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Nutraceutical Application, Bioactive Compounds and Health Benefits of Seaweeds

D.Beula Shiny[1*], J.Vijila Jasmin[2], S. Sujithra[3], M.Jenifer Tamizharasi[4], T.Kumaran[5]

[1,2,3,4,5]PG & Research Department of Zoology, Muslim Arts College, Thiruvithancode, Kanyakumari, Tamilnadu, India.*

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Abstract: ***Human activities lead to many changes in the environment, which ultimately upset the natural balance between living organisms and encourage disease causing pathogens to multiply rapidly, thereby increasing the risk of disease outbreak. Natural resources have become the focus of drug research to deal with the pathogenic microbes, which in many cases, provided vital leads for the development of synthetic compounds. Seaweed is a rich source of nutrients included in Asians traditional cuisine and is being extensively explored for its other merits as a food. Apart from its proven nutritional properties, bioactive molecules found in seaweeds have attracted the interest of health conscious societies. At present, there is a high demand for seaweeds as many quarters have begun consuming healthy and 'natural foodstuffs', mainly because seaweeds are rich in minerals, vitamins and proteins.***

Key words: Natural Resources, Seaweeds, Disease Outbreak, Bioactive, Nutrients

1. INTRODUCTION

Seaweed, also called as algae, is taxonomically classified under four groups namely: red algae (rhodophyta), brown algae (phaeophyta), green algae (chlorophyta), and blue-green algae (cyanophyta). Macroalgae, which include above three groups of seaweed other than blue-green algae, have a long history of utilization as direct or processed food across the globe. Seaweeds are traditionally used in human and animal nutrition. Little information is available on the nutritional value of algal proteins and, especially, on the compounds that decrease their digestibility. The optimal advantage of seaweed is that it is a phenomenal source of a nutrients missing in almost every other food. Algae extracts have been utilized for treatment in medical conditions since ancient times. Traditionally more concentrated on biologically active compounds of Seaweeds (fucoidan, alginic acid, carotenoids, phlorotannins, and peptides) have been demonstrated to play an emergent role in eradication of certain degenerative diseases such as cancer, inflammation, arthritis, diabetes and hypertension.

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Seaweeds

Recently, scientific research is exerting more attention on applications of seaweeds in the field of health food, medicines, pharmaceuticals, textiles, fertilizers, animal feed etc. due to their potentiality as valuable source of nutrients and bioactive molecules of human healthcare importance. The major nutritive value of seaweeds is due to their high mineral (iodine, calcium) and soluble dietary fiber contents, the occurrence of vitamin B12, n-3 PUFA, functional amino acids and specific components such as astaxanthin, fucoxanthin, βcarotene, fucosterol, phlorotannin, etc (Burtin, 2003). Most Asian countries such as India, China, Japan and Korea have consumed these seaweed species as medicinal foods, dietary supplements and fortified products for human consumption through their diets. This is due to the biologically active compounds present in these species, such as carbohydrates, dietary fibers, vitamins, minerals and others that provide great human health benefits and deputized for an inexhaustible source of materials for the nutraceutical applications (Cotas *et al.,* 2020).

Seaweed nutrients

Seaweeds are rich sources of many trace elements, minerals, protein, iodine, bromine, vitamins, polysaccharides, bioactive substances and micronutrients (Chapman and Chapman, 1980). Seaweeds are used as food in many countries like Malaysia, Indonesia, Korea, Australia, Japan and Singapore especially in the form of salads, soups, jellies and in vinegar dishes and its use as food and medicine prior to 2000 BC has found a mention in ancient Chinese medicinal literature (Abbott, 1996). The species used as food includes *Caulerpa sp., Codiurn sp., Hydroclathurn sp., Sargassurn sp., Porphyra sp., Laurencia sp.* And *Enterornorpha, Gradiaria, Sargassurn, Padina* and *Dictyota* sp. are used as feed for cattle and poultry (Qasim, 1998).

Nutraceuticals

Generally, a nutraceutical compound is defined as a compound that will intensify the food products' benefits when added. Meanwhile, cosmeceutical compounds will add a therapeutic value on cosmetic products (Cotas *et al.,* 2020). Seaweeds not only possess nutrient potentials but also nutraceutical potentials like antioxidant, antimutagenic, anticoagulant, anticancerous and antibacterial activity. Hence, seaweeds can be considered as futuristically promising plants forming one of the important marine living resources of high nutritional value and nutraceutical potentials.

Seaweeds are low in calories from a nutritional perspective. The lipid content is low, and even though the carbohydrate content is high, most of this is dietary fibres and not taken

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up by the human body. Cofrades S. et al (2010) studied about nutritional and antioxidant properties like total dietary fiber(TDF), mineral contents, fatty acid and amino acid profiles, polyphenolic concentration and antioxidant activity of two brown (Himanthalia elongate and Undaria pinnatifida) and red (Porphyra umbilicalis) seaweeds. Skrovankova S. (2011) indicated seaweed vitamins as nutraceuticals. He reported that seaweed vitamins are important not only due to their biochemical functions and antioxidant activity but also due to other health benefits such as decreasing of blood pressure(vitamin C), prevention of cardiovascular diseases (beta-carotene), or reducing the risk of cancer (vitamins E and C, carotenoids). Misurcova L, et al.(2010) reported seaweed minerals as nutraceuticals. PUFAs effectively reduce the risk of cardiovascular diseases, cancer, osteoporosis, and diabetes. Nevertheless, growing requirements of healthy functional foods have led to produce PUFAs as nutraceuticals in controlled batch culture of marine microalgae, especially Thraustochytrium and Schizochytrium strains. Kasimala M. B. et al.(2015) studied on biochemical composition and nutritional aspects of seaweeds. They reported the importance of seaweed by their high protein content, which are more important for the food industry. Sea weeds are good additive to improve the nutritive quality of various foods.

Uses of seaweeds

The seaweeds have immense biomedical potential and have been used in folk medicine for a variety of remedial purposes such as in eczema, gallstone, gout, scrofula, cooling agent for fever, menstrual trouble, renal problems, scabies etc. (Hoppe, 1979).The sulphated galactan polymers, agar and carrageenan, obtained from various red seaweeds, have been used for gelling and thickening in confectionary and food industries and as stabilizer for the preparation of cheese and salad. Agar is also used as a drug vehicle medium, in bacterial, fungal culture and as constituents of skin creams and ointments. Alginates have been used in the manufacture of tablets, pills, ointments, tonics, creams, making of dental molds and as denture fixative (Kaliyaperumal, 2003).

Seaweed Flora of India

With a coastline of about 7,500 km, the Indian subcontinent has some of the longest uninterrupted coastal ecosystems in the world which support rich seaweed diversity. Most important seaweeds in India in terms of ubiquitous nature are Ulva and Caulerpa among greens, Hypnea and Kappaphycus among reds and Sargassum and Turbinaria among browns. The coasts of Gujarat, Kerala and Tamil Nadu have most of the seaweeds described in India (Subba Rao and Mantri, 2006)

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Edible seaweeds

Edible seaweed in foods Red macro-algae (Gracilaria spp.) are used as a fresh food. Species commonly marketed include G. coronopifolia, G. parvispora, G. salicornia and G. tikvahiae, however, these seaweeds have a short postharvest life of about 4 days (Paul and Chen, 2008). Seaweeds are a rich source of phytochemicals having anti-oxidant and antimicrobial properties. Presence of fibres and minerals helps in improving the mineral content reduces the salt content. The adding of seaweeds or their extracts to food products will help in reducing the utilization of chemical preservatives (Gupta and Abu-Ghannam, 2011). Edible sea weeds contain various bioactive compounds with potential health benefits and their use as functional ingredients opens up new prospects for food processing, meat product formula tions included. Seaweeds basically contain high proportions of polysaccharides along with various other potentially beneficial compounds such as good-quality protein and essential fatty acids, particularly long-chain n-3 polyunsaturated fatty acids (PUFAs).

Seaweeds are considered as a source of bioactive compounds as they are able to produce a great variety of secondary metabolites characterised by a broad spectrum of biological activities. Compounds with antioxidant, antiviral, antifungal and antimicrobial activities have been detected in brown, red and green algae (Bansemir *et al*, 2006). The environment in which seaweeds grow is harsh as they are exposed to a combination of light and high oxygen concentrations. These factors can lead to the formation of free radicals and other strong oxidising agents but seaweeds seldom suffered serious photodynamic damage during metabolism. This fact implies that seaweed cells have some protective mechanisms and compounds.

Phenolic compounds

Phenolic compounds can act as antioxidants by chelating metal ions, preventing radical formation and improving the antioxidant endogenous system. The term “phenolic compound” describes several hundred molecules found in edible plants that possess on their structure a benzenic ring substituted by, at least, one hydroxyl group (Manach *et al*, 2004). These phenolic compounds are commonly found in plants, including seaweeds. Polyphenols represent a diverse class of compounds including flavonoids (i.e. flavones, flavonols, flavanones, flavononols, chalcones and flavan-3-ols), lignins, tocopherols, tannins and phenolic acids (Shukla *et al*, 1997).

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Vitamins

Seaweeds species have been in high demand in cosmeceutical as they contain high carbohydrates, proteins, fiber, vitamins, minerals and low-fat content. Also, seaweeds are an excellent source of B group vitamins (B1, B2, and B12), vitamins with antioxidant activities, vitamins C and E, provitamin A and carotenoids (Škrovánková, 2011). Sufficient and good nutrition is the key to a healthy lifestyle. Intake of nutritious food keeps diseases at bay, apart from enhancing the well-being of a human. Nutritional deficiency often occurs among the elderly, which may cause them to suffer from nutritional anemia, such as iron, folate and vitamin B12 (Shahar, Budin, Bakar, Umar, & Halim, 2005). Besides, the world has reported multiple issues related to health, such as vitamin deficiencies that affect all ages, including pregnant and lactating women.

The availability of vitamins, minerals and trace elements is labelling this green seaweed as a potent nutritive biomass for the healthcare of young children and pregnant women. Strict vegetarians are more susceptible to vitamin B12 deficiency since they limit meat consumption (Bo et al., 2019). As stated by Ganesan, Tiwari, and Rajauria (2019), algae contain the highest amount of both essential and non-essential vitamins. For example, vitamin B12 content is higher in microalgae *Chlorella*, Nearly 60 % of active vitamin B12 aggregated coenzymes from the macroalgae nori (Ganesan et al., 2019). Subramanian, Manivannan, Sona, Ravi, and Sasikala (2015) highlighted the vitamins A, B1 and B2 contents in *U. rigida* and *U. lactuca*, respectively. Therefore, the algal species is a promising species that acts as an alternative source of vitamins in the future, especially to older people and strict vegetarians, which later can be exploited in the nutraceutical industries.

Bioavailability of seaweed minerals

The biological availability of minerals depends on the diet composition and is influenced by the levels and forms of present nutrient or nonnutrient components, and finally by nutrient synergistic or antagonistic interactions (Watanabe et al., 1997). Dietary form of nutrient determines the extent of its utilization. Mineral bioavailability is defined as a part of the ingested nutrient that is absorbed and consecutively utilized by humans for maintaining normal physiological functions (Fairweather-Tait and Hurrell, 1996). The best iron source is iron from animal sources or heme iron (Whittaker, 2008). Finally, reciprocal antagonistic or synergic behavior between minerals affects the range of mineral absorption in seaweed by binding-site competition. In aqueous solutions, Fe impairs the absorption of Zn. On the other hand, Ca inhibits the absorption of Fe and Zn (Maret and Sandstead, 2006). Finally, food preparation and cooking could determine the final mineral content of the food by the loss of water-soluble minerals (Santoso et al., 2006).

Health Benefits

Seaweeds offer a wide range of therapeutic possibilities both internally and externally. Eating unprocessed dried seaweeds can yield many healing benefits. Many physical ailments in humans can be regularly resolved with the simple addition of seaweeds to their respective diets. The metabolic active compounds already isolated from seaweeds have helped in the development of new drugs against cancer, microbial infections and inflammation

Francisco, M et al., 2001). Preventing disease outbreaks or treating the disease with drugs or

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chemicals tackles these problems. Nowadays, there is an increase in use of antibiotics due to heavy infections and the pathogenic bacteria becoming resistant because of indiscriminate usage of antibiotics. Study on rats has shown that simultaneous consumption of fish (fish oil) and brown seaweeds decreases the concentration of triacylglycerol in the serum and liver. Dyslipidemia is a main cardiovascular risk factor for coronary heart disease incidence and mortality. Lipid disorders can accelerate the atherosclerosis process and result could bechronic heart failure. Nutraceuticals are effectively able to reduce the atherosclerosis process and coronary heart disease progression. Carotenoids are produced by seaweeds, plants and microorganisms. Brown algae contain α, β and δ tocopherol while the green and red algae contain only the α tocopherol where the α and δ tocopherol help in the prevention of cardiovascular disease.

Seaweeds and their organic extracts contain various bioactive compounds with potential health benefits (Rindi et al., 2012). Marine seaweeds that are capable of reducing postprandial hyperglycemia by inhibiting enzymes such as α-amylase and αglucosidase is found to be an effective strategy for the management of diabetes (Etxeberria et al., 2012). Recently, seaweeds and their bioproducts are getting greater attention toward the treatment of diabetes as studies have proven their capabilities on that matter (Lordan et al., 2013). There is an improved interest in natural substances with valuable medicinal properties, such as terpenoids (Yermakov, 2010) as some of the terpenes are one most potent drugs against life threatening diseases. Triterpenic acids exhibit various biological and pharmacological activities, including antiinflammatory, antimicrobial, antiviral, cytotoxic, and cardiovascular effects (Shaban et al., 2012; Sumayya and Murugan, 2019).

2. CONCLUSION

Seaweeds are becoming one of the most desirable natural sources for obtaining biological compounds due to their high potential for producing novel nutraceutical and cosmeceutical products. In the current research, the focus is more on the cultivation method of seaweed that will give a higher concentration of bioactive compounds, which correspond with the bioactive compounds from wild seaweed. Likewise, the optimization of the extraction method needs also to be further studied to yield better quality and quantity of the extract. Also, it is crucial to develop an optimized extraction method that will help industries obtain more than one compound to create value added to the products. This review has emphasized the biological compounds, biological activities, and application in the industries that might also benefit future researchers in improving *Chlorophyta* sp. cultivating methodology and optimizing extraction methods. Though the nutritional properties and healthcare benefits are promising, there is little documentary evidence and awareness on utilization of seaweeds, especially available in Indian Waters, for the industrial scale extraction of novel biomolecules and food formulation ingredients. The nutrients and bioactive molecules present in seaweeds could be developed as nutraceuticals, chemopreventive agents and therapeutic drugs.

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