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Review Article

Seaweeds and It's Utility

S. Kameswaran

Department of Botany, Vikrama Simhapuri University Post-Graduate Centre, Kavali-524201, Andhra Pradesh

*Corresponding author:
E-mail: kambharath@gmail.com

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ABSTRACT

The unprecedented population growth, unchecked industrial expansion and urbanization have diverted the human attention for ocean exploitation. Among its vast living resources, seaweeds are one of the best sources of food, fodder, fertilizer, medicine and chemicals. Seaweeds produce a varied and versatile biomass useful for multiple applications. They can be used in a broad variety of formats (e.g. fresh, dried, powder or flakes, salted, canned, liquid extracts or as prepared foods) for direct human consumption or processed into food additives and nutraceuticals, feeds, fertilizers, biofuels, cosmetics and medicines, amongst others. The macrophytic benthic marine algae, often called as seaweeds are used as food in Far East Countries since ancient times. According to FAO, over 30 countries around the world harvest annually about 3.8 million tones weight of seaweeds. Of this total, half of the quantity is utilised for human consumption and the rest for production of industrially important phycocolloids such as agar, carrageenan, and algin. The main types of edible seaweeds are Laminaria, Undaria, Porphyra and Monostroma. Almost all the edible seaweeds are cultivated on commercial scale especially in China, Japan and Korea to meet the market demands. The Porphyra cultivation in Japan is the World's biggest seaweed industry with a turnover of more than US $ 1.5 billion per annum.

Keywords: Seaweeds, algae, phycocolloids, laminaria, biofuels, fertilizer

1. Food and Nutrition Values

The food value of seaweeds mainly comes from their various micronutrients including essential vitamins, minerals and iodine content. The patterns of free and proteinaceous amino acids of Porphyra are more or less similar to that of vegetables with respect to alanin, aspartic acid, glutamic acid and glycine content. Some of the Porphyra species contain a high amount of orginin, a basic amino acid that in general is abundant in animal protein. The lipid contents of seaweeds are low in general, but contain a higher percentage of unsaturated fatty acids, which are more than 10% of total fatty acid content. Eicosapentanoic acid (EPA) constitutes about 50% of this. These fatty acids have gained prominence in recent years due to their effectiveness in preventing Atheroselerosis, cancer, coronary heart disease, ageing etc. It has also been reported that derivatives of EPA are beneficial to the human body because they act as local hormones and helps in human metabolism. Like vegetables, seaweeds contain all types of vitamins, antitoxidants, including Superoxide Dismutase (SOD) and ascorbic acid. Seaweeds are rich in group B vitamins, particularly B12 than their vegetable counterpart. Vitamin A content of seaweed amounts to half of the same spinach contents. The dried sheets of Porphyra contain vitamin C in higher proportion than in raw oranges. Seaweeds contain sufficient amount of diverse micro as well as macro nutrients of human food value.

2. Health Security

Chineese and Koreans recognized the pharmaceutical values of many types of seaweed for centuries. They have been extensively used in the traditional medicines of maritime nations, especially for the treatment of goiter, cancer, hypertension, cough, wounds and other diseases. They are used as verminfuges and in treatment of many viral diseases including herpes. Most seaweed contains sterols and related compounds, which are antagonistic to cholesterol in mammalian systems and could reduce elevated blood pressure. The vitamin and mineral content of these macroalgae are potentially important in the prevention of dietary insufficiency diseases. Carrageenan is used in the treatment of peptic ulcer in humans. The abilities of carrageenan and alginates to form metal salts indicate an important use as non-toxic chelating agent in the treatment of heavy metal and radio-nucleotide poisoning. It is known that agar is useful in the preparation of food prescribed for diabetic patients and promotion of tissue growth.

In India, few seaweeds are utilised in self-help mode traditionally by the villagers of coastal areas. In recent studies, numerous bioactive components and polysaccharides have been identified for use in medicines. Sulphated polysaccharides from some seaweeds have been reported to inhibit the activities of viruses especially the herpes virus and HIV. These carbohydrates have shown to strengthen the immune system of humans and animals and thus form an ideal health food that prevents dietary insufficiency diseases in human being. Seaweeds also possess active principles that control and prevent various microbial infections such as virus diseases, cough and dysentery. The sterols and related compounds present in seaweed could control cholesterol in blood and reduce elevated hypertension and blood pressure. Thus seaweeds could function as a unique 'therapeutic super food' for human beings.

3. Seaweeds as Food

Seaweeds occur in large number throughout the World Ocean and sea and reported safe as many are eaten as staple food in Japan and China for centuries. The use of members of Laminariales, especially Laminaria and Undaria dates back to 5th century in Japan and China. Sea vegetables were considered a delicacy used in everyday cookery in Japan. At present it accounts to form 10% of the Japanese diet and consumption reached an average of 3.5kg per household utilising the species of Porphyra, Laminaria and Undaria. Porphyra, red alga popularly known as 'Nori' in Japan is an important food source and cultivated extensively. High food value of Nori is due to its high protein, vitamins and mineral salts especially iodine. Over 80% of proteins and carbohydrates are digested and absorbed in the human digestive system. The vitamin C content is high and is estimated about 1.5 times that of oranges. Undaria pinnatifida is considered more valuable than Laminaria as food. At present, its availability is more from cultivated resources rather than natural growth. Hybrid with fast growth and superior nutritional characteristics have also been developed and cultivated in Japan. This alga is consumed in a variety of forms virtually with every meal in Japan, Koreans utilise many types of seaweed as food for centuries.

People from Hawaiian Islands, Scandinavian and a few other European countries are also reported to use seaweeds and products from seaweeds as food additives and supplements. Most of these countries have realized the worth of seaweeds in earning foreign exchange and therefore have already commenced mass cultivation in their coastal waters. Some of the green algae grown exclusively as sources of food are species of Enteromorpha, Ulva, Caulerpa, Codium. These are often eaten as fresh salads or as cooked vegetables along with rice.

The use of this renewable resource as an alternate staple food and as additives and supplements of food has not caught any appreciable level in India. The seaweed industry in India is entirely dependent on natural stock harvested from the sea. The Central Salt and Marine Chemicals Research Institute (CSMCRI) and Central Marine Fisheries Research Institute (CMFRI) Cochin and Mandapam, developed technologies for the cultivation of industrial seaweeds in the inshore in 1974 in the Palk Bay and Gulf of Mannar. These technologies were further perfected in the lagoons of Lakshadweep Islands in 1990.

4. Pharmaceuticals and Industrial Applications

Seaweeds are called sea vegetables with valuable properties and wide application in food, pharmaceutical and textile industries. Being rich in minerals, vitamins (A, B1, B2 and C), trace elements and bioactive substances, seaweeds are called medical food of the 21st century. Today seaweeds constitute the basis for a multi-million dollar industry in which billions of dollars' worth agar, agarose, algin, carrageenan and valuable minerals and chemicals are extracted annually. Many of these products are extensively used in industries such as textiles, paper, food, confectionery, dairy and pharmaceuticals all over the world. World's largest producers of seaweeds are Philippines and Indonesia and all harvested biomass is exported. The seaweeds exported to USA, Japan, European countries and processed for the production of phycocolloids agar, algin and carrageenan. The combined market values of these products are over US $ 200 million annually.

In India, seaweeds are exploited commercially only for manufacture of phycocolloids such as agar and algin. Major species utilised are Gelidium acerosa, Gracilaria edulis, Gracilaria verrucosa and Gracilaria sp. For agar production. All agar and algin industries in India use the seaweeds naturally occurring mainly in coastal regions between Mandapam, Vizhinjam and Gujarat Coast. Since starting of many new agar and algin extracting industries in 80's, the increased need for raw materials has caused vast depletion of natural seaweed vegetation along the India coast and more particularly southern coastal belt.

India has a good wealth of naturally occurring seaweeds along its coastline of 8129 km. Seaweeds grow abundantly along Tamil Nadu and Gujarat coasts and to a lesser extent in and around Mumbai, Ratnagiri, Goa, Karwar, Vizhinjam and Pulicat in TN and Chilka in Orissa. Along Kerala coasts, approximately 1000 tons of seaweeds are produced annually, of which about 20 tons of red and brown seaweeds are commercially viable. Out of 844 species of marine algae, a number of species of marine algae are utilised as raw material for agar, algin and liquid seaweed fertilizers for food, manure and pharmaceuticals. Extraction of carrageenan from Eucheuma, Kappaphycus and Hypnea is also growing in importance. Among the documented species, presently the exploitation is limited for extraction of industrially important phycocolloids from a handful of these.

5. Seaweeds in Body care Products

Algotherapy is the use of seaweed or seaweed extracts in health or beauty treatments. Seaweed baths were a common feature of seaside resorts in several southern and western locations at the end of the 19th century and the beginning of the 20th. The remains of some of these treatment centres are to be found at Victorian seaside resorts such as Kilkee, Co. Clare and Salthill, Co. Galway. The practice survives in some resort hotels in Co. Clare and in Co. Cork, but the only dedicated, fully-operational seaweed bath centre with the original fixtures and fittings is in Killala Bay at Enniscrone, Co. Sligo. This centre does most of its business during the summer months, offering seaweed baths in seawater using steamed serrated wrack - *Fucus serratus* -freshly collected from the shore nearby. It has a considerable number of regular customers that firmly believe in regular seaweed baths as a palliative for arthritis, rheumatism and other aches and pains. There is little doubt that there is a restorative effect but the precise nature of the active agent or agents is unknown. Seaweed Baths are becoming increasingly popular in Ireland.

That seaweed and seaweed extracts are good for the skin is beyond dispute according to cosmeticians and beauticians. Again, one can only assume that alginates, carrageenans and agars, found in large quantities in many seaweeds, have a beneficial effect in combination with warm seawater; however, it is probable that there are other constituents of seaweeds that have restorative powers. An Irish company is producing a seaweed powder (made mainly from *Ascophyllum nodosum*) for the cosmetic and algotherapy market, and another is producing a number of dedicated bodycare products containing seaweed extracts.

It seems likely that the market for algotherapy will expand and that this could be a very attractive area for niche companies to exploit. In France, the seaweed equivalent of "le health-farm weekend" is available where you can go to have your skin cleansed of the grime and grit of 20th-century living. The health-conscious are prepared to pay dearly for these courses of "algotherapy" or "thalassotherapy" and the attendant pampering of the mind and body. Style and location is essential in these operations: the surroundings must be well-designed and the staff exceptionally well trained. The customers expect quality and are prepared to pay dearly for it. A number of compounds extracted from seaweeds are thought to be of value in various cosmetic applications and some are now becoming commercially important.

6. Product Development and Utilities

Seaweeds are consumed both raw and in cooked form. Large numbers of food products are now available in countries like Japan, where seaweeds are either the principal component or added as garnishing. Seaweeds are eaten as staple items of diet in Japan and China for centuries and are used in everyday cookery in Japan since the 8th century. At present, seaweeds account for some 10% of Japanese diet and seaweed consumption reached an average of 3.5 kg per house hold in 1973, a 20% increase in 10 years. Most important of these sea vegetables are species of *Porphyra* (Local name 'Nori'), *Laminaria* (Kombu) and *Undaria* (Wakame). In the west seaweed is largely regarded as health food and there has been an upsurge interest in seaweeds as food. The use of members of Laminariales especially *Laminaria* and *Undaria* are used mainly in Japan and China for making fish and meat dishes as well as soups and also as a vegetable diet with rice. Powdered Kombu is exployed either in sauces or soups or added to rice in the same way as curry. The food value of Nori lies in its high protein content (25-30 of dry weight), vitamins and mineral salts especially iodine. Its vitamin C content is about 1.5 times of oranges and 75% of the proteins and carbohydrates are digested by humans, which is very high for seaweeds. Both algin and agar are used as thickening agents in cream, pudding, ice cream, fruit, salads, soap and confectionary. Edible seaweeds like *Ulva lactuca*, commonly known as salads and as curry leaves. Further dried or fresh, seaweeds can be made into seaweed masala. Seaweed pickle, porridge, jelly and jam.

7. Cultivation for Large Scale Production

The global seaweed production has increased to 9 million tons worth of US $ 6.0 billion and South East Asian Countries, especially China, shares the bulk of the total quantity. The cultivation technology is simple with low investment when it is done in the sea. In India, a good growth of seaweeds (3 kg per sq. m. in 60 days *Gracilaria edulis*) is reported from Mandapam area in Tamil Nadu. For cultivation, there is need to plan seaweed farming in the open sea. The agar-rich *Gracilaria* can be cultivated in ponds and canals than open sea farming. A demonstration of pond and canal culture of seaweed in shrimp farming area will not only help treat the effluent water, but will also prevent the viral diseases. This will also extend the employment to the women working in seaweed production. Coastal lagoons such as Chilka Lake and Pulicat Lake and many estuaries, shrimp ponds, canals and sheltered bays of Andaman and Nicobar Islands could be utilised for seaweed cultivation to produce at least one million tons, worth of US $ 500 million per annum to feed our people and export the excess quantity. Product development through R & D is also equally important to make it suitable for Indian palate and introduce it in daily food consumption.

The sea around India harbours more than 50 species of seaweeds holding nearly one third of the total seaweed resources of the Indian Ocean. Seaweeds flourish well in intertidal, shallow coastal water and in open seas upto depth of 180 meters. Although marine resources of fish, prawn, lobsters and oysters are being fully exploited and successfully cultivated, seaweed farming and exploitation are restricted to a very few countries only. Edible seaweeds occurring along the Indian coasts are seasonal and confined to selected locations; even in these locations the natural abundance is limited. While recognizing the seaweeds as an important source of food, especially highly nutritious food and its limited natural availability in Indian waters, there is need to develop proven technologies for commercialization and also to take up mariculture practices as done in countries like Japan and Philippines. Many of the countries with long coastlines, estuaries, backwaters and shallows-bays have commenced cultivation and exporting of specific economically important seaweeds. In India also, there are many edible species of seaweeds occurring in various quantities during different seasons at different places. However, seaweed cultivation in India is yet to begin on commercial scale. Although protein rich seaweeds species like *Caulerpa*, *Ulva*, *Porphyra*, *Gracilaria* and *Acanthophora* are commonly used on South Eastern countries, seaweeds are seldom used as food in India, except for making gruel with *Gracilaria edulis* in the coastal areas of Tamil Nadu. Among important edible seaweeds like *Porphyra*, *Enteromorpha*, *Monostroma*, *Eucheuma*, whose cultivation on large scale have recently been taken up in India, are also reported as a food item in the Philippines, where it is being cultivated on a very large scale. Cultivation of seaweeds in suitable areas along the coastal could increase the potentials for job and income generation among the common villagers. Development of palatable cuisines using the nutrient rich algae and their acceptability as staple food as well as additives and supplements of food, could support life of the malnourished. Permanent establishments associated with cultivation, processing and utilization of seaweeds for food and phycocolloids could also improve the economy, health and educational standards of rural community.

8. Other Uses

The seaweeds in general constitute one of the best renewable resources for food, fodder, fertilizers, medicines and fine chemicals. Seaweed, which is already known as feed for fish, can be very good source of energy for farm animals. The residue after extraction of agar from seaweed contains considerable quantities of colloids, other carbohydrates, proteins, vitamins and minerals. Instead of discarding the residue, it can be utilised as a feed for dairy, piggery and poultry or can be used as binder-cum-carbohydrate substitute in the food preparation for farm animals. Some of them have been used for farm animals. Some of them have been used for drugs, including antibiotics, anticoagulants, anti-helminthes, anti-hypertension agents, reducers of blood cholesterol and dilatory agents and even insecticides.

The efforts in seaweed cultivation and its utilization through product and process development could help in meeting the food and nutritional security and health measures of Indian population. It could also be beneficial to exploit the non-traditional source of nutritional food readily available and could help towards developing a new industry with accompanying benefits of employment generation and wealth creation.

Competing interests

The authors have declared that no competing interests exist.

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