along with a lone report of agar from cultured Gelidiella acerosa giving agar with gel strength 790 g/cm\(^2\), which does not describe the process of extraction [31]. Mairh et al. [32] reported culture studies on Gelidium pusillum from which agar having yield 22% and gel strength 210 g/cm\(^2\) was obtained. It has also been widely reported that alkali pretreatment of the seaweed improves upon the gel strength of agar through desulphation reaction thereby
improving the overall quality of agar. However, even with alkali pretreatment the maximum
gel strength of agar that has been reported from Indian sources is 300 g/cm² [cf. 25, 29].

Therefore, the existing information tells us that Indian agarophytes are not the source
of good quality agar. In CSMCRI work have been under progress to develop process for
extraction of agar from agarophytes growing in Indian waters with a focus on Gelidiella
acerosa and Gracilaria spp. Using an improved procedure involving alkali modification, that
has been developed in our laboratory during my dissertation work, superior quality agar and
agarose from Gelidiella and Gracilaria spp. were prepared (Tables 1.2 & 1.3) [11, 12, 33]. The
agarose of Gracilaria dura prepared in our lab was found to have specifications comparable
to several grades of agarose mentioned in the Sigma-Aldrich and Fluka catalog (Table I.3).
The agarose that has been prepared from Gelidiella acerosa and Gracilaria dura has been
found to be suitable for DNA electrophoresis (unpublished results).

**TABLE 1.2** Agar and agarose from Indian agarophytes

<table>
<thead>
<tr>
<th>Seaweed</th>
<th>Yields*(%)</th>
<th>Products</th>
<th>Gel strength (g/cm²)</th>
<th>T_gel (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gelidiella acerosa</td>
<td>25-30</td>
<td>Native agar</td>
<td>800±50</td>
<td>41±1</td>
</tr>
<tr>
<td>Gelidiella acerosa</td>
<td>16-19</td>
<td>Agarose</td>
<td>2400±50</td>
<td>41±1</td>
</tr>
<tr>
<td>Gracilaria edulis</td>
<td>25</td>
<td>Native agar</td>
<td>≤100</td>
<td>37±1</td>
</tr>
<tr>
<td>Gracilaria edulis</td>
<td>16</td>
<td>Alkali treated agar</td>
<td>450±50</td>
<td>37±1</td>
</tr>
<tr>
<td>Gracilaria crassa</td>
<td>25</td>
<td>Native agar</td>
<td>250±50</td>
<td>36±1</td>
</tr>
<tr>
<td>Gracilaria crassa</td>
<td>15</td>
<td>Alkali treated agar</td>
<td>800±50</td>
<td>36±1</td>
</tr>
<tr>
<td>Gracilaria corticata</td>
<td>20</td>
<td>Native agar</td>
<td>&lt;100</td>
<td>37±1</td>
</tr>
<tr>
<td>Gracilaria corticata</td>
<td>10</td>
<td>Alkali treated agar</td>
<td>&lt;100</td>
<td>37±1</td>
</tr>
<tr>
<td>Gracilaria fergusoni</td>
<td>22</td>
<td>Native agar</td>
<td>&lt;100</td>
<td>38±1</td>
</tr>
<tr>
<td>Gracilaria fergusoni</td>
<td>12</td>
<td>Alkali treated agar</td>
<td>135±50</td>
<td>38±1</td>
</tr>
<tr>
<td>Gracilaria dura</td>
<td>27</td>
<td>Native agar</td>
<td>250±50</td>
<td>34±1</td>
</tr>
<tr>
<td>Gracilaria dura</td>
<td>23</td>
<td>Agarose</td>
<td>2200 d</td>
<td>35±1</td>
</tr>
</tbody>
</table>

*Yield (%) with respect to as received seaweed containing ca. 10% moisture; b in 1.5% gel at 20°C,
unless otherwise stated; c in 1.5% gel; d in 1% gel at 20°C.
TABLE I.3 Comparison of CSMCRI Agarose with commercially available agarose

<table>
<thead>
<tr>
<th>Source</th>
<th>Agarose</th>
<th>Gel strength (g/cm²)</th>
<th>$T_{gel}$ (°C)</th>
<th>Sulphate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gracilaria dura</td>
<td>CSMCRI Agarose</td>
<td>2200</td>
<td>35±1</td>
<td>≤0.25</td>
</tr>
<tr>
<td>Gelidiella acerosa</td>
<td>CSMCRI Agarose</td>
<td>2400</td>
<td>41±1</td>
<td>≤0.28</td>
</tr>
<tr>
<td>Sigma-Aldrich</td>
<td>Product No. A0576</td>
<td>≥1800</td>
<td>36±1.5</td>
<td>≤0.12</td>
</tr>
<tr>
<td>Sigma-Aldrich</td>
<td>Product No. A9918</td>
<td>&gt;1000</td>
<td>36±1.5</td>
<td>&lt;0.25</td>
</tr>
<tr>
<td>Sigma-Aldrich</td>
<td>Product No. A9668</td>
<td>&gt;1100</td>
<td>36±1.5</td>
<td>&lt;0.30</td>
</tr>
<tr>
<td>Fluka</td>
<td>Product No. 05068</td>
<td>≥1500</td>
<td>34-37</td>
<td>≤0.60</td>
</tr>
<tr>
<td>Fluka</td>
<td>Product No. 05070</td>
<td>≥1400</td>
<td>40-43</td>
<td>≤0.50</td>
</tr>
</tbody>
</table>

*a In 1.5% gel at 20°C, unless otherwise stated; *b in 1.5% gel at 20°C; *c in 1% gel at 20°C.

I.11 BACTERIOLOGICAL AGAR

Bacteriological grade agar is used in clinical applications, auxotrophic studies, bacterial and yeast formation studies, bacterial molecular genetics applications as well as in mammalian and plant tissue cultures. Agars are used in final concentrations of 1-2% for solidifying culture media. Smaller quantities of agar (0.05-0.5%) are used in culture media for motility studies (0.5% w/v) and growth of anaerobes (0.1%) and microaerophiles.

We have prepared superior quality agar, named SAgar, from Gelidiella acerosa of Indian waters which were found to be suitable for bacteriological and molecular biology works\(^1\) (Table I.2).

I.12 AGAROSE

Agar is composed of two principal components e.g. agarose and agaropectin. Agarose is the gelling component; agaropectin has only a low gelling ability. There are several methods of producing agarose; mainly by removing the agaropectin from the agar. There are only a small number of processors who produce purified high quality agarose for a small but growing market, mainly in biotechnological applications. These processors use good quality agar as starting material rather than seaweeds, are often not in the seaweed processing business\(^1\).
During this dessertation work superior quality agaroses have been prepared directly from *Gelidiella acerosa* and *Gracilaria dura* of Indian waters employing an improved method of extraction (Table 1.3). This method is eco-friendly and cost-effective \[^{11,12}\]. Agarose has high end applications such as in molecular biology, protein electrophoresis, cell culture works in the R&D labs, pharma and biotech industries world over.

### 1.13 APPLICATIONS

Agar is used predominantly for its stabilizing and gelling characteristics. It has the unique ability of holding large amounts of moisture. It is mainly employed as a stabilizer in pie fillings, piping gels, icings, cookies, cream shells etc. Agar is useful in low-calorie breads or biscuits since they are nonnutritive, because it acts as a bulking agent.

Agar, which is extracted from different seaweeds by simple and unmodified methods, could be used for food applications because they have low gel strength, high gelling temperature, high metal ions concentration and high sulphate contents. Moreover, some *Gracilaria* species of Indian waters produce good quality food grade agar\[^{33}\].

Microbiological and bacteriological agars are the most valuable in microbiology and the ideal agar is low in metabolizable or inhibitory substances, debris, and thermoduric spores; has a gelation temperature of 35-40°C, and melting temperature of 75-100°C. Agar is also used in prosthetic dentistry, forensic medicine, pharmaceutical, electrophoresis, photographic stripping films, cosmetics, lotions, papers, as well as biodegradable thin films for wide variety.

### 1.14 AGAR COMPOSITES

Hydrogels from gelatin (protein), agar and κ-carrageenan (polysaccharides) have good properties, due to their natural origin, low cost, good biocompatibility \[^{34-37}\]. Composites of agarose-maize starch \[^{38}\], agar-gelatin and agar-κ-carrageenan have been studied \[^{37}\]. Hydrogels of these blends will have applications in drug delivery systems.

### 1.15 NEW APPLICATIONS

Recent new applications of agar harness its viscosity enhancing property and hydrophilicity in microfluidic and visible image receiving devices \[^{39,40}\].
1.16 BIOSYNTHESIS OF POLYSACCHARIDES AND AGAR

In brief the biosynthesis of polysaccharides involves first the formation of the appropriate precursors, secondly, the polymerization process and, finally in some cases, modifications of the polysaccharide molecule by substitution or other reactions \[^{[41]}\].

Enzyme preparations isolated from *Porphyra umbilicalis* \[^{[42]}\], and from *Gigartina stellata* \[^{[43]}\], converted L-galactose-6-sulphate and D-galactose-6-sulphate respectively into the corresponding 3, 6-anhydrogalactose. These results have been ascribed to the removal of a "kink" in the polysaccharide chain and permitting thereby more extensive double helix formation to give a more compact and rigid gel framework. This adaptation allows the plant to produce stiffer gels when, for example, it is exposed to more severe wave action. Little is known of the biosynthesis of the macromolecule of these galactans. Radioactive studies with \(^{14}\)C indicated that uridine diphosphate glucose is converted into UDP-galactose and this is utilized in the synthesis of these galactans \[^{[44]}\]. Production of ADP-D-glucose from ATP and \(\alpha\)-D-glucose-1-phosphate using a *Chlorella* ADP-glucose pyrophosphorylase was also reported earlier \[^{[45]}\].

Agar is a galactan polymer consisting of 1,3-\(\beta\)-D-galactopyranosyl 1,4-3,6-anhydro-\(\alpha\)-L-galactopyranosyl repeating units containing substantial amounts of methylated and sulphated units (Figure 1.1).

![Figure 1.1 Agar (Repeating units)](attachment://agar_repeating_units.png)

The substitutions are primarily at O-6 and/or methylation giving 3-linked 6-O-methyl-\(\beta\)-D-galactopyranosyl residues and sulphation giving 4-linked 6-O-sulpho-\(\alpha\)-L-galactopyranosyl residues.
It is generally believed that chains of alternating D- and L-galactopyranosyl residues are assembled on primer molecules in the Golgi apparatus \[^{[46]}\]. Sulphation of L-galactopyranosyl residues is believed to occur in the Golgi at an early stage in the biosynthesis, while ring closure and methylation may occur somewhat later. At some stage in the biosynthesis, migration out of the Golgi into the cell wall matrix takes place and further modification of the agar polysaccharides can occur as the new tissue ages. Floridean starch, a branched glucan similar to amylopectin having some $\alpha-1\rightarrow3$ branchings, and floridoside [$\alpha$-D-galactopyranosyl-(1→2)-glycerol] act as dynamic carbon pool for glucose and galactose, which can be used in the dark for cell processes, one of which may be agar biosynthesis. A tentative pathway for this biosynthesis has been proposed. This involves degradation of floridean starch to its precursor glucose 1-phosphate, via a phosphorylase, with subsequent formation of UDP-D-galactose and GDP-L-galactose, the precursors of the agarobiose repeating unit. Glucose 1-phosphate is also a precursor of floridoside, which is formed via UDP-D-glucose and UDP-D-galactose, while floridean starch is formed via ADP-D-glucose \[^{[47, 48]}\]. These processes have been validated by Hemmingson et al. \[^{[46]}\], by introducing $^{13}$C-enriched NaH$^{13}$CO$_3$ into samples of the red seaweed *Gracilaria chilensis* Bird, McLachlan et Oliveira, and subsequently identifying the metabolites using GC/MS techniques.

I.17 FUTURE PROSPECTS

It is possible to prepare superior quality agar and agarose from agarophytes other than only *Gelidium* spp., a source of superior quality agars, as opposed the prevailing perception. It is also possible to prepare superior quality agarose from the Indian agarophytes e.g. *Gelidiella acerosa*, *Gracilaria* spp. and *Gelidium* spp. It is extremely necessary to have a composite strategy which involves bioprospecting for new agarophyte species, value addition of seaweed sources through extraction process improvements as well as large scale cultivation of seaweeds.

The work that has been done in CSMCRI is expected to bring about a change in the scenario of seaweed based industries in India creating renewed investment and employment opportunities in the country’s coastal districts for the fisher folk who would participate in the large scale cultivation activities of value added seaweeds.
1.18 CONCLUSIONS

Agar is a phycocolloid isolated from several red marine algae. It is a very useful gelling biopolymer of plant origin, which is obtained only from certain red seaweeds, called agarophytes. Agar is a galactan polymer with average molecular weight ca. 10^5 Da. Agar’s application started as a gelling agent in foods. Later on it was extensively used in microbiological applications. Recent new applications harness its gelling property and hydrophilicity in microfluidic devices besides other applications involving agar and agarose composites.

Indian agarophytes have not been known to be sources of very good quality agar. In this account we have endeavoured to capture the developments that have taken place in our laboratory during this dissertation work, in an ongoing programme of value addition of seaweeds, highlighting the fact that Indian agarophytes can be used for preparation of superior quality agar and agarose. This review is due to be published in a monograph published by CSMCRI [49].

1.19 REFERENCES


13. www.botany.uwc.ac.za

14. www.enaca.com


