

A Short Review on Application of Fish Proteins in Functional Foods

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Abstract

Functional foods contain specific nutrients that have beneficial physiological benefits, such as lowering the risk of chronic diseases and improving overall health. Functional foods are created by adding additives that have been shown to enhance health. This review article investigates several fish-derived products as functional dietary components, with an emphasis on fish protein hydrolysates (FPH), fish protein concentrate (FPC), fish collagen, fish gelatine, fish enzymes, fish protein powder (FPP) and surimi powder. Fish Protein Hydrolysates, produced from fish waste, are high in bioactive peptides and have unique nutritional value, making them useful in food manufacturing. Fish Protein Concentrate contains a high protein content and bioactive peptides with multiple health benefits, making it ideal for improving nutritional quality in an array of food products. Fish collagen, with its biocompatibility and versatile capabilities, is used to increase protein content and improve sensory attributes in food products. Fish gelatine, made by thermal denaturing collagen, is used for its gelling, viscosity, and emulsifying qualities, which improve the texture and stability of food items. Fish enzymes, due to their specific catalytic activity, enhance flavour, solubility, and nutritional value in a range of food processes. Fish Protein Powder, a stable and high-protein product, improves the nutritional value of ready-to-eat meals and snacks. Surimi powder, a dehydrated form of frozen surimi, is versatile in food formulations. The sustainable extraction and processing of fish proteins not only reduce waste but also offer promising avenues for functional food development. The future of fish protein in functional meals appears promising, with continuing research concentrating on sustainable extraction as well as processing methods. As consumer awareness of functional foods increases, so will the worldwide market, which is driven by the demand for nutrient-rich, health-promoting foods. To meet this need, producers must present convincing scientific proof for their health claims.

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INTRODUCTION

Japan is where the phrase "functional food" was initially used. Functional foods are foods that have been enhanced with particular ingredients that have positive physiological effects. The term "functional food" is formally categorised and governed in Japan under the Foods for Specified Health Uses (FOSHU) statutory category [29,46]. Food products fortified with specific ingredients that have beneficial physiological benefits are referred to as functional foods [9] Adding particular substances (or ingredients) with proven health benefits is a necessary step in the development of functional foods [18]. Fish, among

a broad spectrum of protein sources, play a dynamic function in terms of nutritional, socioeconomic, cultural, and aesthetic advantages in human community, because these are regarded as the most abundant protein sources [34]. Apart from fish protein-rich products used by human beings, which constitute just 40 percent of the whole, the remaining 60 percent of fish comprises of waste components such as skin, head, frames, fins, trims, roes, and viscera which include a substantial quantity of protein [73]. [26] have opined cereal based snack products such as pasta and noodles provide a potential for value-addition by fortifying with animal protein-rich fish mince, surimi, and surimi powder to improve the nutritional quality and amino acid profile of such cereal-based food products, thereby fulfilling consumer needs for low-carbohydrate, protein, and fiber-rich ready-to-cook food products, and thus providing nutrition from fish. Furthermore, fish proteins are more easily digested than plant proteins, therefore cereal products can be fortified with fish proteins to minimize glycemic impact and maintain a balanced nutritional profile for individuals [11]. Furthermore, a wide range of characteristics expand the significance of fish peptides and make them particularly attractive in formulation of innovative functional foods[1]. Functional foods offer additional secondary metabolites with biological activities and physiological advantages to fight against infections and disorders in addition to the daily nutrients that are needed. By enhancing their physiological processes, certain functional foods assist the elderly in reducing and/or stopping their medication consumption. Functional foods, on the other hand, offer physiological benefits that have been validated and can lower the risk of chronic disease beyond their basic nutritional roles, such as maintaining intestinal health, when compared with conventional diet [63]. Researchers are persuaded that fish proteins could be leveraged to enhance functional foods, and the incorporation of fish proteins in various foods has emerged as an intriguing field of study. Consumers are growing more acceptances towards functional meals and drinks in search of dietary components that have health-promoting properties. As a result, the food industry has increased the creation and marketing of a wide range of functional food items utilising various food sources whose positive effects on disease prevention and health promotion have been verified by biological tests [17].

FISH PROTEIN HYDROLYSATES (FPH)

Fish waste may yield protein hydrolysates containing bioactive peptides with relatively short amino acid sequences of 2-20 amino acids [49]. Fish waste can be converted into protein hydrolysates using methods such as fermentation, synthesis, and enzymatic hydrolysis. Fish hydrolysates are being studied for possible industrial applications as functional food components because of their superior nutritional contents, favourable amino acid profiles, and valuable biological activity [15] Given their safer and more natural source of contribution to disease management over synthetic medications, FPH, which largely display enhanced bioactivities, required special attention [4]. Functional qualities refer to the total physicochemical properties of proteins when they are processed, stored, and ingested in a food system. When FPH was incorporated to the diet, texture, emulsification, and water holding capacity increased significantly [65]. FPHs have emulsifying and excellent forming qualities, and they are employed as an emulsion stabilizer and emulsifying component in various products, making them more beneficial in food production and stabilization [33].

APPLICATION OF FPH

Fish protein must be able to stabilise residual lipids during specific processing procedures in order to be used as a useful ingredient in food systems [54]. However, the useful properties of proteins such as emulsion capacity, water holding, gelation, and foam stability limit the usage as a food additive [64]. Amizate, a protein hydrolysate generated from Atlantic salmon, is a reliable and efficient dietary supplement for children who are under nourished due to its high concentration of free amino acids and short peptides [38]. Better understanding of fish hydrolysate's nutritive value, benefits to health, bioactive peptides with antioxidant, anti-inflammatory, anticancer, neuroprotective, or antihypertensive properties may find use in fortified foods, pharmaceuticals, and cosmetics [50]. Furthermore, FPH could be utilized to increase the protein content of beverages [2],

biscuits [13], bread [70], and ice cream [56].

FISH PROTEIN CONCENTRATE (FPC)

The FPC is defined as a sustainable fish product with a greater protein level than the original fish and intended for dietary purpose. Basically, the FPC can be made from various fishes or fish waste. However, it is often manufactured from fish by separating the oil, separating the bones, and drying, resulting in a product with a greater protein concentration (85% to 95%) and reduced levels of ash and water compared to fish meal [53]. The FPC contains limited antinutritional factor and thus can be utilized primarily in food product processing [32]. Furthermore, the peptides with various molecular weights found in the FPC exhibit exceptional bioactivities such as anti-cancer, anti-inflammation, antimicrobial, anti-hypertensive, antioxidant, anti-aging, anti-diabetic, anti-germicide, anti-coagulant, and calcium-binding activities, therefore enhancing health status of human [28].

APPLICATION OF FPC

Fish extracted components enhanced functional and nutritional standard while cynically impacting sensory qualities of end product [55]. Due to its high quality and low cost, FPC is utilised in food supplements to improve and enhance the nutritional quality of low nutritious food [52]. Because it is an excellent source of lysine, higher-quality protein concentrate could be a great additive in cereal products, like rice, which has a low amount of lysine [22]. Additionally, adding FPC can help to prepare a protein rich diet. For instance, in comparison with non-fish protein-containing diet, human infant food prepared with 10% FPC had higher biological value (BV), a greater protein efficiency ratio (PER), true digestibility (TD), and net protein utilization (NPU) [23]. Freshwater FPC and by-products (*Tilapia nilotica*) are used in the making of various types of cookies. *T. nilotica* protein extracts could be incorporated at a maximum level of 6% in biscuit making. Furthermore, by-products of *T. nilotica* up to 5% have been incorporated in biscuit making with no adverse impacts on sensory attributes. In another remarkable study, Binsi and coworkers effectively added 8% *C. idella* protein in the production of an eggless protein-rich cake which does not affect its nutritional quality. The panellist recommended the cake incorporated with 10% FPC for its fragrance and presentation [7, 37]. Investigated snacks and pasta enriched with fish bone dispersion, wheat flour, and fish meat. The findings showed that fish meat had a substantial influence on protein content and an inverse relationship with water holding capacity (WHC) and hardness, whereas fish bone enhanced hardness, ash, and calcium contents while decreasing WHC, expansion, and colour parameters. The optimal formulation formula (w/w) comprised wheat flour (35.71%), potato powder (28.57%), fish meat (21.42%), and fish bone (14.28%), resulting in 37% bioavailable calcium, better texture, and nutritional value [71].

FISH COLLAGEN

One of the proteins that is most common in animals is collagen, which is found in connective tissue's extracellular matrix such as blood vessels, skin, bones, tendons, ligaments, cartilage, and inter vertebral discs [39]. Collagen is composed of substantial levels of hydroxyproline, glycine, and proline, which can denature in the dilute acid standard and be transformed into soluble protein by dispersing in a hot solution [31]. Due to its multifunctional properties, collagen is a protein that can absorb large amounts of water, is highly biocompatible, has low immunogenicity, is biodegradable, has high porosity, is easy to process, can permeate lipid-free interfaces, blends naturally with other substances (synthetic polymers), poses few or no ethical or religious problems, and can be extracted on a large scale. Collagen is a protein that is widely used in the food, cosmetics, medicinal products and biomedical industries because of all these benefits [67].

APPLICATION OF COLLAGEN

Studies have been carried out on fish collagen as a nutritive and functional food additive to increase protein levels in food items [58,72]. Bhagwat [6] studied the significance of using collagen from carp (*Cyprinus carpio*) in the milk-based food item paneer. The findings indicated that the paneer made from collagen produced from fish scales had good texture and sensory qualities. The physical,

sensory, and textural behaviour of dietary cookies containing marine collagen peptides has been studied by [30]. The protein and antioxidant properties were improved by the incorporation of collagen peptides. The sensory panellists chose the collagen added biscuits because they were slightly darker. According to [24], adding 0.5 mg/g of a gelatin hydrolysate extracted from Alcalase cuttlefish skin to turkey meat sausage led to a delay in lipid oxidation. Researchers have looked into the possibility of using collagen as an emulsifying agent food. The emulsifying capacities of collagen fibres in an oil-water emulsion have been assessed at various pH levels, protein concentrations, and emulsification equipment. The results showed that reducing pH and protein concentration reduced phase separation and dimensions in the emulsion, enabling the development of stable emulsions at an acidic pH of 3.5. According to the studies, fish collagen has potential applications in the food sector as an emulsifier, especially for acidic products [47].

FISH GELATINE

Gelatine, a high-quality protein biopolymer found in animal and fish bones and skin, can be obtained by thermal denaturing of collagen, which is a key source of gelatine with several uses in the food, pharmaceutical, and cosmetics sectors [9]. Three groups of high amino acids are present in gelatine molecules: glycine and alanine make up one third of the group, bases and acids make up nearly a quarter, and proline and hydroxyproline make up the remaining 25%. The three hydrophilic polar amino acid groups in high quantity gave the gelatine molecule a strong affinity for water. The distribution of molecular weight plays a significant role in determines gelling properties. The three most significant gelatine qualities for food applications are gel strength, viscosity, and melting point. The chemical characteristics of gelatine are associated with its functional capabilities. The molecular weight distribution and amino acid makeup of gelatine determine its gel strength, viscosity, and melting point [36].

APPLICATION OF FISH GELATINE

Gelatine is a versatile substance in the food sector that may be added to enhance the consistency, elasticity, and stability of food. It is utilised in the manufacturing of candies, edible films, fruit juice clarifying, encapsulation, dairy processing, soups, and other products [51]. Given its low-calorie content, gelatine is typically utilised to increase protein content and lower carbohydrate content in diets prepared for people with diabetes [25]. Gelatine has been utilised in edible items like fruit and vegetable juice (particularly for clarified apple and pear juice) and beverage clarifier, as well as a fining agent for white wine and beer. According to a prior sensory analysis of desserts prepared from gel gelatine, fish gelatine with lower gel melting temperatures released aromas stronger and had a richer flavour [19] Fish gelatine may be utilised in milk-based products like acid milk gels [42] and yoghurt [43]. Gelatine is usually opted for preparation of functional foods because of its distinctive combination of chemical, rheological, surface active, and gelling characteristics; thus, further advances in the functional properties of fish gelatine are still need of the hour [59].

FISH ENZYME

Given the specialised nature of enzyme action and their harmless nature, the use of enzymes in the culinary sector is widely accepted. The industry is still driven to look for new solutions by the never-ending need for process innovation and/or the creation of unique products or processes. Under specific operating conditions, such as temperature or salinity, these enzymes may exhibit desirable and potentially novel catalytic activity, which could provide them an advantage in process or product improvement and market competitiveness [40,41].

APPLICATION OF FISH ENZYME

According to Husain [21], β -galactosidase is a carbohydrase that is commonly utilised in the food business to enhance flavour, sweetness, solubility, and digestibility. The food industry uses lipases and esterase's extensively for a variety of purposes, such as enhancing the flavour of butter, cheese, and margarine, enhancing the nutritional value of bread through modification of flour lipids,

producing crackers, pasta, and other identical foods, degumming vegetable oils, synthesising structured lipids for baby formula and nutraceuticals, raising the titre of polyunsaturated fatty acids in vegetable oils, and improving the digestibility of natural lipids [3,14,71] Proteases are used instead of dietary proteins to achieve particular goals, including: enhanced solubility and/or digestibility; altered functionality, such as emulsification, water- or fat-binding, foaming and gel-stiffening, and scouring qualities; enhanced or changed flavour; and enhanced processing [62] There are other known marine proteases that are used in the processing of meat. Since tenderness is a crucial meat sensory attribute, tenderization of the flesh is largely monitored. Elastin and collagen play an important part in tenderness, these structural proteins provide promise as targets for enzyme activity [5, 60].

FISH PROTEIN POWDER (FPP)

Fish is an ideal source of n-3 and n-6 fatty acids, vitamins, and minerals including calcium and phosphorus. It is also notably high-protein, low-calorie seafood. Freshwater fish products have garnered significant interest as a vital component of a healthy human nutrition [27]. Globally, there is an increasing need for fish protein ingredients, particularly dried fish protein, to make nutritious foods or ready-to-eat (RTE) products [66]. A dried and stable fish products intended for consumer consumption, FPP has a higher protein content than the actual fish flesh. The acceptance and quality of FPP can be altered by a number of criteria. FPP can be used as a useful component in the preparation of RTE foods [53]. Because of the advantageous distribution of essential amino acids, nutritionally, fish proteins are fairly valuable. Contrary to most proteins derived from plant sources, that are deficient in one or more necessary amino acids, fish proteins are abundant in all the essential amino acids, especially methionine and lysine [61, 69].

APPLICATION OF FPP

When paired with FPP, cereal protein's nutritional value can be increased. Accordingly, adding 3% of fish protein powder to wheat flour (which had a protein level of 10.4%) raised the protein content to 12.4% and raised the net protein utilization from 50 to 67 [69]. By using FPP as a protein source, a wet yellow noodle with high protein content was created. Additionally evaluated were the physicochemical and sensory qualities of the noodle. The colour, hardness, and elasticity of the noodles with 5% FPP integrated and the control group did not significantly differ from each other. According to Chin [8] the highest concentration that could be added to the noodles was thus determined to be 5% FPP. The result of adding varying amounts of FPP to Persian ice cream (0%, 3%, and 5% FPP) on its chemical composition and sensory attributes were studied after four months of storage at -18 °C. The ice creams were identical in terms of fat content, lactose content, acidity, and pH. After production, the sensory attributes of the enriched ice creams were similar, but after two months in storage, it influenced dramatically. The making of ice cream supplemented with FPP may be a useful strategy to improve the ice creams functional and nutritional value [56]. The nutritional quality and storage durability of cutlets enriched with 30% FPP were investigated by [57]. During the six-month storage period, the product's nutritional quality increased and its chemical, biochemical, and sensory characteristics remained unchanged. The fortification of FPP in extruded maize snack seasoning revealed novel methods to utilize it as an ingredient. For example, children of 7 to 12 years age group of Iran liked the flavour and nutrition of extruded puffed maize snacks enriched with 18% FPP. After 4 months at ambient temperature, the product was found to have greater stability [55]. Nearly 7% of FPP was utilized to make high protein maize extruded snacks seasoned with vegetable oil, salt, cheese powder, and colorant. For consumer acceptance, this product was distributed to two communities' children (Iran and Iceland) aged 6 to 16, with Iranian children showing more interest than Icelandic children. A significant number of parents indicated a readiness to purchase this product [45].

SURIMI POWDER

Surimi powder is the dehydrated form of frozen surimi, which is convenient to store at room temperature as it does not require frozen storage. Surimi powder also has the benefits of being simple

to handle, affordable cost of distribution, and can be utilized as dry mixes in order to produce value-added products [35]. Several types of drying techniques, including freeze drying, spray drying, oven drying, solar drying, and mechanical drying, are used to dehydrate surimi [48]. Cryoprotectants, such as sugar or poly-alcohols, that are commonly added to surimi to prevent protein denaturation during freezing and frozen storage, also act as dryoprotectants in surimi powder. Dryoprotectant inhibits protein denaturation in surimi powder during the drying process. The protective activity is critical for maintaining fish protein functional qualities such as solubility, gelation, water holding capacity, emulsion, foaming ability, and colour [10, 12].

APPLICATION OF SURIMI POWDER

According to [44], surimi powder's nutritional content and physicochemical attributes make it appropriate for the formulation of seafood and other food products. Several studies have been conducted to date that focus on the use of surimi powder in food preparations. Rice-fish snacks was successfully prepared by [16]. Surimi powder, obtained by oven drying surimi at 60 °C for 12 h, was used to replace tapioca flour in the formulation of Indonesian traditional crackers. The resulting crackers increased in protein and ash content while decreasing in linear expansion, crispiness, and colour brightness. Crackers with 20% surimi powder contained 11.8% protein, compared to 0.6% protein in the control. The investigation found that surimi powder did not influence the aroma of the crackers, but appeared to improve the flavour of the cracker [20].

CONCLUSION

The future of fish protein in functional foods is bright, with ongoing research focusing on sustainable extraction and processing methods. Utilizing fish processing byproducts reduces waste and increases protein availability. The development of fish protein analogs for plant-based alternatives opens new possibilities, aiming to replicate the health benefits of fish protein in a sustainable manner. Nonetheless, increased consumer awareness of functional foods will fuel more worldwide revenue growth. Growing healthcare expenses and an ageing global population have caused consumers to place more emphasis on secondary source diagnosis or medicine, healthier lifestyle, and current and future trends on functional foods [68]. Consumers today, regardless of age or the existence of a disease linked to nutrition, are more likely to base their food choices on widely accepted information about the health advantages of a food product or food compound, and it's likely that the current trend remains in the years to come. Manufacturers should therefore concentrate on promoting the possible health advantages of functional foods by providing solid scientific proof of their impact along with an authorized health claim. A functional food product's ability to promote health should be demonstrated by credible clinical research, which should form the basis of the health label claim. Fish protein fortification in functional meals is a potential development, as continued research and technological improvements open up new product avenues to meet the growing demand for nutrient-dense, health-improving foods.

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