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Seaweed Composition and Potential Uses

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Abstract : This article presents information on the chemical components of seaweeds, proteins, amino acids, minerals, lipids, vitamins, dietary fiber, antioxidant, anti-bacterial and anti-fungal compounds are reviewed in relation to potential food and medicinal uses. The nutritive values of seaweeds are briefly discussed for uses as a food. Bioactive compounds found in seaweeds are also discussed for pharmaceutical uses.
Keywords : seaweed, biochemical composition, food resources, pharmaceutical resources.

Introduction

Seaweed is a marine algae, it is growing from natural shock or pond culture. Seaweeds have no true roots and leaves. They are attached to substrates such as sand, mud, rocks and shells or ranging from tide level to considerable depths in the ocean and seas. Currently seaweeds are used in food, chemical, textile, agriculture industries including pharmaceuticals and medicine [1]. Some European countries, like France to establish a specific regulation concerning the use of seaweeds for human consumption as a nontraditional of mineral elements, macro elements and trace elements as they have rich dietary fibres, carbohydrate content, low calorie, excellent source of vitamins A, Bl, B12, C, D, E, riboflavin, niacin, pantothanic acid and folic acid, as well as minerals such as Ca, P, Na, and K and vitamins A and C and bio-protective features such as antioxidants and antimicrobials[2,3,4]. Seaweeds contain all or most of the essential amino acids needed for life and health [1]. Seaweeds are could be used as part of the daily diet. Seaweeds classified into three classes: green algae (Chlorophyta), brown algae (Phaeophyta) and red algae (Rhodophyta) [5]. Currently, human utilization of green algae (5%), brown algae (66.5%) and red algae (33%) is high in the Asian countries [6].

Various Components of Seaweed

Protein and amino acids

Proteins with adequate amounts of essential amino acids are main factors creating the nutritional value of food. Red and green seaweed have high protein content compare with brown seaweed and the average reaches 10-30% dry matter [7,8,9]. The red seaweed such as Dulse and Nori have relatively high protein

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range from 35-47% dry matter and form a large part of their chemical composition [7, 8, 10]. Conversely, brown seaweed has low protein content between 5 and15% [8, 11]. Seaweed proteins as well as plant proteins contain all the essential amino acids.

Amino acids are structural units of protein, except from this main function, they are also play important roles in many metabolic pathways [12]. Alanine, glutamic acid and glycine are the main constituents of seaweed flavor. Phycoerythrin and phycocyanin are light-harvesting photosynthetic pigments. Phycobiliprotein has antioxidant propertie, it could prevent of neurodegenerative diseases, cancers and gastric ulcers caused by oxidative stress [8].

Minerals

Seaweeds are important source of minerals because they have ability to absorb inorganic substances from the environment. This ability is regarded with the presence of polysaccharides in seaweed cell walls and also is capable of predestine a lace of mineral storage in different parts of seaweed tissue [13, 14]. Red seaweed has more cationic sites than brown seaweed so it could show the low similarity for positively charged metal ions such as cadmium, but higher similarity for hexavalent chromium [14].

The contribution of red seaweed *Porphyratenera* of iron to recommended daily intake (RDI) was 146.6%. Seaweed contribution of copper and manganese to recommended daily intake (RDI) ranges from 0.4 to 63.6% and 0.6 to 82.3%, respectively[11, 15]. The highest value of copper was observed in green seaweed *Ulva reticulata* and the highest amount of manganese was established in red seaweed *Porphyratenera*[15, 16]. However, seaweed is a weak contributor of zinc to RDI. The maximum percentage of 30.7% zinc to RDI was observed in red seaweed *Porphyra*sp. [11]. The effect of interaction between toxic metals and macroelements in seaweed has also been observed. The bioabsorption of cadmium considerably decreases with growing concentration of calcium ionts. The correlation between cadmium and copper, cadmium and zinc as well as between lead and iron has been established [17].

Vitamins

Seaweed is an important source of some water-soluble and lipid-soluble vitamins. Some green and brown seaweed contain high amounts of vitamin C on average between 500 and 3000 mg/kg dry matter. This level of vitamin C is comparable with the content of this vitamin in significant vegetable sources of vitamin C such as parsley and red pepper [8]. The majority of red and brown seaweeds contain other water-soluble vitamins of the B group, particularly thiamine and riboflavin. The riboflavin content and thiamine contents are similar in seaweed. In red seaweed *Porphyra umbilicalis*a content of 3.4 mg/100 g dry matter of riboflavin was determined [18]. However, in brown seaweed *Undaria pinnatifida* different contents of this vitamin were observed. The higher concentration of 11.7 mg/100 g dry matter was determined by in contrast to 1.35 mg/100 g dry matter was documented [18, 19]. Seaweed is a significant source of fat-soluble carotenoids (as provitamins of vitamin A) and vitamin E and. Vitamin E has strong antioxidant activity and its unique function is lipid membrane protection from peroxidation. It exists in eight forms: α, β, γ, δ-tocopherols and α, β, γ, δ-tocotrienols. The α-forms show the highest antioxidant effect [20]. Carotenoids are represented by different pigments which formthe resulting seaweed color together with chlorophyll. Fucoxanthin, β-carotene and violaxanthin are found in brown seaweed. The main carotenoids of red seaweed are α- and β-carotene and their derivates such as zeaxanthin and lutein. Green algae have a similar composition of carotenoids in comparison to higher plants. The main part of carotenoids of brown seaweed is formed by β-carotene, lutein, violaxanthin, anteraxanthin, zeaxanthin and neoxanthin[8]. Red seaweed *Gracilaria changi* is a good potential source of β-carotene due to established high content of 5.2 mg/100 g, which is in comparison with 6.8 mg/100 g in carrots [2].

Lipids

Seaweed has very small amounts of lipids, ranging between 1 and 5% of dry seaweed matter. However, the main parts of lipids are polyunsaturated ω-3 and ω-6 fatty acids, which effectively reduce the risk of diabetes, osteoporosis and cardiovascular diseases [21]. Red and brown seaweed predominantly include the polyunsaturated 20 carbon-fatty acids eicosapentaenoic acid (EPA, ω-3, C 20:5) and arachidonic acid (AA, ω-6, C 20:4) [2, 22].

Dietary fiber

Seaweed polysaccharides are an extensive group of compounds with various biological functions. From the nutritional point of view, seaweed polysaccharides play a significant role as dietary fiber (DF). Based on their chemical structures and functions, Seaweed polysaccharides can be divided into storage and structural polysaccharides. Starch is the major storage polysaccharide of green seaweed. It is placed in the chloroplasts of green algae as semicrystalline granules [23]. Floridean starch is the most important storage polysaccharide of red seaweed. It has a comparable structure as starch without amylose. But, it was verified that some species of red algae form also amylase [24]. Laminaran is the main storage polysaccharide of brown seaweed. Its chemical structure is formed by (1,3)-*β*-Dglucan with *β*-(1,6) branching. Seaweed is rich in dietary fiber (DF), which is associated with the reduction of LDL-cholesterol in plasma and could influence the glycemic response.

Antioxidant compounds

The ability of *Sargassum siliquosum* to prevent the starting of free radicals to cause cellular damage in *vitro*. They obtained *S. siliquosum* has a significant free radical scavenging activity against OH, NO and H_2O_2 radicals by taking different scavenging methods[25]. Strong antioxidant activity of both the extracts of acetone and chloroform extracts of *Gracilaria verrucosa* was fined out by the DPPH scavenging potential against Butylated hydroxyl toluene (BHT). The strong antioxidant capacity of these extracts might attribute to the presence of phenolic compound and flavonoids [26]. *Sargassum wightii Greville* (Sargassaceae) is a main source of alginic acid used extensively in food and drug industries. Successive extraction of *S. wightii*has antioxidant properties .The reducing power of the seaweed was assessed by ferric reducing antioxidant power and reducing power assay [27]. It was reported that phlorotannins and fucoxanthin are active compounds from brown seaweeds with anti-oxidative properties. Different phytochemicals like steroids, alkaloids, phenolic compounds, saponins, flavonoids and anthroquinones obtained from brown seaweed *Sargassum wightii*. *Sargassum wightii*is one of the important species demonstrates a good amount of flavonoids in support of its antioxidant activity [28]. Estimated the high concentration of flavanoid was effect on antioxidant activity of two seaweeds methanolic extract S. wightii and U.lactucathe[29]. The total flavanoid content was decided by evaluation of the total phenolic contents (TPC) analysis by taking gallic acid as standard. The total flavanoid content of methanolic extract in *Ulvalactuca* and *Sargassum wightii*was 1.35±0.04mg GAE/g and 2.02±0.07 mg GAE/g respectively. The total antioxidant activity of methanolic extract of S. wightii was higher than *U. lactuca*. The flavanoid content and molecular structure position of hydroxyl groups of both these alga are possibly effect on antioxidant activity.

Antibacterial and antifungal compounds

Methanol crude extracts of *Gracilaria corticata* against Fungus and Human Pathogenic Bacteria as compared to other solvent extracts[30]. The results were pointed out the seaweed extracts having traditional maintains of effectiveness and could serve as useful source of new antimicrobial agents. Antibacterial activity of five different solvents like methanol, acetone, chloroform, and hexane ethyl acetate extracts of *Gracilaria corticata* was assessed against pathogenic bacteria *Streptococcus pyogenes, Staphylococcus aureus, Streptococcus epidermis, Klebsiella pneumoniae* and *Enterobacteraerogenes, Bacillus subtilis and Bacillus cereus.* The methanol extract demonstrated the biggest region of inhibition against Gram positive bacteria as compare to Gram negative bacteric. The methanolic extract of *Gracilaria corticata* showed highest mean zone of inhibition against the Gram positive cocci and the Minimum inhibitory concentration (MIC) values of *Gracilaria corticata* against bacteria was ranged between 1.25 to 80 mg and ml.

The antibacterial activities of methanolic extracts of two brown seaweeds *Turbinaria ornate and Sargassumwightii*[31]. The antibacterial activities were exanimate against various Gram and human pathogenic microbes counting nine pathogens for example *Aeromonas hydrophila, Bacillus subtilis, Enterococcus faecalis, Escherichia coli, Klebsiella pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa, Shigella flexneri* and *Staphylococcus aureus*. This activity because of Phenolic compounds and polyphenols are affect growth and metabolism of bacteria, finding recommend that methanol extracts of *T. ornate* could be used as a best source of antimicrobial agent.

Antibacterial Properties of different extract of green Seaweeds such as *Codium adherens, Halimeda tuna and Ulva reticulate* from Vedalai Coastal Waters. These organisms have antibacterial effect on gram and bacteria. The ethanol extract demonstrates the highest antibacterial activity was against *Staphylococcus* species[32].

Seaweed Use in Foods

Seaweeds are utilized as additives in their food preparation. seaweeds are used as food and medicine apart from their importance as a hydrocolloids source in Malaysia because of it has important components for human nutrition[33, 34, 35, 36]. Besides, seaweeds have been used for soups, salads and also as low-calorie foods. Even though most Malaysians show little interest in consuming seaweeds, however it is consumed by small pockets of the people along the coastal areas of Peninsular Malaysia and East Malaysia [33]. There are many economically valuable species of seaweeds that have been utilized as vegetable and medicine, one of which is to *Kappaphycus alvarezii.*

Kappaphycus alvarezii is red seaweed which comes under the class Rhodophyceae and is widely cultivated in many countries [37]. Kappa carrageenan is derived from *Kappaphycus alvarezii* and it is commercially important as a phycocolloid that is extensively applied as a thickening and stabilizing agent in food, pharmaceutical and cosmetic industries and needed for its cell wall polysaccharide, in addition, it has been used in health beverages and anticancer nutraceutical because of its antioxidant content and other nutritive compounds [38, 39]. Marine red seaweed *Kappaphycus alvarezii* are the main seaweeds found in Malaysia and cultivated on a large scale in the coastal areas of Sabah and is sold in the local markets[40]. The seaweed industry has been identified by the government for priority development in Malaysia. It is consumption as salads, soups and puddings. Recently, health drinks, cordials, jelly cups, jams, chilli sauce and shampoo, have been produced from the *Kappaphycus alvarezii*.

Seaweed Use as a Medicinal Source

Seaweeds are a critical source of minerals and they are little in sodium, seaweed extractions have been used in wound dressings, also they may be used in heart conditions due to cholesterol reduction and appetite suppression. Aqueous extract from some Mediterranean brown seaweeds such as *Cystoseira crinita*, *Cystoseira sedoides* and *Cystoseira compressa*, and antiproliferative activity was studied on normal cells (MDCK and rat fibroblast) and cancer cell lines (A549, MCF7 and HCT15), because of antiproliferative compounds are exist in those extracts like sulfated polysaccharides, phlorotannins, terpenes[41]. Also, this research observed the antioxidant and anti-inflammatory effects of those extracts, the result explained that they have high antioxidant and anti-inflammatory activities.Significant difference in liver total protein and glycogen level after *Padina boergesenii* extract treatment in Streptozotocin induced diabetes in rats[42]. The aqueous extract of P. boergesenii reduced gluconeogenesis by the activity of gluconeogenic enzymes such as fructose -1, 6-diphosphatase and flucose-6-phosphatase, and raised the activities of the key glycolytic enzymes such as phosphoglucoisomerase, hexokinase, and aldolase in liver. Pharmacological properties of bryozoan extract by using standard methods on albino rats, and they found that the bryozoan extract had antipyretic, analgesic, anti-inflammatory, dose dependent and Central Nervous System (CNS) stimulant activity[43]. The antimicrobial properties against human pathogenic bacteria and fungus of crude extracts of *Gracilariacorticate*[44].The results were explained the seaweed extracts having traditional claims of effectiveness and could serve as useful source of new antimicrobial agents.

Anti-infectious activity of various seaweed extracts in vitro against both gram positive and gram-negative bacteria. results indicated that reactive antioxidant molecules like ascorbate and glutathione (GSH) are occur in fresh seaweeds to synthesize bioactive metabolites, in addition to carotenoids (α and ß carotene, fucoxanthin, astaxanthin), mycosporine like amino acids (mycosporine glycine) and catechins, gallate, phlorotannins and tocopherols are worked as anti-infectious and antioxidant compounds in secondary metabolites[45]. The anticancer activity of *Sargassum oligocystum* water extract against human cancer cell lines had observed [46]. The result showed that different concentrations of the alga extract have most effective antitumor activity against Daudi and K562 cell lines. The remarkable antitumor activity has been shown at the extracts of brown alga *Sargassum oligocystum.* Cytotoxic and antitumor properties of these species belong to different structural types: functions of the immuno organs and anti-oxidative capacity can be improved by terpenes, nitrogen containing compounds and polysaccharides from Sargassum. Alginic acid is major component in the Sargassum wightii Greville (Sargassaceae) which is widely used in food and drug industries. Successive extraction of S. wightii have high antioxidant properties. Different phytochemicals like alkaloids, phenolic compounds, flavonoids, steroids, saponins and anthroquinones of brown seaweed Sargassum wightii which has wide range of bioactive properties. Anti-ulcer activity of bryozoan extracts had evaluated [47, 48]. This extract increases pH, decreases total acidity, volume of gastric juice, serum alkaline phosphatase level and the

serum calcium level. The alkaline phosphatase related with bone diseases, liver diseases and gastrointestinal lumen containing gastrointestinal ulceration, therefore, the decrease in alkaline phosphatase level due to the bryozoan extracts shows anti-ulcer characteristics.

Conclusion

Seaweeds are natural richness in minerals, vitamins, polyunsaturated fatty acids and their low content lipids as well as high content of bioactive molecules. They can serve as good source of healthy food. Also seaweeds may solve the problems of deficiency of protein, carbohydrate and mineral deficiency in human nutrition by consuming them in daily life. Furthermore it is potent source of human health due to active constituents that is responsible for various pharmacological activities. Seaweed could be exploited for its multi-functional properties in the form of food and medicine.

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