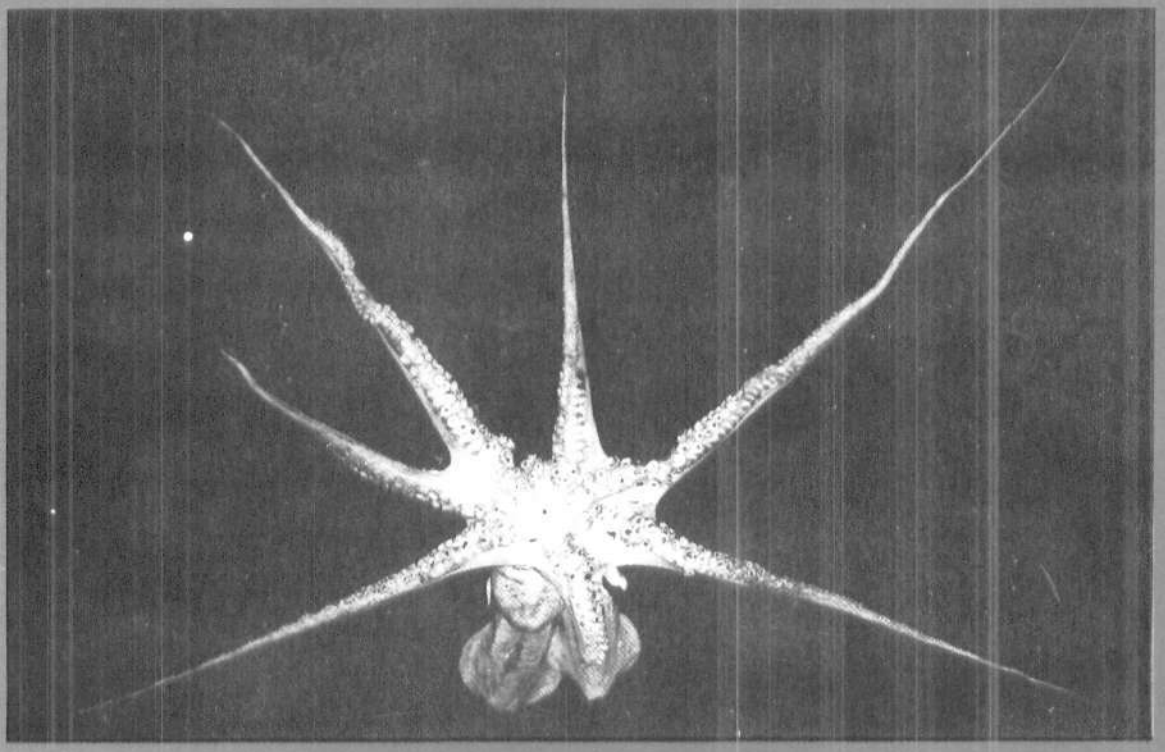
ISSN 0254-380 X

समुद्री मात्स्यिकी सूचना सेवा
MARINE FISHERIES INFORMATION SERVICE

No. 157 OCTOBER, NOVEMBER 1998



तकनीकी एवं विस्तार अंकावली
TECHNICAL AND EXTENSION SERIES

केन्द्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान, कोचिन, भारत
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE COCHIN, INDIA

भारतीय कृषि अनुसंधान परिषद
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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Introduction

Marine macroalge which are popularly termed as **Seaweeds** belong to the primitive group of nonflowering plants known as Thallophyta. They are autotrophic plants and grow in the intertidal and subtidal regions of the sea. They grow abundantly wherever rocky or coral substratum is available for their attachment with the help of rhizoids or holdfast. For centuries, seaweeds of various kinds have been put into use in the south and southeast Asian countries. Seaweeds are the only source for the manufacture of colloids like agar, algin and carrageenan which are used in food, chemical and pharmaceutical industries. Seaweeds are rich in protein, vitamins, minerals and trace elements. They are also used as food, fodder, fertilizer and recently as a source of drugs and therapeutically important substances. In India about 720 species seaweeds are available, of which 60 are commercially important. They occur abundantly along the coasts of Tamil Nadu, Gujarat, Lakshadweep and Andaman-Nicobar Islands.

Developing countries produce nearly 40 % of the world's seaweed supplies for the manufacture of phyco-colloids. Fifty per cent of seaweeds are utilised for agar production, 32 % for carrageenan and 18 % for alginate production. Although, the major share of seaweeds is produced by developing nations, the phycocolloid manufacturing industries remain concentrated in a few developed nations viz., Denmark, France, Japan, Norway, Spain, UK and USA the main reason being the secracy maintained by the industries in the extraction and purification technologies.

In India there exist more than 60 seaweed industries and are involved in the production of agar alginates. Many more such industries are also coming up. There is a growing awareness and enthusiasm among the private sector to develop seaweed industry in our country, although it is centered at present in the production of agar and algin only. The utilization of edible seaweeds is practically nil. Seaweeds like *Gracilaria edulis*, *G. crassa*, *G. foliifera* and *Gelidiella acerosa* are widely exploited for agar manufacture and species of
Sargassum and *Turbinaria* for algin extraction from the east coast of India. However, the edible and other seaweeds consisting about 70 % of the standing crop of seaweeds are under-exploited for want of awareness. This article is prepared with the object of evincing awareness of the manifold utilitarian aspects of seaweeds.

I. Seaweeds as phycocolloids

1. Agar

Agar is the major constituent of the cell-wall of certain red algae (Rhodophyceae), especially the members of families Gelidiaceae, Gelidiellaceae and Gracilariaceae. Agar-agar is the Malay word for a gelling substance extracted from *Eucheuma*, but now known to be carrageenan. The term agar is now generally applied to those algal galactans, which have agarose, the disachharide agarobiose as their repeating unit. Agar (Fig. 1) consists of a chain of 9-β galactopyranose units linked in 1, 4 bonds with a sulphated L. galactose.

Fig. 1. Dry agar strips.

Sources: Raw materials for the production of agar are red algae such as *Gelidiella acerosa* (Fig. 2), *Gracilaria edulis*, *G. verrucosa* and species *Gelidium*, *Pterocladia*, and *Ahenfeltia*.

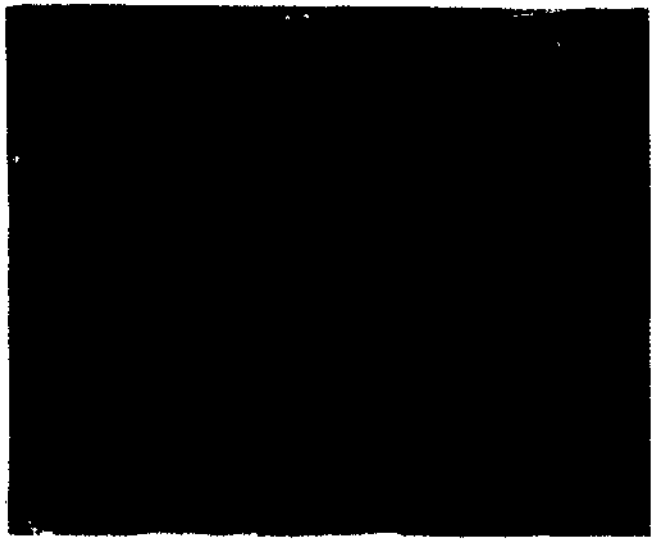

Fig. 2. *Gelidiella acerosa*, highly priced seaweed extensively exploited by the industries for producing agar.

Method of extraction: The dried raw materials are purified from debris, sand and shells and other attached weeds. Then they are soaked in freshwater and dried in sun. The soaking and drying are repeated till the seaweeds are bleached. Boil the seaweed for 3 to 4 hours with occasional stirring. The boiled slurry is filtered by means of filter press. The filtrate becomes gel at room temperature. Repeated freezing and thawing of the flocculated gel purify the gel further. This gel is air dried or sun dried to get agar strips (Fig. 3). Agar strips can be powdered and marketed. To increase the yield and gel strength of agar, it is preferable to apply an alkaline treatment with sodium hydroxide for nearly one hour at the rate of 2 to 3 % alkali solution of 20,000 l/tonne at 90°C. This pretreatment before boiling eliminates sulphuric esters and converts a-L-galactopyranose units into 3, 6-anhydro-a-L-galactopyranose thereby increasing the gel strength.

Fig. 3. Freez-thawed agar gel kept for drying.

Uses: In food technology agar is used for gelling and thickening in the confectionary and bakery industries, as stabilizer for the preparation of cheese and for salad dressings. In fish and meat processing industry, agar is applied for canned products, as a protective coating against the effect of metal containers and against shaking during transport of these products.

Agar is also used as a clarifying agent for wines, beers and liquors. In pharmaceutical industry, agar is used as a laxative for chronic constipation, as drug vehicle and as a substratum for bacterial and fungal cultures. Agar is an ion exchanger and is used in the manufacture of ion exchange resins. In cosmetic industry agar serves as a constituent of skin creams and ointments. Agar is also employed in paper and textile industries as finishing and sizing agents.

2. Alginic acid

Algin or alginic acid is a membrane mucilage and a major constituent of all alginates (Fig. 4).

Fig. 4. Sodium alginate powder.

The various salts of alginic acid are termed 'alginates' (for example sodium alginate, calcium alginate etc). The term algin is used as a collective name for alginic acid and alginates but also as a trade name for sodium alginate. Alginic acid and its salts with divalent and trivalent metal ions are generally insoluble in water, while alkalimetal salts are water soluble.

Sources: Alginic acid is obtained from brown seaweed species such *as Ecklonia, Macrocystis, Undaria, Laminaria* and *Durvillea* from temperate areas and *Turbinaria, Sargassum* (Fig. 5), *Cystoseira* and Harmophysa from the tropical areas.

Fig. 5. *Sargassum wightii*, an algin yielding brown seaweed.

Extraction: The alginate or sodium alginate can be isolated from the brown seaweed materials by extraction with dilute sodium carbonate solution which converts the alginate into the soluble sodium from. The polysaccharide is then recovered by precipitation with acid.

In the laboratory, 10 g dry seaweed cut into small pieces are dipped in warm distilled water (60°C, 300 ml). After 2 hours the seaweed is removed from hot water by decanting. After homogenizing the seaweed, 200 ml of sodium carbonate solution (1.5 % w/v) is added and the mixture is heated under stirring for one two hours. 500 ml of water is added and mixed thoroughly. The hot solution is separated from the solid matter by filtration through a layer of celite-545 and then acidified with 10 % HCl (at pH 1.0) to give a gelatinous precipitate. To the gel is added, 200 ml of 50% methanol and the mixture is exactly neutralised with 10 % NaOH solution under sterring. After standing overnight the mixture is filtered through a layer of cotton cloth to separate the neutral gel. This gel is washed successively with 60 % and then 95 % alcohol or acetone and is dried at 40°C for 12 hours. Carbonate salts of calcium or sodium are added at the desired level as to get desired pH of Calcium alginate or sodium alginate.

In industries, to one part of kelp (fresh or dried materials) three parts of 0.8-1% $CaCl_2$ solution is added either hot or cold, to remove laminaran, mannitol and other salts, washed with soft water. To remove residual alkaline earth salts, 5 % HCl is also added and then washed with excess soft water and is then digested with 4 % sodium carbonate solution in the proportion of two volumes of solution to one volume of kelp. Lixiviation is continued for about 3 hr at 40 - 50 C and the kelp is macerated at the same time until it is reduced to a paste.

The resulting paste is diluted with water in the ratio 3:7 and after being beaten into a homogenous suspension it is vigourously aerated. The liquid is then passed continuously at high speed through a centrifuge, where it is charged with air bubbles and then led to a clarifying tank. After 6-10 hr in this tank, the cellulose particles agglomerate to form a floating cake and the liquor is drained. The coloured liquor is decolourised by the addition of an adsorbant jelly made of hydrated alumina, gelatinous silica and aluminium alginate at a proportion of 20-25 parts of jelly to 100 parts of alginous material. The jelly is removed by centrifugation. The alginate is now precipitated by running the clear liquor into a mixing baffle where the liquor meets a strong stream of HCL arranged in such a way that the precipitate passes into another tank. The pH of the solution is maintained at 1.5-2.0 throughout. The precipitated alginic acid is placed in baskets and drained (Fig. 6) after which it is purified by alcohol and dried.

Uses: In pharmaceutical industry alginic acid is used as emulsifiers in watery emulsions with fats, oils and waxes, as fillers in the manufacture of tablets, pills and as base of any ointments, alginate is extensively used. An alginate guaze is used as a blood stoping plaster. As a slimming agent, the alginate forms a jelly in the sto-

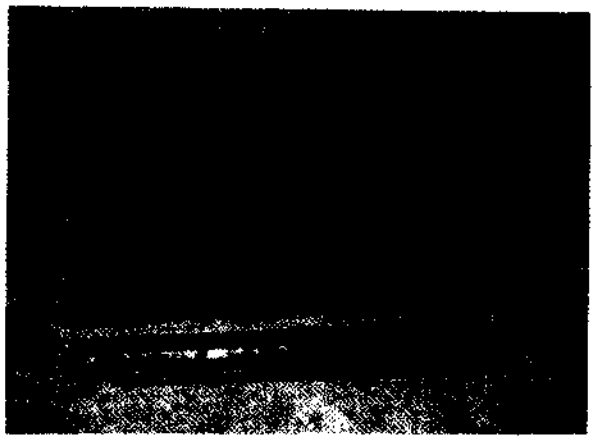

Fig. 6. Alginic acid seperated from the alkaly digested seaweed by centrifugation.

mach which produces the feeling of saturation in stomach. Ammonium alginate wool is used as a filter for microorganisms for laminar flowhood.

In cosmetic, detergent and soap making industries alginates serve as thickening and dispersing agents in the production of ointments, creams, liquid emulsions, lotions and toothpaste as weel as an additive in hair dye, hair fixing tonics, shampoos etc. due to the ability of alginates to form films. Alginates increase the consistency of shaving creams. In dental technology, alginates are used for making denture mouldings as well as denture fixatives.

In food technology, alginates improve the baking properties and they are constituent of baking emulsions. Alginates are used to make sugar glazings, egg, fruit and other cream fillings and in confectionary for making imitation fruits. Jelly products are made with water insoluble alginates (calcium alginates). In a number of countries alginates are suggested as a gelating agent in marmalades and jams. In dairy products such as cheese, creams, milk shake mixed in chocolates, puddings, cold prepared pudding powder, soft cheese and custards alginates are extensively used. Alginates act as stabilizers in milk mixes and impart uniform viscosity and good whipping ability.

In beverages alginates act as clarifying agents for making wines and raw liquor of sugar and molasses. Alginates act as foam stabilizers in lager beer and malt beer. In meat and sausage industry, meat and sausage products are given a longer shelf life with an alginate film. Artificial casings with as alginate base have been developed for making small sausages particularly for vegetarians. For deep-freezing of fish, meat and poultry products an alginate gel is used and this has been patented in many Western countries.

Alginate filaments are used in the production of calcium alginate rayons. In ceramic and leather industries, addition of alginates stabilizes the pigment and glazing suspensions to ceramic, porcelain and Chinaware as well as leather goods. Alginates find extensive application in textile industry particularly as a thickening agent for printing dyes and paints that prevents smudging and promotes quick drying and evenness of prints.

3. Carrageenan

Carrageenan is a sulphated galactan polymer obtained from various red seaweeds belonging to families such as Gigartinaceae, Solieriaceae and Hypneaceae. The term carrageenan comes from the name of the small coastal town Carragheen in Ireland, where commercial harvests of *Chondrus crispus* were made in the late 19th century.

Carrageenan (Fig. 7) differs from agar chiefly in its higher sulphated fraction and a higher ash

Fig. 7. Carrageenan powder.

content. The back bone of the carrageenan polymer consists of 1, 3- and 1, 4-linked D-galactopyranose units which vary in the degree and the location of sulphated esterification. Car-

rageenan can be separated into two fractions - k-carrageenan and λ-carrageenan whose polymer chain is branched in the former and linear in the latter. k-Fraction is separated from λ-fraction by precipitation with potassium choloride and amounts to 40 % of the carrageenan, the balance being the λ-fraction. The fraction soluble in hot water stands for k-carrageenan and the cold water soluble fraction to be λ-carrageenan.

Sources: *Chondrus crispus, Gigartina stellata, Iridaea* spp., *Eucheuma alwarezii, Kappaphycus* spp. and *Hypnea* spp. Fig. 8) are the chief raw materials for extraction of carrageenan.

Fig. 8. *Hypnea valentiae*, carrageenan yielding red seaweed.

Extraction: Ten g of seaweed is crushed and cooked for 4 hours at 90°C with 750 ml of water and 2g of CaO with occasional stirring. The hot extract is centrifuged for 5 min at 8000 rpm. The pellet is washed with warm water and centrifuged again. Save the supernatents each time and pooled together. The pH of the extract is adjusted between 8 and 8.5 with mild alkali solution. The alkaline supernatent is then added with 2 volumes of ethanol or isopropyl alcohol. The coagulam is collected either by filtration or by centrifugation at 5000 rpm for 5-8 min and dried at 50-60°C. The dry coagula are milled to obtain fine powder of carrageenan.

Uses: In food industry, carrageenan finds its use in bakery, confectionery and for culinery purposes especially in the preparation of condiment products, syrups, whipped creames, ice desserts, cheese etc. Carrageenan is used for clarification of beer, fruit juices and other beverages. Carrageenan improves the quality of wheat flour in *spaghetti* and *parotta* making. The food sector accounts for nearly 70 % of world market for carrageenan.

In pharmaceutical industry, carrageenan is used as emulsifiers in cod liver oil and emulsions as granulation and binding agents in tablets, elixirs, cough syrups etc. It is used extensively in ulcer therapy and for diseases of blood vessels. In cosmetics, carrageenan is applied as stabilizer and thickening agents in tooth-paste, skin ointments and solid air freshners. In textile industry, hot water extracts of carrageenan is used in printing designes with dye and act as finishing and sizing agents. Carrageenan, also called "Painters' Moss" has been used for some time in paint manufacturing as stabilizers for pigments. They are also good film-forming agents.

II. Seaweed as food

Seaweeds are not actually a sought after vegetable to most westerners. However, the orientals have been eating a veriety of seaweeds for thousands of years. It is known that about 100,000 tonnes of seaweeds are eaten annually in Japan in the name *Nori, Kombu (konbu)* and *Wakame.* Seaweeds are rich in proteins, vitamins, aminoacids, growth hormones, minerals and other trace elements. Hypothyroidism (goitre) can be cured and controlled by intake of iodine rich seaweeds like *Asparagopsis taxiformis, Sarconema* spp. etc.

1. Nori

Nori is the name of various edible products derived from *Porphyra* after processing. Nori (Fig. 9) is prepared by harvesting porphyra, pounded,

Fig. 9. Shredded *nori* strips ready for sale.

washed with water, drained, chopped and finally mixed with freshwater before being spread on bamboo mats for drying. When dried thin sheets of nori are obtained. These are pressed flat, stored and bundled and packed for marketing. Nori is used as a flavouring agent in soups, sauces and broths or even soaked in soyabean sauce and eaten with boild rice. Nori is also used in well known dishes- *tempura* and *sushi*.

2. Kombu

Kombu is prepared from *Laminaria*. After harvesting and drying the laminaria is separated from the stipe and hold fast are sorted for quality and sent to kombu factories. Kombu processing involves boiling the kelp in a green aniline dye solution, air drying, compressing in frames and then cutting into blocks which are shredded. Kombu is used as soupstock, boiled vegetable, snack or seasoning for rice dishes (as curry leaves are used in India).

3. Wakame

Wakame has become more popular in recent times. It is made from large brown seaweed *Undaria pinnatifida*. Undaria is processed as wakame by washing, desalting and drying. Desalting is achieved by boiling with water. Wakame is popularly known in the forms of roasted, or sugar candied products.

4. Salad

Following seaweeds are used for making salads either singly or in combination of two or three seaweeds. *Caulerpa racemosa*, *Caulerpa sertularioides*, *Codium* spp, *Gracilaria confervoides*, *Gracilaria eucheumoides*, *Hydroclathrus clathratus*, *Laurencia papillosa* and *Porphyra* spp.

Fresh seaweeds are cleaned of sand, debris, attached stones etc. and then washed in fresh water. Chopped tomatos, carrot, onion, chilly and ginger are added and mixed. Salt is added to the taset (Fig. 10).

Fig. 10. Salad prepared from *Ulva lactuca* and *Caulerpa peltata*

5. Seaweed masala

Materials	Quantity
Fresh seaweed, *Ulva lactuca* (washed and clean)	200g
Onion (big)	2 nos
Tomato	2 nos
Oil	2 teaspoon
Chilly Powder	1/2 teaspoon
Coriander powder	1/2 teaspoon
Turmeric powder	1/2 teaspoon
Salt, curry leaves, mustard and ginger	as desired

Cut onion and green seaweed into pices and garnish them in low fire with oil, mustard and curry leaves. When about to turn grey add the powders, salt, ginger and tomato pices and mix well. Serve hot. Good for rice and chappatis.

6. Seaweed pickle

Materials	Quantity
Fresh seaweed, (*Gracilaria edulis*)	500 g
Vinegar	500 ml
Chilly powder	2 teaspoons
Peeled garlic	10 nos
Mustard	1 teaspoon
Gingelly oil	100 ml
Fenugreek, asafoetida and salt	to the taste

Take cleaned fresh seaweed and remove moisture with cloth. Cut into small pieces. Soak in vinegar for 2 days. Remove from vinegar. Add gingelly oil, chilli powder, mustard and fenugreek powder. Season with asafoetida. Add peeled garlic. Mix thoroughly and bottle.

7. Seaweed wafer

Materials	Quantity
Dry seaweed meal *(Gracilaria edulis)*	150 g
Raw rice powder	100 g
Green chillies	6-8 nos
Gingelly seed	1 teaspoon
Cumin seed	1 teaspoon
Asafoetida and salt	to the taste

Boil cleaned dried seaweed in 2 litres of water. Filter through organdie cloth. Add raw rice paste, chilly paste and asafoetida powder. Add gingelly seed and cumin seed, and mix well. Cook together. Dry the paste in small lumps on cloth. Store in air tight jar before serving fried in oil.

8. Seweed porridge

Materials	Quantity
Dry seaweed meal *(Gracilaria edulis)*	100 g
Milk or coconut milk	3 Cups
Sugar	500 g
Cashew nut	50 g
Raisins	25 g
Cardamom	10 g
Edible grade colour	as desired

Boil dried cleaned seaweed in 1 litre of water for 20 minutes. Grind it into a fine paste. Boil the paste in 1 litre of water. Add sugar and milk. Mix thoroughly. Add cashew nut raisins and cardamom. Serve hot.

9. Seaweed jelly

Materials	Quantity
Dry seaweed meal *(Gracilaria edulis)*	200 g
Sugar	500 g
Lemon	5 nos
Edible essence and colour	as desired

Boil cleaned dried seaweed in 3 litres of water for 45 minutes. Stirr frequently. Filter through organdie cloth into a vessel. Add sugar, lime juice, essence and colour to taste in hot condition. Mix thoroughly. Pour in an enamel or stainless steel tray. Allow to set. Refrigerate for minimum 30 minutes. Cut into pieces and serve.

10. Seaweed jam

Materials	Quantity
Dry seaweed powder *(Ulva lactuca)*	100 g
Sugar	500 g
Edible colour and essence	as desired

Prepare sugar syrup. Add seaweed powder and boil for 15 minutes with stirring. Add edible colour and essence. Ready to serve

III. Seaweed as drugs and chemicals

More than 600 secondary metabolites belonging to the categories of terpenes, alkaloids, fatty acids and nitrogenous compounds have been isolated from marine algae. Many of these compounds are therapeutically active and have been extensively studied using laboratory and pharmacological assays. Species of *Sargassum* were used for cooling and blood cleansing effect. They contain sargalin, a blood sugar reducing agent. *Hypnea musciformis* is employed as vermifuge and *Centroceros clavulatum* as cathartic agent. Seaweeds rich in iodine such as *Asparagopsis taxiformis* and *Sarconema furcellatum* can be used to check goitre.

1. Mannitol

Mannitol is an important sugar alcohol of the hexite series found in brown algae. Mannitol (Fig. 11) is a constituent of cell sap. Mannitol occurs also as mannitan.

Fig. 11. Mannitol powder.

Sources: The chief raw materials for the extraction of mannitol are *Fucus vesiculosus, Laminaria hyperborea, Eklonia radiata, Bifurcaria brassiformis, Sargassum* spp. and *Turbinaria* spp.

Extraction: The dried brown seaweed materials are pretreated with dilute HCl (10-15 %). The aqueous acid extract after neutralization is evaporated to dryness. From this mixture of salts, mannitol and soluble polysaccharides the mannitol is extracted with boiling methanol for 5 hours in the Haanen and Badum extractor. The solution containing the extracted material is allowed to stand for 24 hours at 5°C and the precipitate–the crystalline mannitol is filtered and dried before weighing.

Sargassum johnstonii	-	Antimicrobial - inhibits the growth of *Pseudomonas, Proteus vulgaris*
Hypnea musciformis	-	Bactreiostatic and immunonodulator
Amphiroa fragilissima	-	Spasmogenic and hypotensive.
Lithothamnium californicum	-	GABA mimetic oligopeptides (Gama amino butyric acid), a neurotransmitter helps to settle bivalve larvae and induces morphogenetic changes in abalones
Hypnea musciformis Halmenia venusta and *Enteromorpha intestinalis*	-	Rich in saturated fatty acids mainly plamitic acid
Acanthophora spicifera	-	Antifertility activity
Ulva fasciata	-	Contains many sterols and an antiviral agent - UF 131. The structure of UF 131 is established as 2-N-palmitoyl, 4,5-dihydro 1,3,4,5- tetrahydroxy sphinogosine and exhibits antiviral activity against the Semliki Forest virus as well as the eusephlo mycocardiatis virus
Cladophoropsis zoolingeri and *Grateloupia lithophila.*	-	Strong haemolyic activity in rabbit blood.
Laurencia venusta	-	Antiviral property against *Herpes simplex* virus type-1 and vesicular stomatitis virus (VSV)
Caulerpa racemosa	-	Cytokinin a plant growth hormone
Schizymenia sp.	-	Antiviral substances effective against *Herpes simplex* virus and interfers with fusion between cells infected with HIV
Acanthophora spicifera and *Hypnea valentiae*	-	Heparin, a drug used in cardio–vascular surgery

Uses: In pharmacy, mannitol is applied for the production of tablets. Mannitol is also usd for making diabetic food, chewing gum etc. Mannitol is employed as dusting powder in the paint and varnish industry, leather and paper industry, pyrotechniques and in making explosives. In organic synthesis and in plastic production maniitol is used as plasticizers for the production of resins.

The names of a few more seaweeds and their bioactive properties are listed below.

It is evident that seaweeds from marine environment will from the basis of new products and services important to technology and utilization in the years to come.

IV. Seaweed as manure

The earliest record of utilization of seaweeds as manure was that of palladius in 4th century AD as described by Chapman (Chapman, V.J., 1980. In; *Seaweeds and their uses*, 62-97). It has been found that seaweeds contain many growth promoting harmones such as auxins, cytokinins etc apart from macro and micro–nutrients. Hence seweeds can be used as eco-friendly manures either as compost or the extract as liquid seaweed ferilizer (LSF).

1. Seaweed compost

Basal application of seaweeds as a green manure to coconut and other plantation crops along the Lakshadweep islands and coastal areas of Taml Nadu and Kerala is still in practice. This treatment improves the water holding capacity of soil, besides supply of micro and macro nutrients upon decomposition. A method for composting seaweeds with cow dung has been described by Thivy (Thivy, F. 1960, *Proc. Symp. Algology, ICAR*, 345-365). Field experiments have been conducted in the CMFRI applyin g seaweed compost to bhendi, sweet potato, tapioca and brinjal plants and high yields were obtained from these vegetable crops *(Bull. Cent. Mar. Fish. Res. Inst., 41).*

2. Liquid seaweed fertilizer

Now-a-days seaweed extract is made into mineral rich liquid seaweed fertilizer (known as

L.S.F.) and marketed under various trade names. Studies have proved that extracts of *Sargassum wightii, Ulva lactuca* and *Spatoglossum asperum* at 1 % strength show favourable response on the germination, seedling vigour, fruit setting and on the weight of fruit in crops like groundnut, maize, gingelly, tomato and ber. Liquid seaweed extract was first patented in the year 1912. Another patent was offered in 1962 and exploited by Maxicrop Ltd. and marketed as 'Maxicrop' and 'Bio-extract'. When foliar feeding became an orthodox method of plant nutrition in the 1950s 'Marinure', 'SM-3' and 'Trident' brands were made in the UK in the 1966s and 'Algifert' in Norway. In India SPIC is manufacturing and marketing LSF in the name of 'cytozyme' (Fig. 12).

Fig. 12. Cytozyme – a liquid seaweed extract marketed by SPIC Ltd.

Preparation of LSF

Following are the steps adopted in the preparation of liquid seaweed fertilizer.

Thoroughly wash the seaweed to remove sand, debris and other weeds. Dry seaweed. Pulverize the seaweed in a grinder. Soak the seaweed powder in water. Cook the seaweed for 2 hours with water in the ratio of 1:10. Filter and centrifuge the extract. The viscous filtrate is used as LSF. The filtrate is dried at 65-70°C to get dry solid. The dry solid extract is powdered and packed in air-tight bottles.

This powder can be used as LSF by making 0.5 % to 1.5 % (w/v) solution with water. This is used as a foliar spray on green canopy of leafy vegetables and other horticultural crops. Chemical Composition of LSF from *Sargassum* (Raina Rao, K., 1992, *Seaweed Res. & Utiln.*, **14**: 99-101) is given below.

Composition	%
Nitrogen	0.73
Phosphorous	2.00
Potash	3.00
Sulphate	6.10
Chloride	6.70
Silicate	0.20
Sodium	16.00
Lime	0.44
Iron	0.34
Aluminium	0.23
Copper	40.00 ppm
Cobalt	04.00 ppm
Iodide	0.90
Soda	18.90
Bromide	0.80
Magnesium	0.58
Zinc	100.00 ppm
Molybdenum	10.00 ppm
Manganese	40.00 ppm
Boron	01.00 ppm

V. Seweed as feed for farm animals

During the extraction of agar, the boiled extract is filtered to separate agar from the plant material. Indian seweed industries can extract only 50-60 % of the colloid content (10-20 %) from the raw materials. Hence the residue is known to contain considerable quantity of colloids, other carbohydrate, protein, vitamins and minerals. The residue remaining in the filter is normally discarded. This residue can be utilised as a feed for dairy, piggery and poultry or can be used as binder-cum carbohydrate substitute in the feed preparation for farm animals. As seaweeds contain may minerals and trace elements, meals prepared from seaweeds can be utilised as supplements to the daily rations of cattle, poultry, fish and other farm animals.

Seaweed meal prepared from *Gracilaria, Gelidella* and *Hypnea* is added to the feed ingredients while making compounded feed for fish and prawns as excellent binders. The commercial binders are gelatin and tapioca powders. Use of seaweed meal as a binder in fish and prawn feeds can increase the physicochemical standard of the feeds comparing to those feeds manufactured with conventional binders. Feeds made of seaweeds as binders help maintain water quality as the conventional binders get fermented easliy. Because of the flavour of seaweeds, these feeds have more platability and also they are enriched with minerals, aminoacids and carbohydrates. ❐