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Seaweeds - The Less Known Marine Resource of India

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SUMMARY

In recent times, seaweeds are gaining considerable importance due to their wide range of applications in the food sector/industry as natural food either consumed directly or used as an ingredient in food products. The harvests from wild and cultivation in Asian countries like Japan, China, Korea, Singapore, Thailand, India, etc., is being utilized for the production of agar, alginates and carrageenan, among which the carrageenan is almost exclusively from cultivated Kappaphycus alvarezii. The seaweeds form a valuable resource less known to the public with ample opportunity for development, resource management and socio-economic upliftment of the coastal community.

INTRODUCTION

Seaweeds are plants growing abundantly in the shallow marine or brackish water environment, where at least 0.01 % photosynthetic light is available. It serves as a primary producer in the coastal ecosystem. Seaweeds can be classified into three groups such as green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta). India has the highest record of seaweed species from the Indian Ocean. India with a coastline of 8129 km is endowed with diverse resources, with rich biodiversity in lagoons, bays, estuaries, mangroves, reefs, seagrass beds, rocky shores, sandy shores, muddy shores etc**.** About 291 seaweed species are commercially being exploited worldwide. The seaweeds harvesting from wild and cultivation reached a new milestone with 31.2 million tonnes of production per year, with this 95% from farming with a market worth US$ 11.7 billion in 2018.

Resource status from India

There are about 72,500 seaweed species in the world, of which only 44,000 described. In India, 847 species are recorded, mainly along the Gujarat and Tamil Nadu coasts. Gujarat has a coastline of 1600 km, with 198 species, of which 109 are Rhodophytes, 54 are Chlorophytes, and 35 are Ochrophytes. State of World Fisheries and Aquaculture (SOFIA) 2020 reported a Global seaweed production of about 32.4 million tonnes, where farmed seaweeds represent 97.1% by volume in 2018. Seaweed farming is more prevalent in East and Southeast Asian countries. China stands place in seaweed production, followed by Indonesia, S. Korea, and the Philippines. The production had more than tripled from 10.6 million tonnes in 2000 to 32.4 million tonnes in 2018. India too has stepped up seaweed production with rapid growth in *Kappaphycus alvarezii*, producing about 5300 tonnes (wet weight) in 2018. Further, around 25000 tons of wild seaweed are collected in India, and the market value of wild and cultured seaweeds presently is worth Rs. 300-500 crore. A total of 302 species are found along the Tamil Nadu coast, and 147 seaweed species occur in the Gulf of Mannar alone. Several economically important species including Gelidiella acerosa, Gracilaria edulis, *G. follifera, Gracilaria* sp, *Hypnea* sp, *Acanthophora, Sargassum* sp, *Turbinaria* sp, *Cystoseira trinodis* and *Hormophysatriquetra, Ulva* sp, *Enteromorpha, Caulerpa, Codium, Hydroclathrus, Halimeda, Padina, Chondrococcus* and *Laurencia* are available in the Gulf of Mannar (IOM, 2008). Agar yielding seaweeds are harvested and cultured from Rameswaram to Tuticorin of the Gulf of Mannar and from the Sethubavachatram area in the Palk Bay (IOM, 2008).

Importance of Seaweeds

Polysaccharide: Seaweed contains many biologically active substances such as polysaccharides, proteins, lipids, minerals and polyphenols. In seaweeds are rich in polysaccharides are significant and contribute as a good source of fibre in human diet. There are 33-50% total fibers available in the edible seaweeds, higher than in terrestrial plants. The minor polysaccharides are sulphated fucose (brown seaweeds), xylans (red and green seaweeds) and cellulose (all genera). Seaweeds also contain storage polysaccharides such as laminarin (β-1,3glucans) and floridean starch (amylopectin like glucan). These are not easily digestible, and they can be categorized as dietary

fibers in human nutrition. The phycocolloids such as agar-agar, carrageenan, and alginate are also derived from seaweeds. Fucoidan and alginates are sulphated polysaccharides, while cellulose and hemicellulose are neutral polysaccharides.

Protein and related substances: Seaweed protein contents vary enormously, 5-15% in brown seaweeds, 10-30% in green and red seaweeds on a dry weight basis. Red seaweeds, *Palmaria palmata* (Dulse) and *Porphyra tenera* (Nori) have proteins at 35 and 47% of the dry matter, respectively. In the Green seaeed Ulva, it is in the range of 15-20% except for *Undaria pinnatifida*, which contains 11-24% proteins on a dry weight basis. Among the amino acids arginine is high in *Ulva pertusa, Undaria pinnatifida* and *P. tenera*, while glycine is high in *P. tenera*.

Lipids and related compounds: The seaweeds have a low lipids content ranging from 1-3% of dry weight. Generally, tropical seaweeds contain less lipid (<1%) than temperate seaweeds (1.6%). The major lipids in seaweed are glycolipids, neutral and phospholipids. The content and composition of seaweed lipids vary with species, geographical location, season, temperature, salinity, light intensity and species. Seaweeds are rich in essential fatty acids such as eicosapentaenoic acid (EPA, C20:5n-3), especially, red and brown seaweeds are rich in PUFA with 20 carbon atoms viz., EPA and arachidonic acid (AA, C20:4n-6), and the green seaweeds contain more levels of alpha-linolenic acid (C18:3n-3). Omega 6 and omega 3 fatty acids are essential as a nutraceutical for human consumption. Seaweeds belonging to the same genus from different parts of the world generally have a similar fatty acid profile, although the site of collection influences the actual PUFA content. Red and green seaweeds contain carotenoids, such as β-carotene, lutein and violaxanthin, while brown seaweeds are rich in fucoxanthin. The tocopherols, sterols and terpenoids present may contribute to seaweed as their food energy source.

Minerals: Seaweeds have a high mineral accounting for more than 30% of the dry weight. Some minerals are necessary for health, while some are toxic. The mineral composition varies according to species, seasonal, environmental, geographical and physiological variations.

Vitamins: Seaweeds can synthesize all the vitamins. The vitamin content varies according to species, season, algal growth stage and environmental parameters. The unique difference between land plants and seaweeds is that they contain relatively more vitamin B_{12}. Most red seaweeds contain large amounts of provitamin A and significant quantities of vitamins B_1 and B_2. The brown seaweed Porphyra is an excellent repository of B-complex vitamins, specifically choline, lipoic acid, biotin, B6, and B_{12} and it has the highest vitamin A content. On the contrary, land plants do not have Vitamin B_{12}. The levels of vitamin C in green and brown seaweeds are 500-3000 mg/kg of dry matter, whereas red seaweed contains 100-800 mg/kg. Vitamin E is high in brown seaweeds than green and red seaweeds.

Antioxidative Compounds

Seaweeds have many antioxidative compounds, and indole is one compound derived from seaweeds to exert an inhibitory effect on lipid oxidation. Dimethylsulphoniopropionate (DMSP) serve as an effective antioxidant. *Grateloupia filicina* a red seaweed contained BHA, BHT and α-tocopherol, which have high antioxidant efficacy equal to or better than commercial antioxidants. α-tocopherol used as a natural antioxidant in food formulations. *Cystoseria* possessed antioxidant activity than α-tocopherol. Carotenoids have beneficial effects in cancer chemoprevention by acting either as antioxidants or prooxidants, depending on the environment. The phenolic content in seaweeds varies from 386 mg/g to 1352 µg/g on a dry weight basis. Antioxidant activity of seaweeds is due to pigments such as chlorophylls and carotenoids, vitamins and vitamin precursors including α-tocopherols, β-carotene, niacin, thiamin and ascorbic acid, phenols (such as choline), peptides, terpenoids and other antioxidant compounds which either directly or indirectly contribute to inhibition or suppression of free radical generation. Chlorophyll-α, chlorpphyllonolacetone-a, chlorophyllonic acid-a and methyl ester and pyropheophorbide-a produced by seaweeds showed higher antioxidant activity at specific concentrations.

Nutritional benefits:

Seaweed is a rich source of vitamins C, A, E, B_{12} and has good antioxidant properties. Seaweed products are used every day as process food ingredients in dairy products and domestic foods. The viscous soluble polysaccharides such as pectin, guar gum are used for hypercholesterolemia and hypoglycemic effects. The water-

insoluble polysaccharides like cellulose for beneficial for decreased digestive tract transit time. Seaweed dietary fibers are useful as an antioxidant, antimutagenic, anticoagulant, antitumor and assist in modifying lipid metabolism in the human. Red seaweeds are an excellent source of protein due to their high protein level and excellent amino acid composition. The free amino acid fraction of seaweeds comprises alanine, aminobutyric acid, taurine, ornithine, citrulline and hydroxyproline. Seaweeds with high protein levels can also be used as a protein source in aquafeed by fish farmers in aquaculture. The inclusion of seaweeds in fish feed improves the resistance of fish to stress and diseases. The beneficial effects of Porphyra meal used as a feed additive in the diet of red sea bream improved body weight gain and increased the triglyceride and protein deposition in the muscle.

The high level of PUFA in temperate seaweeds indicates their potential use in nutraceuticals and food and feed formulations. They are also used as ingredients in hatchery or nursery diets in shrimp or fish culture, requiring PUFA enrichment during growth and development. Fucoxanthin exhibits antitumor activity against human neuroblastoma cells, induced a remarkable reduction in leukemia and prostrate cancer cells' growth and expressed inhibitory effects on mouse duodenum and skin carcinogenesis. The antioxidant activity of phenolic compounds in seaweeds are radical scavenging activity. The presence of phlorotannins, namely fucolls, phlorethols, fucophlorethols, fuhalols, halogenated and sulphited phlorotannins in brown algae exhibit antiplasmin inhibition, detoxification of heavy, antibacterial effects, UV protection and chemoprevention against vascular risk factors. Phlorotannins and bromophenols play an important role as antioxidants. Phlorotannins extended the induction period in the oxidation of methyl α-linolena against oxidative degradation, prevented free-radical related diseases.

Other uses of seaweeds:

Seaweeds typically consumed as a dish, soups, pickle with sauce and alimentary paste jellies. Alginates from seaweeds are used as thickening agents in sauces, syrups and toppings for frozen dessert, cake and canned foods and vegetables. The gel-forming activity is employed in instant milk desserts and jellies, bakehouse filling cream, fruit pies, animal foods, and reformed fruit. Recently they are being used in the restructured meat merchandise like shrimp or crab meat merchandise and creating structured fruit merchandise. Seaweed carrageenan and agar-agar used as thickening and gelling agents in food, pastry, yoghurts, milk, and growth medium for microorganisms. It can be used as a supplementary ingredient to prepare feed for cattle, poultry, and other farm animals, and it has been observed to increase fertility and birth rate of animals and improves yolk colour in eggs. Seaweeds such as *Gracilaria, Gelidiella, Hypnea* and *Sargassum* are added to feed as an ingredient used for fish and prawn culture because it maintains the water quality and enriches minerals, amino acids and carbohydrates. The presence of more potassium and nitrogen in seaweeds helps to promote hormones and other micronutrients making it an excellent fertilizer. Seaweeds as manure can increase soil fertility and moisture-holding capacity.

CONCLUSION

Seaweeds have high minerals, vitamins, proteins and indigestible carbohydrates content with low lipid content but high nutritional and low-calorie value. There is a high content of essential amino acids, unsaturated fatty acids, and good quality protein in seaweeds than other dietary vegetables. Other than its nutritional value, it also has antioxidative, anticoagulant, antimutagenic, antitumor and anticancerous properties. While consuming, they modify the lipid metabolism in the human body. The consumption of seaweed in India is very low even though it has an excellent nutritional value, however, most people consume seaweeds unaware that it is used as ingredients in making food in some places. The creation of awareness about the health benefits of seaweeds is essential to popularize then as a good nutritional resource among people.

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