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Editorial

Functional Components of Fish

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Functional foods have not yet been defined by European legislation, even though Regulation (EC) No 1924/2006 of the European Union on nutrition and health claims on foods, referring among others to functional foods, came into force in 2006. Generally, functional foods are considered to be foodstuffs that contain biologically active constituents that contribute to human health maintenance and/or reduce susceptibility to pathological conditions leading to diseases. Fish are inherently functional food (natural functional food) due to the fact that they naturally contain a variety of bioactive constituents such as polyunsaturated omega-3 fatty acids [1,2], anti-thrombotic lipid micro-constituents [3,4], bioactive peptides [5], vitamin D_3 [6,7] and minerals [8,9].

Polyunsaturated fatty acids are classed-according to the position of the first double bond-in omega-3 and omega-6 fatty acids. Human body lacks the necessary enzymes to convert omega-6 to omega-3 fatty acids, therefore the latter must be obtained from the diet. The main omega-3 polyunsaturated fatty acids derived from fish oil are Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA). EPA and DHA have been related to several cardioprotective properties such as anti-inflammatory, anti-thrombotic and anti-atherosclerotic activity, along with improving endothelial function and decreasing blood pressure and triacylglycerides concentration, even though the mechanisms of action remain unclear [2]. More specific a suggested mechanism of the anti-inflammatory activity of EPA and DHA could be due to the fact that consumption of omega-3 fatty acids increases eicosapentaenoic acid in the cell membrane, which antagonise the pro-inflammatory activity of the omega-6 eicosanoids, while a proposed mechanism of action related to the anti-atherosclerotic effect of EPD and DHA may be attributted to inflammation reduction, attenuation of growth factor production, or suppression of smooth muscle cell proliferation [2]. Additionally DHA is the most abundant omega-3 fatty acid in the mammalian brain membranes and nervous system and its levels in brain membrane lipids and nervous tissue are altered according to the type and content of fatty acids in the diet. Therefore DHA is essential for cognitive development, neurogenesis, neurotransmission and protection against oxidative stress [10], while vitamin D along with DHA or EPA may attenuate the severity of hyperactivity disorder, depression, bipolar disorder and schizophrenia by regulating serotonin synthesis [11].

According to some researchers, it is believed that the cardioprotective properties of fish oil could be attributed not only to the presence of omega-3 polyunsaturated fatty acids but also to the presence of some other micro-constituents [12,13]. Fish oil have been found to contain polar lipid constituents with chemical structure similar to phosphatidylcholine derivatives [14] that possess both *in vitro* anti-thrombotic [3,4] and *in vivo* anti-atherogenic properties [15]. The anti-thrombotic activity of fish polar lipids is mainly due to the inhibition of Platelet Activating Factor (PAF)-induced platelet activation and aggregation [3,4], while the mechanism of the anti-atherogenic activity of fish polar lipids is mainly attributed both to reduction of the enzymatic activity of PAF-Cholinephosphotransferase (PAF-CPT); a biosynthetic enzyme of PAF and increase of the enzymatic activity of PAF-Acetylhydrolase (PAF-AH); a catabolic enzyme of PAF [16].

Fish bioactive peptides have been found to display several biological properties such as antioxidant, anti-hypertensive, anti-thrombotic, antimicrobial, immunomodulatory, prebiotic, mineral binding and hypocholesterolemic activity. The aforementioned biological properties of fish peptides depend on different factors including their structural properties, amino acid composition and amino acid sequences [17]. More specific the antioxidant activity of fish bioactive peptides is attributed to the presence of hydrophobic amino acids, aromatic amino acids and histidine; the anti-hypertensive activity is suggested to be due to the potent inhibitory activity of fish peptides against angiotensin-I converting enzyme, which plays a crucial role in blood pressure regulation by converting angiotensin-I to angiotensin-II - a potent vasoconstrictor-while the hypocholesterolemic effect of fish protein hydrolysate is exerted by *in vivo* reducing plasma cholesterol level and inhibiting the activity of acyl-CoA:cholesterol acyltransferase [5]. Aditionally fish proteins are good source of essential amino acids such as lysine, methionine, cysteine, threonine and tryptophan [18]. Lysine has been recognized as an important precursor for the *de novo* synthesis of glutamate, the most crucial neurotransmitter in the mammalian central nervous system [19]. Furthermore lysine has been found to enhance intestinal calcium absorption and improve the renal conservation of the absorbed calcium [20], while deficiency or low supply of this compound in the diet may lead to mental and physical handicaps such as osteoporosis.

Fish and fish liver oil are regarded to be the most significant dietary saurces of naturally occuring cholecalciferol (vitamin D_3). Since sun exposure of humans-following the Western lifestyle-is limited, dietary intake of vitamin D_3 is of great importance. Some of the functions of vitamin D_3 is regulation of calcium and phosphorus metabolism in order to ensure normal mineralization of bones and participation in muscle development, since vitamin D receptor is located in muscle tissue [21].

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Another functional component of fish is Selenium (Se). Se behaves both as an antioxidant and anti-inflammatory agent. The antioxidant capacity of Se is due to the ability to (i) reduce hydrogen peroxide, lipid and phospholipid hydroperoxides, by blocking the propagation of free radicals and reactive oxygen species, and (ii) reduce hydroperoxide intermediates in the cyclooxygenase and lipoxygenase pathways leading to inflammatory prostaglandins and leukotrienes. Any condition associated with increased levels of oxidative stress or inflammation (e.g., atherosclerosis) might be expected to be influenced by Se levels [22]. Moreover Se seems to be of great importance regarding immune system function since immune system cells (e.g., T-cells) have a functional need for Se [22]. At the same time Se reduce the toxicity of a number of metals (e.g., mercury or methyl mercury in marine foods) by forming inert metal selenide complexes [22].

In recent years, utilisation of marine by-products and isolation of bioactive constituents gave rise to increasing interest. For instance antioxidant peptides obtained by enzymatic hydrolysis of fish proteins have been used as functional components and nutraceuticals since they exhibit not only nutritional but also biological properties for use in diet or in therapeutic purposes [23].

The overall conclusion is that fish and fish products contain naturally a wide range of functional components that can be obtained either by diet or by utilisation of fish by-products.

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