CHAPTER 7

Seaweed as Potential Nutraceutical and Functional Food

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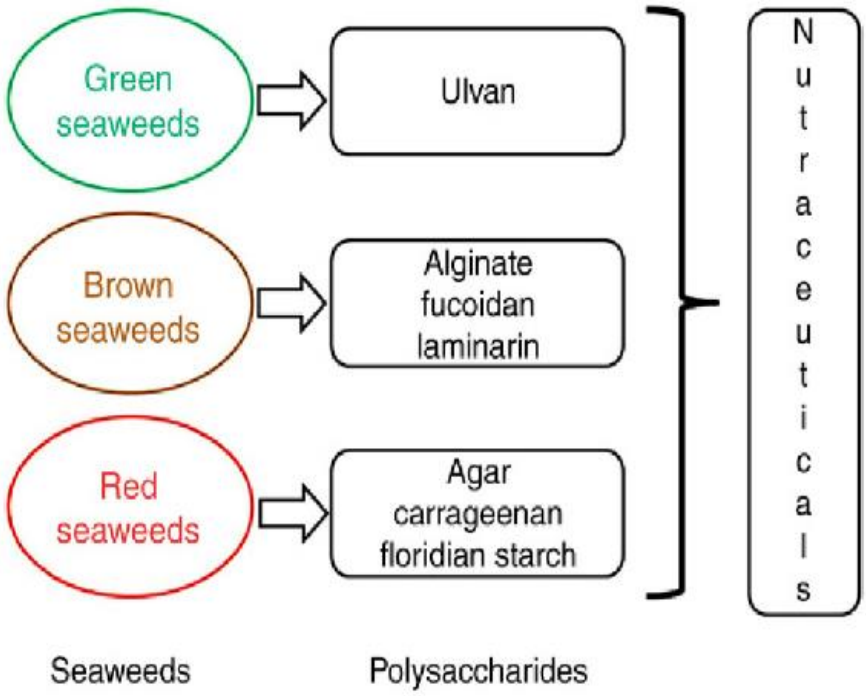
Background

Over 2500 years ago Hippocrates coined a phrase " let food be the medicine and medicine be the food", which is reciving a lot of attention by food scientists and consumer of present era. The medicinal benefits of food have been explored for over thousands of years. Different ancient civilization like Egyptians, Chinese, Sumerians etc have provided evidence suggesting that, foods can be effectively used as medicine to prevent and treat disease. Even in Asian subcontinent natural herbs and spices are used as folk medicine for centuries. The modern era consumers are increasingly aware about their food and interested in the health benefits of food and look beyond its basic nutritional content. The better understanding of how diet affects disease, health care costs and ageing populations have created a huge market for natural health products, functional food and nutraceutical.

The seaweed cell wall consists of polysaccharides. The biochemical composition of these polysaccharides varies with species to species and influenced by several physical, biological and environmental factors. Seaweed polysaccharides can be divided into two major classes, such as cell-wall polysaccharides and storage polysaccharides. Some of the seaweed polysacchardies contain sulphate groups and known as sulphated polysaccharides. Ulvan, fucoidans and carrageenans are examples of green, brown and red seaweeds respectively. Seaweed polysaccharides like alginate, carrageenans, fucoidans and ulvan are widely applied in biological and biomedical field due to their biocompatibility and bioavailability.



Seaweed derived polysaccharides as nutraceuticals

Type of seaweed polysaccharides and its nutraceutical uses

Ulvan

Ulvans are structural polysaccharides present in cell wall of green seaweeds. They are hghly sulphated a essentially composed of rhamanose 3-sulphate, xylose, xylose 2-sulphate, glucronic acid and iduronic acid.Ulvan displays several physciochemical and biological features of potential interest for food pharmaceutical, agricultural and chemical applications.

Alginates

Alginates are the most abundant polysaccharide in the brown seaweed comprising upto 40 % of the dry matter. Alginates are composed of two hexuronic acids such as mannuronic acid and glucronic acid. Alginates are used in the food industry as a gelling agent, stabilizer, emulsifying agent encapsulation and food coating agent. It has been reported the health beneficial effects of alginates on human colonic microflora, reduction of toxicity of colonic luminal contacts, intestinal absorption rate, plasma cholesterol and glycemeic and insulinaemic responses. The application of alginates in the food industry is expanding.

Fucoidan

Fucoidans are sulphated polysaccharides mainly composed of l-fucose in brown seaweeds. Especially, cell walls

of seaweed species in the families, Fucaceae and Laminariaceae contain 2-10% of dry weight of fucoidans. Several studies have demonstrated the antiproliferative, antiangiogenic and anticancer properties of fucoidan and its importance as a marine anticancer agent in the preclinical development has already been presented by the workers in the field.

Laminarin

Laminarin, also known as laminaran, is an active component that is extracted and isolated from the dry thallus of brown seaweeds . Laminarin is a water soluble polysaccharide that consists of β-(1-3)-glucan with β-(1-6)-linkages of 20-25 units. The laminarin contributes to the dietary fiber intake and plays role in cancer prevention.

Agar

Agar is well presence in red seaweeds and it is widely extracted from *Gelidium* and *Gracilaria* species. Generally, the cell wall of these red seaweeds contains 20% (dry weight basis) of agar. In addition, *Pterocladia* and *Gelidiella* species are used to extract agar in some countries. Agar consists with Ca, Mg, K, and Na sulfated esters of D- and L-galactose units. Interestingly, agar will be a key alternative to gelatin (which comes from animal origin) in the jelly and confectionary industries.

Carrageenans

Carrageenans are naturally occurring sulfated linear polysaccharides found in red seaweeds. There are three types of carrageenans such as k-, ι-, and λ-carrageenans. They are commonly extracted from *Kappaphycus alvarezii* and *Chondrus crispus* and their cell walls contain 30%–80% (dry weight basis) of carrageenans. 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.

Functional food and nutraceutical application of seaweed proteins and peptides:

The protein content in seaweeds varies from about 10% to 40% per dry weight, and it differs according to the seasons and the species**.** Many seaweeds species, in particular red seaweeds, have been shown to possess significant levels of protein and in some cases contain higher quantities than some conventional protein-rich foods. Generally, red seaweeds contain higher protein levels (max. almost 50% of dry weight) as compared to green seaweeds and brown seaweeds. These protein levels of

red seaweed are comparable to those found in high-protein vegetables such as soybeans (in which proteins represent 35% of the dry mass). Among seaweed proteins, it is worth noting the occurrence of two groups of functionally active proteins called lectin and phycobiliproteins. Lectins are glycoproteins, which bind with carbohydrates and participate in many biological processes like intercellular communication. Lectin has the ability to agglutinate red blood cells. Lectins may be divided into four main categories, namely, legume lectins, chitin-binding lectins, monocot mannose binding lectins, and type-2 ribosome inactivating proteins. These proteins also 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.

Antioxidant properties

Oxidative stress is a primary cause for development of various human chronic diseases such as cardiovascular disease,

diabetes, cancers, and neurodegenerative diseases. Natural antioxidants have seen a surge of interest and increased research efforts. A wide range of metabolites has been evaluated against oxygen-induced damage for their potential to lower the risk of human chronic diseases. Among them, seaweed derived protein and peptides have the ability to delay lipid oxidation reactions in food and living systems. Bermejo et al. (2002) examined the antioxidant capabilities of phycocyanin and suggested that these bioactive capabilities are attributed to the protein's ability to chelate metal and to scavenge free radicals. The mechanisms behind the antioxidative activity of seaweed-derived protein and peptides are not well known but are very likely due to the amino acids' compositions and sizes. The hydrophobic amino acids present in the peptide sequence contribute greatly to their potential antioxidant activity.

Antihypertensive activity

Hypertension was identified as a cardiovascular risk factor in the late 1950s and remains a public health issue today. Among processes related to hypertension, angiotensin-converting enzymes (ACE) play an important role in the regulation of blood pressure, as they promote the conversion of angiotensin-I to the potent vasoconstrictor angiotensin-II and inactivate the vasodilator bradykinin, which has a depressor action in the renin–angiotensin system. Therefore, inhibition of ACE is considered to be a useful therapeutic approach in the treatment of hypertension. Peptides derived from seaweeds have potent ACE-inhibitory activities.

Food applications of seaweed-derived proteins, peptides, and amino acids have become popular in the last few decades. Recognition of the health benefits associated with the consumption of seaweed proteins is one of the most promising developments in human nutrition. R-phycoerythrin is a powerful and highly sensitive fluorescent reagent, which can serve as a label for antibodies, receptors, and other biological molecules in a fluorescence-activated cell sorter, and phycobiliproteins in general are used in immunolabeling experiments and fluorescence microscopy and diagnostics. An increasing number of investigations have shown their health promoting properties and broad range of pharmaceutical applications.

Conclusion

Seaweeds are rich in bioactive compounds which could be potentially exploited as functional ingredients for both human and animal health applications. Bioactive compounds that are most extensively researched include sulphated polysaccharides, phlorotannins, and diterpene. These compounds have been reported to possess strong anti-viral, anti-tumor and anticancer properties.

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