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NINE

POST HARVEST TECHNOLOGY

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In India, the seaweeds are harvested by handpicking. In the United States rapid industrialisation has been brought in during 1917-1918 in harvesting the *Macrocystis* beds by mechanical harvestors (Dawson, 1966). Mathieson (1969) described the harvest of *Macrocystis* using motor-driven barges with mowers. The mechanical harvestors cut the kelp canopy just under one metre below the water surface and transport the material to the barge. This way, several hundred tons of seaweed can be cut in a day. After being harvested, the material is washed and chopped, and the algin extracted. Irish moss *(Chondrus)* is gathered by raking from a small boat or from the shore. Long handled rakes (3 to 5m long) are used to scrape it from the rocks where it grows A good raker will remove only the large blades and leave the others to be harvested at a later date. More than one crop can be harvested per season if a bed is properly raked. Large mechanical dryers have been used for drying the wet weed (Mathieson, 1969).

Gelidiella acerosa and *Gracilaria edulis* are the red algae used in India for commercial agar extraction. These plants are handpicked, dumped in boats, brought to the shore and dried on the beach sand. The impurities are

cleared before weighing and packing the seaweed. Species of *Sargassum* and *Turbinaria*, which are used for algin extraction, are either dried on the beach sand or treated with formalin in wet condition and then dried on the beach sand. The percentage of moisture and purity decide the cost of seaweed at the time of sale. Cleared dry seaweeds are weighed, packed in gunny bags and despatched to industries. The process of manufacture of agar-agar and algin are detailed below.

Agar-Agar

The extraction of agar-agar in the case of species of *Gracilaria* is done by soaking the dried seaweeds, grinding into pulp, leaching in soft water and introducing as dried pulp into boiling water for extraction. The supernatant clear sol is romoved after it gels. Drying of the gel is done on plastic netting. The resulting agar, which analysis compares favourably with any imported product, is 45% to 50% in weight of the clean dry seaweed. The residue (which is high in mineral and trace element contents) obtained after the removal of agar. when dried and pulverised, is a useful supplementary stock feed. The water used in leaching the seaweed pulp is a rich source of trace elements potassium, calcium, magnesium, sulphur etc. and organic compounds and could be used in fish ponds, gardens, orchards or for yeast culture.

In the method of Bose *et. al.* (1943) for preparation of *Gracilaria* agar, the whole seaweed is leached for 18 hours and then extracted. The sol is allowed to gel, and the gel is heated to 60°C and maintained at it for sometime, this last step resulting in sedimentation of the suspended impurities. The starch is removed by treating the gel with 0.2% acetic acid for one hour; this is followed by washing the gel with water. Karunakar *et. al.* (1948) employed bacterial growth for breaking down and absorbing algal metabolites. They suspended the chopped up gel in soft water containing inoculum, keeping the culture for two 24-hour periods, with one change of water. Chakraborty (1945) applied the Japanese freezing method to *Gracilaria verrucosa* of Chilka Lake. With same species from Chilka Lake, Mahonty (1956) found autoclaving at 230°F necessary, as a previous step to freezing for removal of suspended impurities. A cottage industry method for *Gracilaria edulis* agar in which freezing is not obligatory was worked out by Thivy (1958). The method is based on the finding of Pillai (1955 b) that a third of the carbohydrate, 60 to 90% of the inorganic compounds and some of the organic nitrogen are withdrawn from the seaweed when it is finely ground in distilled water. Early workers had found that most of the ash of seaweeds is water soluble. The speed of the dissolving out of ions depends on nature of the epidermal layer and this is in turn on the depth at which the algae are growing (Vinogradov, 1953). Thus, by comminuting the seaweed, the barrier formed by the epidermal layer is broken up and the water soluble compound is more complete in this method than in the other methods studied in India with reference to *Gracilaria*. The advantage of this method is that the comminuted seaweed is purified whereas in the other methods the gel also has to undergo purification, and it is easier to manipulate the seaweed pulp than the sol or gel for removal of impurities. Furthermore, the yield in the cottage industry method is higher because extraction from the seaweed pulp is efficient.

Freezing Method

In the case of *Gelidiella acerosa*, the weed which was soaked in acidulated water for 24 hours is introduced into soft water at 100°C, the proportion being one part by weight of dry weed to forty of water preferably rain water or distilled water. The pH at the beginning of the extraction is adjusted to 6.0 after introducing the seaweed, but slightly acidic conditions will enhance extraction of the product. Extraction is carried out for one hour at this temperature, then the liquid is allowed to simmer for another hour. Finally, the enamel vessel in which the extraction is carried out together with the liquid is

left in a warm chamber to cool gradually, permitting sedimentation of the suspended particles. When cold, the gel is removed, melted in a water bath and poured into enamel trays to gel again. After three hours the gel is cut into strips and these are placed in wooden trays and frozen at temperatures between 0° and -5°C. They are frozen for 24 hours and then allowed to thaw at room temperature. As soon as the thaw water has drained off, the strips of gel are placed on plastic screen placed on galvanised wirenetting and dehydration is completed either in the sun or in hot air at 65°C. This agar is of superior quality and is 40% of the dry seaweed.

In Japan and United States the freezing is done by simple exposure and no costly equipment is involved. For eliminating this cost, the filtrate is treated with 90% industrial alcohol, so that agar is flocculated.

Method of Extraction for Commercial Grades of Sodium Alginate

Stanford (1883) discovered the presence of alginic acid in the cell walls of brown algae. Several methods were then devised for the extraction of alginate. Two industrial processes are those of Kelco Co. and Algin Corporation.

Stanford's method consists of macerating the algae with ten times the weight of sodium carbonate, and acidifying the extract to obtain alginic acid. It is mixed with either sodium or calcium salts to make sodium or calcium alginate. In the Kelco Co. and Algin Corporation processes, they are first treated with acid or calcium chloride to reduce the salt content. Sodium alginate in crude form extracted by digestion with sodium carbonate is treated with calcium chloride solution to form calcium alginate and then acidified before converting to sodium alginate.

Viscosity of the alginate solution is a very important property for its use in textile and pharmaceutical industries. Viscosities as high as 4000-5000 centipoise are required by the industry, whereas the sodium alginate obtained from the above methods have very low viscosity. Therefore, it is desirable to modify the process so that different grades of alginate can be prepared (Desai, 1967). The details of the process are as follows.

The dry algae are thoroughly cleaned in running water and washed for 2 hours in hot water at 52°C, the water drained out and immersed in 0 3 to 0.5 N sulphuric acid in the ratio 1:3 and kept at 42°C. The acid is washed out and the pH is brought to neutral. The algae are then digested in 4% solution of sodium carbonate overnight. The solution is centrifuged and filtered through a filter press to obtain a clear fluid of crude sodium alginate. It is then bleached with sodium hypochlorite and with sodium bisulphite. The resultant solution is mixed with half the volume of 90% industrial alcohol. The used alcohol could be redistilled for further use. Sodium alginate is collected and dried at 70° in oven.

This method has been found to give most suitable quality of sodium alginate. Different grades of viscosities can be easily produced by varying the time and temperature of acid wash. If both the temperature and time increased, the viscosity is lowered and if the temperature is reduced with a slight increase in time, higher viscosity is obtained.

Some studies on alginic acid were also made in India. Valson (1955) determined the alginic acid content of several species of brown algae occurring in the Gulf of Mannar. Varier and Pillai (1952) studied the extraction of alginic acid and determined the optimum condition. Pillai (1957) employed acidified potassium permanganate as the bleaching agent in his process. Kappanna *et. al.* (1962) have determined the alginic acid content in several species of brown algae occurring on the Saurashtra

coast. Visweswara Rao and Mody (1964) gave a slightly more simplified process than the one described earlier. Shah *et. al.* (1967) reviewed the work done on alginates till 1965.

The cultivation of seaweeds for industrial purposes may be practised anywhere, but the greater demand for edible seaweeds will probably continue in Asia, at least in the future. The red alga known as dulse (*Rhodymenia palmata*) is widely eaten in Canada and Europe. Certain large kelps are made into pickles in Alaska. Other uses of seaweeds and their products are narrated by Chennubhotla (1977) and Chennubhotla *et. al.* (1981).

The laver (nori) harvested in Japan is first washed in seawater and then chopped up finely and again washed in fresh water. The chopped laver is spread out by hand or machine within a frame or on a mat of bamboo splints with a measure of 600 sq cm. By this procedure the chopped lavers only remain on the mat as a sheet. The water is removed by passing through the mat. Chopped lavers of 4 kg produce 100 or more sheets. The mats with the wet laver sheets are dried in the sun. During cloudy days the sheets are dried in a drying room maintained at a temperature of 35°C. Here the sheets dry in about 3 h. The dried sheet of laver is generally 20 X 19 cm in size and weighs 2.5 g. The sheets are used for domestic consumption (Sreenivasa Rao, 1967).

I. S. I. Specification for Agar-Agar and Algin

Agar-agar : The agar should be white or pale yellow in colour. It should be either odourless or having a slight characteristic odour, and a muscilaginous taste. It should be insoluble in boiling water. The other requirements are as given in the following table.

S. No.	Characteristics	Requirements
1.	Moisture, percent by weight, on drying at 105°C for five hours maximum	20
2.	Total ash, percent by weight, maximum	6.5
3.	Acid insoluble ash, percent by weight maximum	1.0
4.	Insoluble matter, percent by weight maximum	1
5.	Arsenic (as As), mg/kg, maximum	3
6.	Lead (as Pb), mg/kg, maximum	10
	Water absorption Gelatin Starch and dextrines	As given in Indian Standard specification for agar; food grade, 1970

Alginic Acid: It occurs as a white to yellowish-white fibrous powder. It should be odourless and tasteless. It should be insoluble in water, readily soluble in alkaline solution and insoluble in organic solvents. The material should conform to the I. S. I. requirements given below.

(Indian Standard Specification for alginic acid, food grade, 1976)

S. No.	Characteristics	Requirement
1.	Purity $(C_6 H_8 O_6)n$ percent by mass, minimum	91
2.	Moisture, percent by mass, on drying at 105°C for 4 hr, maximum	15
3.	Insoluble matter, percent by mass, maximum	0.2
4.	Ash percent by mass, maximum	4
5.	Lead (as pb) mg/kg, maximum	10
6.	Arsenic (as As), mg/kg, maximum	3

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