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Review

Biological activities and potential health benefits of bioactive peptides derived from marine organisms

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ABSTRACT

Marine organisms have been recognized as rich sources of bioactive compounds with valuable nutraceutical and pharmaceutical potentials. Recently, marine bioactive peptides have gained much attention because of their numerous health beneficial effects. Notably, these peptides exhibit various biological activities such as antioxidant, anti-hypertensive, anti-human immunodeficiency virus, anti-proliferative, anticoagulant, calcium-binding, anti-obesity and anti-diabetic activities. This review mainly presents biological activities of peptides from marine organisms and emphasizing their potential applications in foods as well as pharmaceutical areas.

Contents

1. Introduction

The world's oceans, covering more than 70% of the earth's surface, represent an enormous resource for the discovery of potential therapeutic agents. During the last decades, numerous novel compounds have been found from marine organisms with interesting pharmaceutical activities [1–4]. Therefore, marine organisms are believed to be a potential source to provide not only novel biologically active substances for the development of pharmaceuticals but also essential compounds for human nutrition. In particular, marine peptides have attracted a great deal of attention due to their potential effects in promoting health and reducing disease risk.

These peptides have been obtained from algae, fish, mollusk, crustacean, and marine by-products including substandard muscles, viscera, skins, trimmings and shellfish. Marine bioactive peptides based on their structural properties, amino acid composition and sequences have been shown to display a wide range of biological functions including antioxidant, anti-hypertensive, antimicrobial, opioid agonistic, immunomodulatory, prebiotic, mineral binding, anti-thrombotic and hypocholesterolemic effects [5–9]. In this regard, the present review focuses on the biological activities of peptides derived from marine resources and their potential applications in functional foods, nutraceutical and pharmaceutical industries.

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2. Development of bioactive peptides derived from marine organisms

Components of proteins in marine foods are containing sequences of bioactive peptides, which could exert a physiological effect in the body. Especially, some of these bioactive peptides have been identified to possess nutraceutical potentials that are beneficial in human health promotion. Moreover, the possible roles of marine food-derived bioactive peptides in reducing the risk of diseases have been reported. Bioactive peptides usually contain about 3–40 amino acid residues, and their activities are based on amino acid composition and sequence. These short chains of amino acids are inactive within the sequence of the parent protein, but can be released during gastrointestinal digestion, food processing, or fermentation [10,11].

Bioactive peptides can be produced by in vitro enzymatic hydrolysis of different marine resources using appropriate proteolytic enzymes. Proteolytic enzymes from fish and aquatic invertebrates can be used for the hydrolysis process of marine products to develop bioactive peptides and applied in the food industry. The physicochemical conditions (temperature and pH) of the reaction media must be adjusted to optimize the activity of the enzyme used [12–14]. The crude proteinase was extracted from the pyloric caeca of tuna for the enzymatic hydrolysis of cod frame protein under optimal pH and temperature conditions of the respective enzymes to obtain maximum yield. Furthermore, the molecular weight of the bioactive peptides is one of the most important factors in releasing peptides with desired functional properties [15,16]. Therefore, a suitable method for the production of bioactive peptides with specific functional properties and desired molecular size characteristics is the use of an ultrafiltration membrane reactor system. This system has the main advantage that the molecular weight distribution of the desired functional peptide can be controlled by adoption of an appropriate ultrafiltration membrane. In order to obtain functionally active peptides, it is a suitable method to use a three enzymes system for sequential enzymatic digestion. Moreover, it is possible to obtain serial enzymatic digestions in a system using a multi-step recycling membrane reactor combined with ultrafiltration membrane system to separate marine-derived bioactive peptides [17,18]. This membrane bioreactor technology equipped with ultrafiltration membranes is recently emerging for the development of bioactive compounds and considered as a potential method to utilize marine proteins as a value added nutraceuticals with beneficial health effects.

3. Biological properties of marine bioactive peptides and potential health benefits

3.1. Antioxidant activity

Antioxidants may have a positive effect on human health since they can protect human body against deterioration by free radicals and reactive oxygen species (ROS), including singlet oxygen, hydrogen peroxide, superoxide anion, and hydroxyl radicals. ROS and free radicals attack macromolecules such as DNA, proteins and lipids, leading to many health disorders including inflammatory, aging, diabetes, neurodegenerative, cardiovascular and cancer diseases [19,20].

To retard peroxidation processes in food, many synthetic antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), tert-butylhydroquinone (TBHQ) and propyl gallate (PG) have been used. However, the use of these synthetic antioxidants must be strictly controlled due to their potential health hazards. Hence, search for natural antioxidants as safe alternatives to synthetic products is important in the food industry. Recently, the use of natural antioxidants available in food and other biological substances has attracted significant interest due to their presumed safety, nutritional and therapeutic values [21–23]. A number of studies have shown that peptides derived from various marine protein hydrolysates such as fish [13], blue mussel [24], conger eel [25], microalgae [26] and squid [27] act as potential antioxidants (Table 1). The antioxidant activity of bioactive peptides derived from marine has been determined by different in vitro methods, such as 2,2-diphenyl-1-picrylhydrazyl (DPPH), carbon-centered, hydroxyl and superoxide anion radical scavenging activities which have been detected by electron spin resonance (ESR) spectroscopy method as well as intracellular free radical scavenging assays. The beneficial effects of antioxidant marine bioactive peptides are well known in scavenging ROS and free radicals or in preventing oxidative damage by interrupting the radical chain reaction of oxidation [36]. Oxidation in foods affects lipids, proteins and carbohydrates. However, lipid oxidation is the main cause of deterioration of food quality, leading to rancidity and shortening of shelf-life. Oxidation of proteins in foods is influenced by lipid oxidation, where lipid oxidation products react with proteins causing their oxidation. Carbohydrates are also susceptible to oxidation, but they are less sensitive than lipids and proteins [37]. Bioactive peptide from jumbo squid inhibited lipid peroxidation in the linoleic acid model system and its activity was much higher than α-tocopherol, and was close to highly active synthetic antioxidant, BHT [28]. Moreover, the bioactive antioxidant peptide from oyster (*Crassostrea gigas*) exhibited higher protective activity against polyunsaturated fatty acid peroxidation than natural antioxidant, α-tocopherol [30].

Table 1
Antioxidant peptides derived from marine organisms.

Source	Amino acid sequence	Refs.
Conger eel	LGLNGDDVN	[25]
Microalga	VECYGPNRPQF	[26]
Squid	NADFGLNGLEGLA	[27]
	NGLEGLK	[27]
	FDSGPAGVL	[28]
	NGPLQAGQPGER	[28]
Hoki	ESTVPERTHPACPDFN	[29]
Oyster	LKQELEDLLEKQE	[30]
Blue mussel	HFGDPFH	[31]
Tuna	VKAGFAWTANQQLS	[32]
Rotifer	LLGPGLTNHA	[33]
	DLGLGLPGAH	[33]
Prawn	IKK, FKK, and FIKK	[34]
Yellowfin sole	RPDFDLEPPY	[35]

The antioxidant activity is suggested to be due to the specific scavenging of oxygen containing compounds, or metal-chelating ability, scavenging of radicals formed during peroxidation. In addition, peptides isolated from marine fish proteins have greater antioxidant properties than α-tocopherol in different oxidative systems [35]. Antioxidant activities of bioactive peptides are mainly due to the presence of hydrophobic amino acids, some aromatic amino acids and histidine. Gelatin peptides are rich in hydrophobic amino acids, and the abundance of these amino acids favors a higher emulsifying ability. Hence, marine gelatin peptides possess higher antioxidant effects than peptides derived from other proteins because of the high percentage of glycine and proline [28]. Therefore, antioxidant bioactive peptides derived from marine may have great potential use in pharmaceuticals, nutraceuticals and as a substitute for synthetic antioxidants. For example, Shahidi et al. [38] clearly demonstrated that capelin fish protein hydrolysate which added to minced pork muscle at a level of 0.5–3.0% reduced the formation of secondary oxidation products including thiobarbituric acid reactive substances (TBARS) in the product by 17.7–60.4%.