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Review Article

Nutrient and Therapeutic Compounds from Fish and Fish by Products–A Mini Review

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Abstract

Globally the preference for the food products has a high nutritional value, more health benefits with less or no side effects is increasing. Fish and fish by-products fulfil all nutritional requirements and is a potential food option. The fish and fish by products can provide considerable amounts of protein, fatty acids, vitamins, minerals and other biologically active compounds which can provide nutrition and health benefits. The fish by products is a valuable source of nutrients and have biologically active compounds which exhibit antiviral, antibacterial, antifungal and anti-cancer properties. Though the fish by-products are used for low value products like fish oil, fish meal and fish manure to certain extent, the full potential of valuable ingredients in fish by-products is not utilised. The fish by-products which are nutritionally rich can be used for extraction of high value bioactive compounds pragmatic in nutraceutical and pharmaceutical fields.

Keywords: Fish, Fish by-products, Nutrients, Bioactive compounds.

1. Introduction

Globally consumers are becoming more health conscious and are concerned about the quality of the food they are consuming. According to World Bank data from 2016, the food sector accounted for 10% of the world's GDP or \$4.8 trillion dollars [1]. In this context, the aquatic foods as a diverse provider of health and nutrition benefits are now playing an important role in providing not only quality food but also in food security. Owing to its unique health benefits, people are now moving towards their preference to fish from other protein sources. This is supported by the fact that, from 213 million tonnes in 2018, the fisheries and aquaculture production increased to 214 million tonnes in 2020 (178 million tonnes of aquatic animals and 36 million tonnes of algae). Further, aquatic animal production has also increased to 178 Million tonnes in 2020 from 177.4 Million tonnes [2]. The contribution from capture fisheries was 90.3MMT and 87.8 MMT from culture fisheries. There is a trend towards increase of culture fisheries and decrease in capture fisheries. The increase in fish production also mean that increase in fish by products in the form of skin, head, viscera etc., from fishes besides huge wastes from the processing plants. Though the fish wastes are converted into low value fish meal, fish manure to certain extent, the full potential of valuable ingredients in fish by-products and its bioactive compounds is not utilised. These bioactive

compounds also exhibit antioxidant, antiviral and anti-cancer properties. The purpose of this article is to present the possible nutritional and physiological benefits of bioactive chemicals derived from fish and fish by-products.

2. Nutrient and Bioactive Compounds from Fish and Fish by Products

The term Fish includes organism living in aquatic environment and is used for commercial purpose. Finfish is a poikilothermic and aquatic vertebrate where the body is covered with scales, respire by gills and swims with the help of fins. Shell fish includes aquatic invertebrates where the body is covered by shell and includes Crustaceans (shrimps, Crabs etc) and Molluscs (Univalves, Bivalves etc) [3]. Certain components of fish and prawns are thrown away as waste during processing and preservation. These leftover materials serve as a significant source of fish by-products, which are then utilized to create various beneficial fish by-products. Fish meal, fish body and live oils, fish maw, isinglass, are some of the traditional fish by-products. Other by-products that are typically processed from fish and fish waste include fish protein concentrate, fish albumin, glue, gelatin, peptones, amino acids, etc. However, there are certain nutrients and bioactive chemicals are also derived from these by products. A chemical molecule found in food, such as protein, fat, carbohydrate, vitamin, or mineral, is referred to as a "nutrient." The body needs these substances in order to develop and operate [4]. Bioactive compounds are those natural substances having the capacity to interact with one or more components of a living tissue and have a favourable impact on human health [5].

Fish processing generates 60-65% non-edible tissues like bones, skin/scales, swim bladders, intestines, roes, liver, blood etc. [3]. When finfish are processed, 10-50% of their weight is produced by inedible portions such as the head, intestines (viscera), skin, bone, and meat that is still attached to the bone. Up to 85% of the raw material from shellfish, particularly crustaceans, comes from their non-edible sections, which include their head, viscera, carapace, and appendages [6]. Fish processing in capture fisheries discards nearly 75% of total weight of catch and either throwaway in-land or hauled into the ocean. Some studies shown that, the fish processing industry is a major source of by-products and such waste is in the form of skin, head viscera, trimmings, liver, and bones [7]. These by-products are normally processed into low value products like fish meal, animal feed, fertilizer, fish silage and sauce. The disposal of fish wastes is also a cost burden to the processing industry. Hence it is imperative and wistful to extract bioactive compounds which is having varied application in nutraceutical and pharma industry.

2.1. Proteins and Peptides

The average protein content in marine fish and fresh water fish is 13-24%. Fish proteins are complete and possess essential and non-essential amino acids. They are also easily digestible. Fish proteins are known to help in improving insulin sensitivity, wound healing, skin and anti-aging and bone regeneration capabilities [8]. Collagen protein is available in connective tissue of fish skin and scales is a major content of fish processing industry. Fish skin has the highest collagen content (5%-30%). Collagen has been widely used in pharmaceuticals, cosmetics, and food. One of the benefits of collagen is as a wound dressing on burnt injuries [9]. Fish protein hydrolysate (FPH) can be obtained by converting unused fish Parts. Fish protein hydrolysate can be produced by hydrolysing fish muscle or body parts using chemicals (acid or alkaline), or biochemical (microbial enzymes, digestive enzymes) added at appropriate levels in controlled systems [10].

Fish protein hydrolysates has a high nutritional value and they contribute to water-holding, texture, gelling, foaming and emulsification properties in different food systems [11]. Bioactive peptides are a group of biological molecules that are normally buried in the structure of parent proteins and become active after the cleavage of the proteins [12]. It is usually a sequence of 2-20 amino acids that promotes beneficial physiological effects to the consumers when ingested. It has been demonstrated that bioactive peptides derived from the digestive process of fish proteins and protein hydrolysates have a number of health-promoting functions [13], chief among them being those of anti-hypertensive, anti-diabetic, anti-coagulant, anti-inflammatory, antioxidant and anti-microbial [14-19]. For example, antihypertensive peptides extracted from both finfish (salmon, tilapia, tuna, mackerel, basa, etc) and shellfish (squid, shrimp) and have been reported to lower the blood

pressure usually mediated by Angiotensin Converting Enzyme-I (ACE-I) inhibition. Studies shown that Marine origin anti-cancer peptides induce cancer cell death through different mechanisms. Fish of the Salmonidae and Perciformes families are rich in anserine, a functional dipeptide having antioxidant properties [20]. Anserine has been linked to a number of health advantages, including defence against inflammation and infectious diseases, memory and age-related brain functioning, and cardiovascular health [21].

2.2. Lipids and Fatty Acids

Fish and other aquatic foods are main sources of polyunsaturated fatty acids (PUFA). Polyunsaturated fatty acids are liquid at room temperature and remain liquid when frozen or refrigerated. Fish obtain these fatty acids by consuming certain algae and plankton. Omega 3 fatty acids and Omega 6 fatty acids are examples of PUFA. Omega-3 fatty acids are a type of unsaturated fatty acid present in Fishes like Salmon, Sardines, Pilchards, Kipper, Eel, Whitebait, Mackerel, Herring etc. However, the percentage of availability of PUFA from fishes differ in different species which depend on aquatic environment (fresh water or marine) and biological, physical and chemical properties of water. The three most significant omega-3 fatty acids in terms of nutrition are docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and alpha-linolenic acid (ALA). Their chemical forms and sizes, however, are different. By reducing blood clots and inflammation, improving blood vessel elasticity, lowering blood pressure, lowering blood fats and boosting "good" cholesterol, and boosting immunity, omega-3 fatty acids may also lower triglycerides, lower blood pressure, reduce blood clotting, and increase immunity. Additionally, they may lessen the risk of developing dementia, including Alzheimer's disease. [22]

Some studies have magnified that, long chain omega-3 PUFA are precursors of prostaglandins and thromboxanes, hormone-like substances with anti-thrombogenic and anti-atherogenic properties crucial for prevention of human chronic inflammatory and cardiovascular diseases, for cancer prevention, and for brain and retina development during the early life stages [23-29]. Various studies have reported the cardio-protective effect of n-3 PUFA (EPA and DHA) supplementation and recommend 1 g EPA intake per day to prevent coronary heart disease [30]. The anti-cancer roles have yet to be proven. Studies have reported that n-3 PUFA and n-6 PUFA positively affected the prevention of development of different types of tumours. The n-3 PUFA can alter cell growth by interfering in cell replication or by increasing cell death through necrosis or apoptosis [31,32]. More recently, some studies have also highlighted the importance of seafood in ageing [33, 34]. Omega-3 supplements may help manage or prevent depression, Parkinson's disease, and psychosis in those at risk. Studies were also conducted on European eel skin, and concluded that the by by-products a by-product resulting from commercial processing, can be considered a valuable source for the food and pharmaceutical industries by providing value-added constituents such as proteins, lipids, ω 3 FAs, phospholipids, and α -tocopherol [35].

2.3. Vitamins

Vitamins are the complex organic substances which are required in extremely small quantities for performing vital metabolic reaction in the body. They act as co enzymes in bio chemical reactions. Most of the vitamins necessary for human health are present to some extent in fish. Indeed, fish oils such as cod liver oil and fish species like sardine, mackerel, herring, lake trout, and salmon are easily bioavailable sources of Vitamins A, D, E, and K [36]. The fish liver oils are the richest source of Vitamins A & D. Vitamin A is essential for transmission of light stimuli from eyes to brain and for night vision. It also promotes growth and health of all cells. Furthermore, vitamin A can affect the production of numerous proteins that control how cells develop and function, as well as how sensitive they are to hormones and hormone-like substances and how they create hormones [37]. Vitamin D deficiency leads to osteomalacia, osteoporosis and rickets. Vitamin D in fishes exists as Vitamin D3 (Calciferol). Studies suggested that there is a link between Vitamin D deficiency and diabetes, amplified proliferation of cancer cells, and increased incidence of autoimmune and cardiovascular diseases [38].

Alpha-Tocopherol is prevalent form of Vitamin E found in fish. Sea food contains small amounts of Vitamin E. It is observed that Fatty fish have greater quantities of than lean fish. Shell fish have very

little Vitamin E. Salmon muscle have moderate amounts of Vitamin E. Vitamin E acts as antioxidant and protects the cells. Studies shown that Numerous biological systems rely on vitamin E for various activities, including signal transmission, gene expression regulation and modulates cell functions [39]. Vitamin K (phyloquinone or menaquinone) has an essential role in blood clotting and acts as an anti-haemorrhagic factor. It also plays an important role in promoting bone health, helping to produce proteins for blood, bones, and kidneys. Fish contains variable but relatively low amounts of vitamin K. Salmon, canned tuna and mackerel contains highest concentrations of Vitamin K compared to shell fish like lobsters, clams, mussel, oysters etc. B Vitamin group plays an important role in helping enzymes in performing many functions. Without them the body would not have enough energy. The B complex also helps in growth and multiplication of cells. Fish and shell fish are also good sources of Vitamin B and found in fish skin, liver and gut.

2.4. Minerals and Trace Elements

Fish is a good source of minerals and trace elements viz. Sodium, Potassium, Calcium, Magnesium, Phosphorus, Iron, Zinc, Selenium, Iodine, Copper etc. The fish has the ability to absorb from the water. Sodium and Potassium are involved in maintaining electrolyte balance, muscle contraction and Nerve impulse transmission. Studies have shown that a dietary low Na/K ratio is important for cardiovascular health [40]. Fish bone is the vital source of Calcium. Calcium is important for forming cartilage, bones, dental tissues, blood clotting, and regulating nerve impulses. It is also a vital element during pregnancy and lactation. Insufficient calcium in the diet can lead to many diseases [41]. Phosphorus and magnesium are also necessary for the development of teeth and bones.

The main source of Iodine is the Sea fish besides seaweeds. Iodine deficiency leads to malfunctioning of Thyroid hormones and leads to abnormalities in growth and development. Research have revealed that iodine deficiency increases the risk of cretinism, intellectual disability, and other conditions, particularly during pregnancy [42]. Haemoglobin contains iron, which aids in the oxygen's transportation. Deficiency of Iron leads to anaemia. Copper is involved in oxygen transport and enzyme functions. Zinc is an important element of many enzymes which performs vital functions like DNA and protein synthesis, digestion, nerve function, development and function of immune cells, cell growth, and division [43-46]. Selenium though required in small amounts, plays major functions healthy body functions including immune system and thyroid function. Zinc and selenium are highly represented in bivalves.

2.5. Chitin and Chitosan

Chitin and chitosan are extracted from exoskeleton of shrimps and crabs. Chemically, chitin is a polymer of n-Acetyl-glucosamine (NAG) and chitosan is its deacetylation product. After treating the calcium carbonate with acid to dissolve it, proteins are dissolved in an alkaline solution to remove chitin. Both chitin and chitosan provide health benefits such as wound healing, immune system stimulant, anti-ulcer agents, bactericide, antioxidant agent, and antiaging cosmetics [47,48]. Several studies have demonstrated that chitin-glucan reduced wrinkling and skin-ageing, suggesting an interaction between the chitin-glucan and cells of the epidermis. Although these effects may not be attributed to chitin alone, this does demonstrate the strong biological potential of chitin on cells of the human body [49]. Chitosan is widely used in the nanoencapsulation of various nutrients and bioactive substances present in food, such as fish, to aid in the transport, absorption, and protection of those nutrients [50,51]. Both in vitro and in vivo methods have been used to examine the anticancer effects of chitosan and its derivatives [52]. Additional research revealed that chitosan directly affects tumor cells as well; by causing apoptosis, it prevents tumor cell growth [53].

2.6. Carotenoids and Squalene

Carotenoids are lipid soluble natural pigments which have many health benefits to living organisms. Fish and shell fish are rich in certain carotenoids like lutein, canthaxanthin and astaxanthin. Astaxanthin which is a common carotenoid, which has the ability to protect the eye macula (lutein and zeaxanthin) from oxidative stress and blue light damage [53]. Owing to their higher antioxidant capacity, carotenoids are crucial for both disease prevention and overall health maintenance [54]. Some studies revealed that carotenoids have several physiological effects, on the immune system,

reproduction, lipid metabolism, photoprotection in skin, diseases such as adiposity, obesity, diabetes, cardiovascular disease, hypertension, atherosclerosis, and cancer, and inflammation [55]. Besides, provitamin A activity, several studies made on the protective role of carotenoids against chronic degenerative, inflammatory, metabolic, and age-related diseases [56,57]. Hence fish and shell fish with carotenoids is recommended for consumption as per the requirements of balanced diet. Squalene is a polyunsaturated hydrocarbon found in certain fish, especially from liver of deep-sea sharks mainly *Centrophorus* and *Squalidae* species. Good amount of squalene can be obtained from liver oil of these species and can be used as dietary supplement. Small amounts of squalene in fish muscle. Squalene has role in the prevention of cardiovascular heart disease, protection from cancer, skin repairing, UV-filtering, and antibacterial agent [58].

3. Conclusion

The nutrition and health benefits from fish and fish bioactive compounds reveal that such benefits need to be promoted on large scale. Fish consumption shall be increased for getting benefits from the bioactive compounds of fish. Though the majority of people is aware of nutrition and health benefits of unconventional foods i.e., sea weed and fish by products and its uses, availability and accessibility of these products is a major impediment. The large-scale production of these compounds using the latest technologies besides considering its economic viability and the safety aspects is recommended.

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Conflict of Interest

All authors declare that there is no conflict of interest.

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