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UTILIZATION OF SEAWEED RESOURCES

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SEAWEEDS AS SOURCES OF INDUSTRIAL GUMS

The commercial importance of seaweeds derives principally from their use as sources of industrial gums such as agar, carrageenan, and alginic acid. These gums are made up of the structural polysaccharide material found in red seaweeds in the case of agar and carrageenan, and in brown seaweeds in the case of alginic acid. Such gums have many industry applications.

Seaweed gums are unique in that they impart to various processed products special physical properties relating to viscosity, texture, and gelling ability. These properties are dictated by the chemical structure of the polysaccharide. Seaweed gums are made up of unique sugar molecules. Agar is made up of repeating units of *B*-D-galactose and 3,6-anhydro-*B*-L-galactose; carrageenan of *B*-D-galactose and 3,6-anhydro-*B*-D-galactose sulfated at various positions depending on the type of carrageenan; and alginic acid of mannuronic and guluronic acid residues. These different polysaccharidal structures can be distinguished from one another by means of their infrared (IR) spectra. Each spectrum is essentially a "fingerprint" of the polysaccharide. Thus, the spectrum of agar is distinct from that of carrageenan or alginic acid. A spectrum arises as a result of vibrations unique to each kind of molecule. There are peaks that are unique to each polysaccharide and which are indicative of certain structural features present in the molecule, e.g., the 3,6-anhydro galactose moiety gives rise to the peak at 930 cm^{1}; the various ester sulfate groups to peaks between 800 and 850 cm^{1}.

Seaweed polysaccharides are extracted by various processes. Common to all is the extraction of the polysaccharides into water. This indicates that seaweed gums are fairly soluble in water, a property that is again dictated by molecular forces arising from the preponderance of such groups as -OH (hydroxy), $-OSO_3$- (sulfate ester) and -COO (carboxylate) in the macromolecule. In the Philippines, *Eucheuma* is presently the most important source of carrageenan. *Eucheuma alvarezii* yields kappa carrageenan while *E. denticulatum* yields the iota form. There are, however, other carrageenan-containing seaweeds that can be found in tropical waters. The carrageenan isolated from *Acanthophora* appears to be of the lambda form, while that from *Hypnea* appears to be a variant of kappa carrageenan. The cultivation of these seaweeds is a matter that should be further investigated as these are sources of carrageenans that are of great commercial importance. The carrageenan from *Hypnea* can form very strong gels; that from *Acanthophora* possibly can be used as a stabilizing agent in non-viscous liquid products.

The extraction process for agar involves a freezing-thawing process. *Gracilaria verrucosa* appears to be the most promising species. However, other species also have potential economic value, at least in the production of food-grade if not bacteriological-quality agar.

The extraction process for alginate essentially involves the conversion of naturally-occurring alginate into its soluble form, i.e., sodium alginate. Most, if not all, of the alginates that can be bought in the world market today come from kelp. However, there are tropical seaweeds that are potential sources. *Sargassum* appears to be most promising.

CARRAGEENAN AS SUBSTITUTE FOR MICROBIOLOGICAL AGAR

Recent investigations on the use of carrageenan in microbiological media show that this application is indeed feasible. Carrageenan processed from *Eucheuma* has been especially formulated and tested as a medium for the growth of a wide spectrum of microorganisms - bacteria, yeast, and other fungi. The carrageenan medium has been tested in a number of research and teaching laboratories and satisfactory results have been obtained. The use of carrageenan as a substitute for bacteriological agar may be a boon to developing countries such as the Philippines where the rising cost of agar has been most strongly felt.

SEAWEEDS AS BINDERS OF HEAVY METAL POLLUTANTS

The use of seaweeds as a pollution-control agent has also been investigated at some length. Basic chemical studies conducted to date show that such an application is feasible. The approach used in the study consists of the following methodologies: 1) dialysis of solution of pure seaweed polysaccharides against solutions of heavy metal salts; and 2) elution of heavy metal salt solutions through a column of ground, dried seaweed. The metals that have been investigated are lead, cadmium, copper, zinc, iron, and mercury. The affinities of both carrageenan and alginate for these metals have been examined. Both polysaccharides exhibit a preferential affinity for lead, although the affinity for the other metals are not insignificant. The affinity for copper, in fact, almost matches the affinity for lead. *Sargassum* is presently being developed for this particular application because of its ease of handling. Preliminary experiments with actual industrial effluents contaminated with lead and cadmium indicate that an industrial system for wastewater treatment that uses *Sargassum* as metal binder can be developed.

OTHER POTENTIAL SEAWEED APPLICATIONS

Although the use of seaweeds as fertilizer in agriculture and horticulture has been introduced on a commercial scale in some European countries, this particular application still has to be developed in Asian countries. There are reports that some coastal communities in the Philippines do use *Sargassum* occasionally as a fertilizer. However, scientific studies that will lead to its more widespread use have been limited. Pre-development studies involved chemical studies on auxin-like substances from *Sargassum polycystum*. Auxins are plant growth hormones and their presence in *Sargassum* may partly account for the fertilizing property of this seaweed. Substances which exhibit auxin-like activity have indeed been isolated and partially characterized. Chemical formulas have been obtained although their exact identities have not yet been established. None of the compounds isolated were found to be indolic in nature (most known auxins possess the indole group).

The use of seaweeds as food is not as widespread in the Philippines as it is in Asian countries, particularly Japan. A study that looks into the nutritive value of some edible Philippine seaweeds is presently being undertaken. Nutritive value is being analyzed in terms of crude protein content, amino acid composition, and mineral and vitamin content. Results to date indicate that seaweeds are not the best sources of protein. However, they are excellent sources of minerals and do contain some vitamins.