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A review on Antioxidant activity of marine organisms

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Abstract: The marine environment provides a broad range of diverse habitats from which novel sources of natural products can be derived. Marine organisms produce a diverse array of metabolites with novel chemical structures and potent biological activities. Antioxidants are man-made or natural substances that may prevent or delay some types of cell damage. These molecules protect the cells from the damage caused by unstable molecules known as free radicals. Marine bacteria have not been examined for antioxidant compounds as extensively as terrestrial bacteria. It was reviewed that the bioactive metabolites extracted from seaweed and sponges and their associated bacteria had good antioxidant activity which needs extensive attention in terms of drug discovery.
Keywords: Antioxidants, Bioactive metabolites

Introduction

The marine environment has proven to be a rich source of chemical and biological diversity and marine organisms are highly potential sources of commercializing interesting compounds for applications towards food industry, cosmetic industry, neutraceuticals, pharmaceutical industry and other industrially important compounds [1]. Bioprospecting marine macro algae or seaweeds, sponges and their associated organisms for secondary metabolite production are a promising area in marine biotechnology. The marine environment has enormous potential of marine based products is the key for successful innovation in exploiting the vast diversity of marine life. However, despite the great potential of marine microorganisms the major challenge for marine biotechnologists is the production of sufficient amount of products of constant quality at an affordable price [2]. The marine ecosystem is still an untapped reservoir of biologically active compounds, which have considerable potential to supply food ingredients towards development of new functional foods. With the goal of increasing the availability and chemical diversity of functional marine ingredients much research has been developed using biotechnological tools to discover and to produce new compounds. Among the marine organisms, seaweeds and sponges represent one of the richest sources of natural antioxidants and antimicrobials [3]. Marine sponges, seaweeds and their associated bacteria produce bioactive compounds which have been found to be important for health promotion and disease prevention. These beneficial effects can be attributed to the complex mixture of phytochemicals which possess antioxidant, antimicrobial, anticancer and antiviral activity. The compounds responsible for these activities comprise phenolic compounds, sulphated polysaccharides and organic acids [4]. The antioxidants generally produced by marine environment include polyphenolic compounds such as flavonoids, cinnamic acid, benzoic acid, gallic acid, phlorotannins and quercy [5]. The result of oxidative stress to the cells and tissues of the body caused by reactive oxygen species (ROS) arises mainly as a result of metabolic activity of the human body during the aging process. ROS also results in lipid oxidation which is the main reason for deterioration of quality in lipid-containing foods during storage. The use of antioxidants is an

effective way to minimize or prevent lipid oxidation in food products, retarding the formation of toxic oxidation products, maintaining nutritional quality and prolonging the shelf life of foods [6]. Marine organisms as producers of substances are useful for the treatment of human diseases. Though a large number of bioactive substances have been identified, only few drugs from the oceans are approved [7]. Secondary metabolites from marine environment are often produced only in trace amounts so a large quantity of sources must be collected to obtain sufficient amounts of the target compound.

Antioxidants

Free radicals are any chemical species capable of independent existence with one or more unpaired electrons in their outermost shell, which seek out and capture electrons from other substances to achieve neutrality. Although the initial attack causes the free radical to become neutralized, another free radical is formed in the process, resulting in a chain reaction. If two radicals meet they can combine their unpaired electrons, thus forming a covalent bond. Reactive oxygen species (ROS) refers to an array of metabolites derived from molecular oxygen (O_2). These cellular renegades damage DNA, proteins, and lipids, altering biochemical compounds and corroding cell membrane. Such molecular mayhem plays a major role in the development of various diseases such as cancer, atherosclerosis, and respiratory ailments. The antioxidant capacity of compounds has been related to the prevention of several diseases including cancer, coronary heart diseases, inflammatory disorders, neurological degeneration, and aging. Polyphenolic compounds are among the interesting antioxidant compounds isolated from marine resources, including micro and macroalgae. At least 8,000 different bioactive compounds are considered to be polyphenols. In general, phenolic compounds are divided into ten types, based on their structure. These ten groups are: simple phenols, phenolic acids, hydroxycinnamic acids, coumarins, naphtoquinones, xanthones, stilbenes, anthraquinones, flavonoids, and lignins. Among them, flavonoids are the group known to have the greatest number of different structures, and at least 5,000 flavonoids have been characterized and referenced. To date, most polyphenols isolated from marine sources and referenced in the literature are of macro and microalgal origin [8]. These polyphenolic compounds ranges from phenolic acids and other polyphenolic compounds with relatively simple chemical structures, to the more complex structures of phlorotannins, typically isolated from brown algae belonging to the Phaeophyceae class, and which consist of polymeric structures made up of units of phloroglucinol (1,3,5-trihydroxybenzene). It is understood that the intensity of the antioxidant activity of these complex polyphenols is related to the degree of polymerization of the polyphenol. In general, lower degrees of polymerization result in greater antioxidant activities. In addition to their strong antioxidant activities, phlorotannins are known to possess other activities including antibacterial, chemopreventive, UV- protective, and antiproliferative effects. They are also known to act as detoxifying agents against heavy metals, and have myriad other bioactivities that could potentially be exploited for use in functional foods. Addition to polyphenolic compounds, other interesting antioxidants, such as carotenoids is a family of natural pigments that are widely distributed in nature. Carotenoids possess other bioactivities and are thought to be active agents for the prevention of cancer cardiovascular diseases, and macular degeneration [9].

Antioxidants from marine

Marine environment contain various kinds of inorganic and organic substances which probably benefits human health. Particularly, certain edible seaweeds contain significant quantities of lipids, proteins, vitamins, and minerals [10]. These seaweeds and sponges are virtually fat free, low-calorie, and one of the richest sources of minerals in the vegetable kingdom. There is no family of foods more protective against radiation and environmental pollutants than seaweeds and sponges [11]. In recent years, marine sulfated polysaccharides have been demonstrated to have antioxidant activity. Sulfated polysaccharides comprise a complex group of macromolecules with a wide range of important biological properties. Marine algae are the most important source of non animal sulfated polysaccharides. Sulfated polysaccharides from algae possess important pharmacological activities such as anticoagulant [12], antioxidant, and anti-inflammatory, antiviral, antibacterial, anti-proliferative, antitumor, anti-complementary, and anti-adhesive activities. In recent years, algal sulfated polysaccharides, especially those extracted from phaeophyta, have been of interest. They have been demonstrated to play an important role as free radical scavengers and antioxidants for the prevention of oxidative damage in living organisms [13]. Antioxidant activity has become a hot topic and the subject of intensive investigation due to the ever-increasing demand by the food and pharmaceutical industries to develop natural bioactive anti-aging and anti-carcinogenic compounds that demonstrate measurable health benefits. Antioxidative substances obtained from natural sources, such as seed oil, grains, beans, vegetables, fruits, leaf waxes, bark, roots, spices and hulls, have already been investigated. Hence, the present study was undertaken to

evaluate the antioxidant and antibacterial activity of the sulfated polysaccharides with respect to their free radical scavenging properties [14].

Seaweeds

The marine environment, which contains a vast array of organisms with unique biological properties, is one of the most underutilized biological resources. To date, algae and microalgae are referenced in the literature as sources of bioactive compounds for use as functional food ingredients. The huge diversity in terms of the number of different species of macro and microalgae that exist, coupled with the hostile environments in which these organisms live, makes macro and microalgae key targets for bioactive compound screening projects [15]. Algae comprise a complex and heterogeneous group of organisms characterized by their photosynthetic nature and their simple reproductive structures. According to their size, algae can be roughly divided into unicellular organisms, known as *microalgae* and multicellular organisms referred to as *macro algae.* Algae frequently live in extreme environments of light, salinity, and temperature. In order to adapt to these extreme conditions, most algae produce a high variety of secondary metabolites that often have potent biological activities. Most algae are relatively easy to cultivate or produce at industrial scale. Thus, the production of algal-derived biologically active compounds may be tuned by the selection of appropriate cultivation conditions, making these algae true natural bioreactors. Fresh and dry seaweeds are extensively consumed by people especially living in the coastal areas. From the literature, it is observed that the edible seaweeds contain a significant amount of the protein, vitamins and minerals, which are essential nutrition's for human. The nutrient composition of seaweed varies from species to species and is affected by the geographic areas, and seasons of the year and temperature of the water. Seaweeds have recently received significant attention for their potential as natural antioxidants. Most of the compounds of marine algae show anti-bacterial activities. Many metabolites isolated from marine algae have bioactive effects. Among different compounds with functional properties, antioxidants are the most widely studied. Moreover, the important role of antioxidants in human health has been demonstrated thus increasing the interest in such products and their demand by consumers. It has been suggested that the utility of various nutritional products from seaweeds includes antioxidants that are widely used as health food or nutraceuticals supplements. Marine bacteria often produce anticancer and antibacterial substances as a means of maintaining relationships between epiphytic micro environments, inhibiting competing organisms and microbial pathogens [16]. Many of these secondary metabolites are halogenated, reflecting the availability of chloride and bromide ions in seawater. Interestingly, bromide is more frequently used by algae for organohalogen production, although chlorine occurs in higher concentrations than bromine in seawater. Marine halogenated compounds comprise a assembly of compounds, ranging from peptides, polyketides, indoles, terpenes, acetogenins and phenols to volatile halogenated hydrocarbons. The principal agents responsible for the protective effects could be the presence of antioxidant substances that exhibit their effects as free radical scavengers, hydrogen-donating com-pounds, single oxygen quenchers and metal ion chelators [17]. Bioactive compounds have also been isolated previously from other marine organisms including crustaceans, fish, and there by-products produces [18]. Studies with fucans extracted from algae of different order confirm the heterogeneity of polysaccharides present in the algae. The sulfated polysaccharides possess antioxidant activity.

Seaweeds associated bacteria

Seaweeds surface supplies protected and nutrient rich conditions for the bacterial growth [19], so compare to other multicellular organisms, seaweed haven a rich diversity of associated microorganisms and these microorganisms maybe beneficial or harmful to the seaweeds**.** In particular, epiphytic bacterial communities have been reported as vital for morphological development of seaweeds, and bacteria with antibacterial properties are thought to protect the seaweeds from pathogens and surface colonization of other competition organisms. Since the late 1980s, more than 50,000 bioactive natural products have been discovered from marine microorganisms. Among these compounds more than 8,000 had bactericidal activity [20]. Marine bacteria often produce bactericidal compounds for maintaining the relationships between epiphytic bacterial communities and inhibiting microbial pathogens. Some bacterial species show host specificity and bactericidal activity against specific pathogens; this specificity engage complex biochemical interactions between seaweed and bacteria [21]. The seaweed associated bacteria have the ability to produced bioactive compounds may be useful in biomedical applications [22]. Seaweed and their surface associated microbial communities form complex and highly dynamic ecosystems. Several new bacterial species and genera have been described from seaweeds suggesting that seaweeds represent an interesting biotic environment for discovery of new bacterial taxa, even if the origin does not necessarily indicate a specific association [23]. Several phylogenetic studies have provided insights into the complex epiphytic bacterial communities associated with seaweeds [24]. Although comprehensive assessments of whole bacterial communities on seaweed surfaces are still relatively

scarce, the available data suggest that bacterial communities associated with seaweed are in some degree specific to the seaweed host [25]. The EPSs (exopolysaccharides) produced by marine bacteria have been utilized as ingredients in food products, pharmacy, petroleum industry and emulsification of crude oil, hydrocarbons, vegetable, mineral oils and bioremediation agents in environment management system [26]. Apart from these, they have also been implicated in biofilm formation in marine ecosystem thereby enhancing the survival of microbes under abiotic and biotic stress by influencing their physicochemical environment [27]. Bacteria are ubiquitous colonizers on the surface of seaweed and are reported to play important roles in their growth, development and reproduction [28].

Sponges

Sponges are also marine invertebrates that are most actively investigated in the efforts of finding marine natural products with anticancer properties. Sponges are the most primitive of the multicelled animals that have existed through a long evolutionary history of 700-800 million years. Sponges can provide potential drugs against many major worldwide occurring diseases. Sponges are known to produce bioactive metabolites as part of their defensive system. They occasionally develop symbiotic relationship with both algae and microorganisms and symbionts are to an extent the true source of secondary metabolites found in sponges. Seasonal changes influence various abiotic factors such temperature, pH, salinity etc. as well as biotic factors like morphology and epifaunal diversity ultimately responsible for the biosynthesis of secondary metabolites [29]. Sponges play a role in constructing the coral reefs since they contain active compounds. Moreover, active compounds in the sponges are higher than those produced by land vegetations. Thus far, it is not fully understood why, when, where and how these metabolites are produced in sponges. Many of these metabolites have been found to be cytotoxic or to process other other biological activities [30]. Sponges are considered as gold mine during the past 50 years, have fascinated scientists for isolation of promising bioactive compounds for human welfare. Although many bioactives have been discovered in sponges only a few of these compounds have been commercialized. Therefore, exploration of chemical ecology of secondary metabolites is a promising value and some of these secondary metabolites offer avenues for developing potent drugs [31].

Sponges associated bacteria

Some of the isolated substances from sponges have striking structural similarities to metabolites of microbial origin. Accumulated evidence suggests that microorganisms could well be the true producers. Later investigation proved that they are similar in structure to metabolites of sponge associated bacterial activity, suggesting that these metabolites are of microbial origin [32]. Secondary metabolites of sponge-associated bacteria might have a significant role in the chemical ecology of marine sponges and their homeostasis in the environment. The sponge symbiont relationship could be categorized as obligatory mutualism (i.e. the symbionts play an essential role in the metabolism of their host), facultative mutualism (they have a beneficial effect on their host, but the host will survive without the symbiont) or commensalism (they are present without providing obvious beneficial effects to their host). In the past decade, many studies have focused on the complex ecosystem of sponge associated microbial communities. The sponge-associated microorganisms have revealed high densities, amounting for some sponge species up to 37 % of the sponge biomass, which exceeded seawater concentrations by two-third orders of magnitude. More than 30 different phyla have so far been recognized in the domain *Bacteria* and *Archaea* as being associated with sponges. However, less than 1% of these microorganisms can be cultivated in laboratory conditions. Environmental stressors such as metal pollution, elevated seawater temperature or other climate changes and/or diseases are speculated as having a significant impact both on the symbiotic microbial community and on the health of sponges. Some of isolated bacteria have been specifically associated with marine sponges and are absent from the immediate surrounding seawater, reinforcing the concept of sponge specific microbes [33]. Although the mechanisms of symbiotic associations and their benefits remain poorly understood, the role of bacteria in nutrient uptake in the stabilization of the skeleton of the sponge and in chemical defence against predators or as antibiofouling agents have been suggested clearly. The suspected chemical defence role represented a real turning point in the search for new active marine biomolecules with potential medical and biotechnological applications. The major difficulty pertaining to the development of bioactive molecules concerns the possibility to ensure production at the industrial level. To solve this thorny problem of supply, different strategies have been explored, which have highlighted marine microbes as promising sources for drug leads. Several studies have demonstrated that numerous bioactive metabolites originally isolated from sponges, were in fact synthesised or transformed by bacterial strains. Therefore, the sponge-associated bacteria could constitute a renewable source of biomedical agents. As accumulated evidence suggests, it offers the possibility to use the sponge-associated bacteria for the production of biological active substances instead of the sponge itself. Because bacteria quite rapidly produce

high amounts of biomass, biological active secondary products can easily be produced in large amounts on a biotechnological scale without the necessity to harvest or cultivate the sponge [34].

Applications

The oceans are a unique resource that provides a diverse array of natural products, primarily from invertebrates such as sponges, tunicates, bryozoans, and molluscs, and from marine bacteria and cyanobacteria. As infectious diseases evolve and develop resistance to existing pharmaceuticals, the marine environment provides novel leads against fungal, parasitic, bacterial, and viral diseases. Many marine natural products have successfully advanced to the late stages of clinical trials, including dolastatin 10, ecteinascidin-743, kahalalide F, and aplidine, and a growing number of candidates have been selected as promising leads for extended preclinical assessment. Although many marine natural products have undergone clinical trials for cancer chemotherapy, drug resistance, emerging infectious diseases, and the threat of bioterrorism have all contributed to the interest in assessing natural ocean products in the treatment of infectious organisms [35].

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