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Antioxidant peptides from marine by-products: Isolation, identification and application in food systems. A review

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ABSTRACT

In recent years, several attempts have been made for the utilisation of the protein rich fish processing by-product discards and underutilised fish proteins for the production of commercially valuable food ingredients. There has been an increasing interest in the utilisation of marine products, and novel bioprocessing technologies are developing for isolation of some bioactive substances. Antioxidant peptides isolated from marine food products have been used as functional foods and nutraceuticals. Peptides obtained by enzymatic hydrolysis of fish proteins exhibit not only nutritional but also biological properties for use in diet or in therapeutic purposes. In this review, we have focused on the enzymatic process for generating antioxidant peptides from marine by-products as well as on the isolation procedures of selected antioxidant peptides.

Contents

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1. Introduction

Free radical-mediated lipid oxidation, oxidative stress and antioxidants are widely discussed in many current research areas. Uncontrolled generation of free radicals that attack membrane lipids, proteins and DNA is believed to be involved in many health disorders such as diabetes mellitus, cancer, neurodegenerative and inflammatory diseases (Butterfield et al., 2002; Pryor & Ann, 1982). In addition, deterioration of some foods has been identified to be caused by the oxidation of lipids and formation of secondary lipid peroxidation products.

Many synthetic antioxidants, such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), are used as food additives to prevent deterioration. Although these synthetic antioxidants show stronger antioxidant activities than those of natural antioxidants, such as α-tocopherol and ascorbic acid, the use of these chemical compounds has begun to be restricted because of their induction of DNA damage and their toxicity (Ito et al., 1986). Therefore, in recent years, there is a great interest in finding new and safe antioxidant compounds from natural sources for their use in foods and medicinal materials to replace synthetic antioxidants. Vitamin C, α-tocopherol and phenolic compounds, which are naturally present in vegetables, fruits and seeds, possess the ability to reduce oxidative damage associated with many diseases, including cancer, cardiovascular diseases, atherosclerosis, among others (McCall & Frei, 1999).

Different extracts from plants (Afnani & Manaf, 2011; Cui et al., 2013; Ke et al., 2013; Parejo et al., 2003; Polydoro et al., 2004), microorganisms (Benedetti et al., 2004; Gantar, Simovic, Djilas, Gonzalez, & Miksovska, 2012; Mohamed, Osman, Salem, & Elmalawany, 2014), and foods (Bougatef et al., 2009, 2010; Saiga, Tanabe, & Nishimura, 2003; Suetsuna, Ukeda, & Ochi, 2000) have been already reported to exhibit antioxidant properties through their capacity to inhibit lipid peroxidation.

Furthermore, dietary proteins have been found to play a significant role in improving human health beyond their well recognised nutritional value (Hartmann & Meisel, 2007). In addition, several studies in the past few decades have reported that protein hydrolysates from various food sources, in addition to their nutritional properties, exhibited various biological functions including antioxidant (Bougatef et al., 2009, 2010, 2012), antimicrobial (Salampessy, Phillips, Seneweera, & Kailasapathy, 2010; Sila et al., 2014a, 2014b), hypotensive (Balti et al., 2012, 2015; Balti, Nedjar-Arroume, Bougatef, Guillochon, & Nasri, 2010), anticoagulant (Ren et al., 2014), and cholesterol-lowering ability (Ben Khaled et al., 2012). These functions are associated with bioactive peptides encrypted within protein structure.

Bioactive peptides, which consist of 2 to 20 amino acid residues, are inactive in the sequence of their parent proteins and can be released by enzymatic hydrolysis either during gastrointestinal digestion in the body or during food processing (e.g., cheese ripening and milk fermentation). Once they are liberated in the body, bioactive peptides may act as regulatory compounds with hormone-like activity. Further, bioactive peptides may also be generated by *in vitro* hydrolysis of protein sources using appropriate proteolytic enzymes. The nature of the protein substrate, the specificity of the enzyme used for the proteolysis, the conditions used during hydrolysis (time and temperature) as well as enzyme/substrate ratio greatly influenced the molecular weight and amino acid composition of bioactive peptides, and thus their biological activities (Van der Ven, Gruppen, de Bont, & Voragen, 2002).

Antioxidant peptides are among the most studied bioactive peptides. In particular, fish protein hydrolysates (FPH) with antioxidant properties have become a topic of great interest for pharmaceutical, health foods, as well as for food processing/preservation industries (Alasalvar, Shahidi, & Quantick, 2002; Bougatef et al., 2009, 2010, 2012; Hagen & Sandnes, 2004). The bioactive molecules in FPH responsible for these properties are peptides that are released upon hydrolysis of fish proteins by the enzymes already present in fish mince (endogenous) and/or by appropriate enzyme(s) added to the fish mince (exogenous).

This review describes the use of fish by-products as sources for the production of antioxidant peptides, and points to chromatographic methods used for their purification and identification. Additionally, the structure–activity relationship of antioxidant peptides was presented.

2. Seafood products and by-products proteins

Oceans constitute an extremely diversified alimentary richness (algae, crustaceans, shellfish, molluscs and fish). According to the Food and Agricultural Organization (FAO, 2010), more than 145.1 million tons of fish are actually caught or farmed annually worldwide. In 2010, the quantity of global releases was estimated at 24 million tons, i.e., about 16.54% of the total catches. Commercial fish production and seafood processing generate large amounts of fish waste, which create burdensome disposal problems and environmental concerns. This biowaste contains, however, several biomass materials that can be biotechnologically exploited for the production of useful marketable products.