25. Seaweeds: Scope and potential

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Introduction

The marine environment is natural abode for a great variety of plants like organisms known as seaweeds or marine macrophytes or macroalgae. These marine macrophytes does not have true roots stems or leaves but the appearance resembles non-woody terrestrial plants and are widely distributed from tidal and intertidal regions to considerable depths of oceans. Seaweeds are integral part of marine ecosystem and serve as good source of food and provide habitat to many animals. Some of them grow faster than any other plant on earth and hence known as wonder plants. The seaweed anatomy refers to algal body, thallus; lamina or blade is the flattened structure resembles with the terrestrial leaf, sorus is spore cluster, pneumatocyst is air bladder an organ assists in flotation, stipe a stem-like structure which may or may not be present in all the seaweed, holdfast is a basal structure providing attachment to the substrate which resembles with the root of the terrestrial plants. The stipe and blade are sometime collectively called as the fronds. The seaweeds are classified on the basis of pigmentations in it. On the basis of the pigments there are three broad groups of seaweeds i.e., brown red and green botanist refer these groups as Phaeophyceae, Rhodophyceae and Chlorophyceae respectively. Brown seaweeds usually vary from smaller species to giant kelp which grow as large as 20 m long. The red seaweeds are usually smaller, generally ranging from a few centimetres to about a meter. Green seaweeds are also smaller in size similar to red seaweeds. The red seaweeds are not always red in colour they vary from red to purple and sometimes brownish red but are classified as red because of the pigments present in it.

The seaweeds are used as food source in Asian countries since time immemorial. The use of seaweed as food source is traced back to fourth century in Japan and to the sixth century in China. Today along with Japan and China, Republic of Korea are the largest consumer of seaweeds as food.

Various red and brown seaweeds are used as to produce hydrocolloids. A hydrocolloid is non-crystalline substance with very large molecules which dissolves in water to give thick viscous solution. Three common seaweed hydrocolloids are Agar alginate and carrageenan. Agar, Alginate and Carrageenan are carbohydrate (polysaccharides) that are used to thicken aqueous solution to form gels of varying degrees of firmness which is use to stabilize edible, cosmetic and other industrial products.

Seaweeds are known for their richness in polysaccharides, minerals and certain vitamins, but they also contain bioactive substances like polysaccharides, proteins, lipids and

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polyphenols with antibacterial, antiviral and antifungal properties. This gives a great potential to seaweed as a supplement in functional foods and nutraceuticals.

Seaweed as functional food and nutraceuticals

In recent years seaweed has gained importance as component of functional food and nutraceuticals ingredients by virtue of the biologically active compounds present in it. It is obvious that the seaweed grows marine ecosystem is in an extremely challenging environment where survival requires remarkably diverse biologically active compounds and a seaweed make these compounds through its metabolic process. These diverse metabolic compounds are well known as bioactive compounds and their activity is also linked to improving the human health by altering the metabolic process, quenching free radicals and through altering genetic expression of cellular process. Because of the immense beneficial activities of the primary and secondary metabolites obtained from seaweeds they are considered as future foods. Different compounds present is seaweed having nutraceutical properties are polysaccharides, proteins, small peptides, fatty acids, vitamins, minerals, polyphenols, flavonoids etc.

In 1989 Stephen De Felice defined nutraceuticals by combining the terms nutrition and pharmaceuticals. According to him "nutraceutical is a food or a part of food which provides medical or health benefits, including the prevention and /or treatment of a disease". He explained when a food is cooked or prepared using scientific intelligence, with or without the knowledge of how or why it is being used, it is called a functional food and when the food helps in prevention and/or treatment of disease (s) and/ or disorder (s), it is called nutraceuticals and thus a functional food for a consumer can be a nutraceutical for another consumer.

Polysaccharides

Cell wall of seaweed is primarily containing polysaccharides approximately it is up to 50% of the dry weight. The biochemical compositions of these polysaccharide vary greatly depending on several factors such as species, developmental stage, environmental factors, harvesting period, extraction protocol etc. On the basis of its position, seaweed polysaccharides are classified as cell wall polysaccharides and storage polysaccharides. Some of the Polysaccharides contain sulphate moiety in it and called as sulphated polysaccharides. The common polysaccharides in green seaweeds are collectively known as Ulvan. Polysaccharides in brown seaweeds are Alginate, Fucoidan and Laminarin whereas polysaccharides in red seaweeds are Agar, Carrageenan and Floridian starch. All these polysaccharides are used extensively in food, biomedical, cosmetics and other industrial uses.

Ulvan

Ulvans are the sulphated polysaccharides present in the cell wall of green seaweeds. Rhamanose, xylose, rhamanose 3-sulphate, xylose 2-sulphate, glucronic acids and iduronic acids are the main building block sugar moiety present in the Ulvans. The sulphate group present in the sugar moiety enhance the functionality of the Ulvan polysaccharides and make it suitable for use in pharmaceutical agriculture and other food and pharmaceutical uses.

Alginates

Hexauronic acids like mannuronic acid and glucronic acids are the main building block units of alginate. Alginates are one of the most abundant polysaccharides in the brown seaweeds and extensively used in food and pharmaceutical industry. In food industry alginates are used as gelling agent, emulsifying agent, stabilizer and encapsulating agent. Alginates are known to have activity in human colonic microflora, enhance intestinal absorption rate and also the glycemic and insulinemic responses of alginates are widely reported.

Fucoidan

Fucoidans are the cell wall polysaccharides of brown seaweeds mainly in Fucaceae and Limanariaceae families. It is a sulphated polysaccharide with L-Fucose as main sugar moiety present in it. It has several medicinal properties such as anti-proliferative, antiangiogenic etc. Antiproliferative activity of some fucoidian compound are in preclinical stage.

Laminarin

Laminarin is a good source of dietary fibre, is a water-soluble polysaccharide containing β-(1-3)-glucan with β-(1-6)-linkages of 20-25 units. It is also known for its anticancer properties.

Agar

Agar is a cell wall polysaccharide present in red seaweed. It is mainly extracted from Gelidium and Gracilaria species. Agar is a sulphated polysaccharide containing sulphated esters of D-and G-Galactose units. Agar is generally used as thickening and gelling agent in food and cosmetics industries.

Carrageenans

Carrageenans are sulphated polysaccharides found in the cell walls of the red seaweeds. Mainly extracted from *Kappaphycus alvarezii* and *Chondrus crispus*. Ammonium, Ca, Mg, K, and Na sulfated esters of d-galactose and (3,6)-anhydro-d-galactose units are responsible for the polysaccharide structure of carrageenans. Biological properties, chemical modification, and structural analysis of carrageenans have been reviewed previously. A fermented food "tofu" prepared with k/ι-hybrid carrageenans showed the highest rheological properties and carrageenan could be a practical food additive to modify the food textures.

Proteins and peptides

Seaweed contains different types of protein and peptide which differ from species to species and also depends factors like geographical location, environmental conditions, season habitat in which it grows, growth and developmental stage etc. It is reported that the among seaweeds the red seaweed contains the highest amount of protein followed by green seaweeds and brown seaweed contains the least amount of protein in it. Phycobilioproteins and lectins

are the common type of functional protein present seaweeds.

Lectins are low molecular weight proteins attached with some carbohydrate or sugar moiety and play an important role in biological activities mainly intracellular communications. Lectins are also known to agglutinate the red blood cells. These glycoproteins are known to have antibacterial, antiviral, anti-inflammatory, anticancer and anti-HIV activities.

Phycobiliproteins are a family of reasonably stable and highly soluble fluorescent proteins found in red seaweeds. These proteins contain covalently linked tetrapyrrole groups that play a biological role in collecting light and, through fluorescence resonance energy transfer, conveying it to a special pair of chlorophyll molecules located in the photosynthetic reaction center. There are three major categories of phycobiliproteins: phycocyanins, allophycocyanins, and phycoerythrins, with phycoerythrins as a major, light-harvesting pigment in red seaweeds and regularly used as a fluorescent probe in scientific experiments. These properties allow some red seaweed species to survive in relatively deep water, depending on opacity and other conditions.

The nutritional value of protein depends on the amino acid content and the protein digestibility. Most seaweeds are rich in glycine, arginine, glutamic acid and alanine which are essential for human health. Seaweed proteins are reported to have different biological activity such as antihypertensive, antioxidant and antidiabetic effects. A short sequence of amino acids which are present in an inactive form and they break into shorter peptides during processing, gastrointestinal digestion or fermentation. These short chain peptides are biologically active which has nutraceutical potential to promote human health.

Fatty acids

During the last few decades, the lipid composition of seaweeds has raised considerable interest among researchers and nutritionists because of their high content of PUFAs, especially alpha linolenic acid (ALA) (18:3n-3), arachidonic acid (AA) (20:4n-6), eicosapentaenoic acids (EPA) (20:5n-3) and docosahexaenoic acid (DHA) (22:6n-3). This class of fatty acids are nutritionally important for humans and animals.

Vitamins

Vitamins are organic compounds required by human body for several essential biochemical and physiological processes. On the basis of its solubility, it is classified into two classes i.e., water soluble and fat soluble. Vitamins of B group and Vitamin C are water soluble whereas vitamin A and its provitamins-carotenoids with vitamin A activity, vitamins E, D and K are fat soluble. Though vitamins are required in very small quantities to fulfil the requirements but it is of great importance and people can consume vitamin containing foods as functional food and nutraceuticals. B group vitamins such as B1, B2, B12, vitamin C and fat-soluble vitamins E and β carotene, vitamin A activity have been reported from various seaweeds. Information on vitamin content and bioavailability of seaweeds vitamins are limited. Generally, seaweed contains both water soluble and fat-soluble vitamins. The vitamin profile

of seaweed vitamins varies on species, geographical location, season, environmental condition etc.

Minerals

Cell wall polysaccharides and proteins in seaweed provide excellent binding sites for metal retention. Apart from the inherent metal binding capacity the accumulation of the metals in seaweed also depends on the bioavailability of metals in the surrounding water. Hence the seaweed contains high concentration of a wide range of diversified minerals. Most of the minerals required for human health such as potassium, sodium, phosphorous, calcium, iodine, magnesium, iron, and zinc are sufficiently available in different kinds of seaweeds and hence seaweeds have immense potential to be used as functional food and nutraceutical for the benefit of human health.

Polyphenols and flavonoids

Polyphenols are a group of heterogenous compounds with innumerable phenolic structures which differ structurally from simple molecules to highly polymerized compounds. These are major group of phytochemicals found in the human diet, such as fruits, vegetables, and other essential oils and other food derivatives. These polyphenolic compounds are classified on the basis of their source of origin, biological activities and chemical structure. In general polyphenols are classified as phenolic acids, flavonoids, stilbenes, lignans and other phenolic compounds. Flavonoids are classified into six major subclasses i.e., flavonol, flavanols, flavanones, flavones, isoflavones, and anthocyanins. Seaweeds are rich source of polyphenolic compounds mainly such as catechins, flavonols and phlorotannins etc. Green and red seaweeds are good source of phenolic acids, flavonoids and bromophenols. Evidence based on epidemiological, clinical and nutritional studies suggest that dietary polyphenols play an important role in human health. Regular consumption of polyphenols has been associated with reduced risk of different chronic diseases, including cancer, metabolic and neurodegenerative disorders and CVDs.

Conclusions

Seaweeds grows in huge quantity and there is no constraint of space and nutrient requirement for their growth in marine environment. In the recent era where people are struggling from different kinds of health issue many biologically active ingredients present in seaweed can be helpful in ameliorating the risk of different health issue. But still it is the need of the hour to further research on biologically active compound derived from seaweeds should be aim to study the efficacy of purified compound under different conditions to recognize their true potential.

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