SEAWEED BASED NUTRACEUTICALS – PRESENT AND FUTURE PROSPECTS

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Seaweeds, commonly known as marine macroalgae are photosynthesizing plants that constitutes a major biomass in the intertidal zone. They are a varied group, with sizes ranging from a few centimeters to 100 m in length. In general, they are divided into three main classes based on pigmentation, green (chlorophytes), red (rhodophytes), and brown (phaeophytes). As seaweeds lack many of the distinct organs (roots, stems, leaves) found in terrestrial plants, whole parts can be used as a source of food, cosmetics, and other products. They have high nutritional value, in both fresh and dried forms, and act as ingredients in a wide variety of prepared foods.

Seaweeds were being used as traditional food and complementary medicine. Recently, it has gained popularity as a functional food too owing to the presence of potent biological molecules in it. It is being used directly or indirectly as a functional food ingredient. They are low caloric food but rich in vitamins, minerals and essential trace elements, polyunsaturated fatty acids, bioactive metabolites, proteins, polysaccharides and dietary fibres.

Bioactive compounds from seaweeds

Polysaccharides and Sulphated Polysaccharides

Polysaccharides are the most important macro-molecule in seaweed constituting around more than 80% of its weight. Seaweeds contain a high total dietary fibre content: 10–75% for brown seaweed, 10–59% for red seaweed, and 29–67% for green seaweed. Seaweeds are particularly rich in soluble dietary fibre, which accounts for 26–38%, 9–37%, and 17–24% in brown, red, and green seaweed, respectively. The major polysaccharides from phaeophyceae (brown algae) include alginates, laminarin, sargassan, fucoidans, sulphated galactofucans and ascophyllans. Polysaccharides derived from Rhodophyceae (red algae) include floridean starch, agars, carrageenans, xylans, galactans, sulphated galactans and sulphated rhamnans. Chlorophyceae contain sulphated galactans, xylans and ulvans as the major polysaccharides. Among the seaweed polysaacharides, the one which have spurred great deal of interest in the last decade is fucoidan. Fucoidans are a class of sulfated polysaccharides mainly composed fucose in the cell walls of brown algae, and they have demonstrated various activities, including anticancer, antioxidant, antiobesity, anti-

inflammatory, antimicrobial, antiangiogenic, immunomodulatory and neuroprotective activities (Holdt and Kraan, 2011). Fucoidans may play a role as dietary fiber uptake contributing to lower cancer incidence risk (Tiwari et al., 2015).

Proteins and aminoacids

The proportion of protein in seaweed ranges up to 45% DW and it differs from species, season and geographical area. Seaweed based proteins and peptides are proven to have antioxidant, antihypertensive, and anticoagulant activities. Seaweeds are widely recognized as cheaper protein alternative source due to its high-value proteins containing essential amino acids. The protein content in brown, green and red algae is 1–24%, 4–44% and 5–50% of the dry weight respectively. The major proteins in seaweeds include lectins and phycobiliproteins (Aneiros & Garateix, 2004). Phycobiliproteins are water-soluble and coloured components of the photosynthetic system in red macroalgae.

Lipids

Seaweed lipids mostly contain long-chain fatty acids, especially polyunsaturated fatty acids (PUFA) with 18- and 22- carbon atoms, depending on species. In general, lipid in seaweed ranges from 0.4% to 5% DW, with abundant saturated fatty acids (SFA) and palmitic acid in all species. Likewise, essential fatty acids (EFA) and PUFA were found abundant in brown seaweeds followed by green and red seaweeds which can regulate blood pressure and reduce the risk of cardiovascular diseases, osteoporosis, diabetes etc. (Maeda et al., 2008). Furthermore, green seaweeds like *Ulva pertusa* are reported to have sufficient amounts of hexadecatetraenoic, oleic, and palmitic acids (Ortiz et al., 2006).

Minerals

Seaweeds are reported to contain significant amounts of essential minerals such as sodium, calcium, potassium, magnesium and trace elements such as iron, zinc, manganese and copper. These minerals which have major role in building human tissues and as cofactors of many metalloenzymes due to their cell surface polysaccharides. Because of the richness of mineral content, seaweeds can be used as food supplements to provide the daily intake of some minerals and trace elements.

Vitamins

Algae are the richest source of vitamins almost contain all essential and non-essential vitamins in it. Numerous seaweeds like Porphyra umbilicalis, Himanthalia elongata and Gracilaria changii contains a high level of vitamin C compared to land vegetables. It has been reported that vitamin C is present in very high amounts of 2000 mg/kg dry matter in red seaweed *Eucheuma denticulatum* and 3000 mg/kg dry matter in green seaweed *Enteromorpha flexuosa* (McDermid and Stuercke, 2003). Furthermore, B group vitamins, especially thiamine and riboflavin are found in substantial amounts in most red and brown seaweeds whereas vitamin E content is higher in brown seaweed. Hence, it can be said that seaweeds are good source of vitamins also.

Fucoxanthin

Fucoxanthin is a xanthophyll, found as an additional pigment in the chloroplasts of the brown algae. Fucoxanthin and its de-acetylated metabolite depict anti-inflammatory, anti-nociceptive, and anti-cancer effects (Lee et al., 2013). Fucoxanthin and its metabolites can be used as a novel drug in the field of the bio-medical sector.

Bioactive properties of seaweeds

Marine algae are considered as one of the richest sources of antioxidants among the marine organisms. Seaweed phlorotannins by virtue of its eight interconnected rings are considered as very powerful free radical scavengers. These compounds have been isolated and purified from the brown algae *E. bicyclis, E. kurome, H. fusiformis* and *E. cava* and they have shown potent antioxidant activity against hydrogen peroxide induced cell damage. Some of the phlorotannins like eckol, phlorofucofuroeckol A, dieckol, and 8, 8-bieckol have shown anti-oxidant capacity in phospholipid peroxidation (Shibata et al., 2008). Because of their strong anti-oxidant activities they are even comparable to anti-oxidants such as ascorbic acid and tocopherol. Therefore, phlorotannins from seaweeds can be considered as potent anti-oxidants with wide applications in food and pharmaceutical industries.

Anti-coagulants are therapeutics which have ability to prevent blood coagulation or stop the formation of blood clots. Heparin, a sulfated polysaccharide is one of the most common anti-coagulant drugs used in the world against thromboembolic disorders (Fan et al., 2011). However, because of the several side effects associated with it, scientists are looking for suitable alternatives

for heparin. Sulfated polysaccharides of anti-thrombotic and anti-coagulant properties have been isolated from different marine algae. Fucoidan, a sulphated polysaccharide from seaweeds are reported to display strong anticoagulant properties. The degree of its anticoagulant property is related to its sulphate and polysaccharide content. It was reported that C-2 sulfate and C-2, 3 disulfate in fucoidans is mainly associated with anti-coagulant activity. The outcomes of many studies have proposed that fucoidans can be used as suitable alternatives to heparin and even certain fractions of fucoidan can be qualified as heparinoids.

Sulfated polysaccharides from marine algae are reported to have effects on innate immunity by modulating the ability of immune cells to produce nitric oxide and thereby reducing inflammation (Leiro, Castro, Arranz, & Lamas, 2007). The two important biomolecules from marine algae, fucoidan and arabinogalactan are reported to have immunomodulating effects. As fucoidan can influence the activation and maturation of human monocyte-derived dendritic cells, it can be used for cancer immunotherapy. Fucoxanthin, another marine bioactive compound, has shown anti-inflammatory activities both in vitro and in vivo assays. Because of its strong anti-inflammatory properties, it can be comparable with predinisolone, a commercially available steroidal anti-inflammatory drug.

Marine algae are reported to possess an extensive range of bioactive compounds which can be used to cure various types of cancers. Many of these compounds have been found to destroy tumor cells by initiating apoptosis or activating signalling enzymes that affect cell metabolism and eventually lead to cell death, however the clinical trials are limited due to the risk factors.

Bio-active molecules such as phlorotannins, terpenes, and lipophilic compound extracted from seaweeds depict anti-oxidant and antimicrobial activity against gram positive and negative bacteria. Hence, they find their applications in the field of biomedicals as a natural antimicrobial agent.

Future prospects

Seaweeds are being used as food in many Asian countries. However, the increasing scientific evidences suggests its wider application in various sectors such as biomedical, nutraceutical and cosmetic arenas. However, Apart from all the scientific aspects, another important lacuna associated with the seaweed research is the considerably low consumer awareness about health

benefits of seaweeds. Hence, these all issues need to be properly addressed before this resource can be trapped for its benefits at a large scale.

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