Chapter 10

Innovative Technologies in Seafood Processing: Biotechnological Applications in Fisheries By-Products

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Abstract

Fish processing is the process of converting raw fish captured by fishermen into marketable fish and goods. Common by-products include fish heads, frames, skin, scales, and viscera, all of which have significant nutritional value. Others include bones, fins, and guts, which can be processed to produce PUFA-rich proteins. Discarding fish bycatch and fish processing byproducts is a frequent practice in both fishing businesses and fish processing companies. Given this reality, innovative green technologies are being researched and developed to extract added value components and high-value bioactive compounds from seafood and their byproducts. Food, pharmaceutical, cosmetics, agricultural, and energy industries are all expressing interest in and expanding their usage of fish byproducts. These industries are increasingly relying on the nutritional and functional qualities of fish by-products to improve product formulations and develop sustainable solutions. The growing global population and continued fight against poverty have created sustainability difficulties in a variety of fields, including agriculture. Agriculture necessitates the production of food and high-value substances, as well as the management of land, water, and crops, and the control of erosion and pests. Using fish by-products in agriculture can help achieve sustainable agriculture, promote public well-being, and maintain environmental balance.

Introduction

Fish flesh is made up of macronutrients (moisture, proteins, and lipids) and micronutrients (minerals, vitamins, and enzymes). Additionally, crabs and mollusks contain carbohydrates in the form of glycogen. Because of

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their unique makeup, seafood goods are considered a highly perishable commodity. Because fishing vessels typically gear seafood at great distances from consuming areas, appropriate preservation is required to prevent product spoiling. This requirement is fueled further by consumer desire for high-quality, lightly processed food with minimal nutritional and sensory alterations. This also applies to farmed seafood species, which must be carefully maintained before being safely conveyed to far locations (Kontominas et al., 2021). Traditional ways of preserving seafood include chilling, freezing, drying, salting, smoking, fermenting, and canning, all of which regulate water activity, enzymatic and oxidative changes, and microbiological activities. Traditional techniques of preservation incur significant processing and storage costs. Furthermore, customer desires for clean label ingredients and natural foods, as well as worries about the safety of chemical additives and preservatives, have encouraged the food industry to look at green food preservation technology. There are several nonthermal and green technologies accessible, including pulsed electric fields and ultrasonication. However, HPP is gaining acceptance in the seafood business ahead of other technologies (Roobab et al., 2022).

Fish Processing Industry and Its By-products

Fish processing is the process of converting raw fish captured by fishermen into marketable fish and goods. It includes industries such as fish handling, marketing, and distribution. Raw fish can be converted into marketable fish using either mechanical or manual processes. Often, first treatment of raw fish is required to eliminate fish spoilage or flight from the viscera, head, or skin. Such treatment involves cleaning, washing, or a combination of washing and cleaning whole fish obtained from fishing vessels or cold warehouses. The fish is then processed into commercial goods like as fillets, steaks, curing, and so on through further stages such as heading, filleting, trimming, shelling, cutting, slicing, or a combination of these methods. A final processing step is commonly given to packed fish to preserve it and allow for long-term storage and transportation fresh, frozen, or dried (Siddiqui et al., 2023).

Fish processing generates a variety of byproducts, depending on the method and species. Understanding the many types of byproducts is crucial to fully grasp industrial applications. Common by-products include fish heads, frames, skin, scales, and viscera, all of which have significant nutritional value. Others include bones, fins, and guts, which can be processed to produce PUFA-rich proteins. The most abundant byproducts are heads and frames, or minced muscle without the backbone. Pieces of muscle may

contain bone and skin remnants (Antonio Vázquez et al., 2019). The head, which is made up of skull, rostral cartilage, and other soft connective tissues, can contain up to 50% crude fat. Crude ash in heads and frames is higher than in muscle, accounting for around 49% of dry mass and being primarily used to calculate total PUFA levels. The frame's composition is roughly 50-60% muscular. Because of their chemical composition, such byproducts, particularly the heads, show promise for the combined extraction of oils and gelatines. Fish by-products vary in composition based on species, size, handling, freshness, season, processing methods, conversion mode, and time between landing and processing (Šimat, 2021).

Techniques for Utilization

Because of its well-known health benefits, fish intake generates a substantial amount of by-products. To make use of these byproducts, a variety of processes have been developed, including fish oil extraction, protein hydrolysate manufacturing, and gelatin. Fish oil, which contains omega-3 acids, is extracted from the fatty tissues of fish using industrial rendering techniques or vacuum conditions. Protein hydrolysates, which are easily absorbed high-quality protein sources, can be created from marine byproducts via compound enzymatic hydrolysis. Gelatin is created in controlled acidic or basic conditions and then removed from fish skin or bone heated in water (Ozogul et al.2021).

Discarding fish bycatch and fish processing byproducts is a frequent practice in both fishing businesses and fish processing companies. To combat present unsustainable fishery methods in the oceans, the use of fish byproducts is a critical and difficult undertaking. In general, fish byproducts are high in vital nutrients and biologically active compounds that benefit human health, such as proteins, lipids, minerals, and vitamins. Given this reality, innovative green technologies are being researched and developed to extract added value components and high-value bioactive compounds from seafood and their byproducts (Al Khawli et al., 2019). Fish oil extraction is a significant attempt to use fish byproducts. Fish oil, rich in □-3 polyunsaturated fatty acids (PUFAs) like eicosapentaenoic acid (EPA; 20:5n-3) and docosahexaenoic acid (DHA; 22:6n-3), has been shown to prevent cardiovascular, hypertension, arthritis, and inflammatory diseases (Kulås, 2021). Furthermore, fish oil is well recognized to contain a number of other dietary elements such as natural tocopherols and other antioxidants, which are currently being researched as natural food supplements (Kapoor et al., 2021). If future improvements in fish oil extraction techniques result in higher fish oil yield and quality, their implementation at the industrial level

has the potential to improve the overall efficiency with which fish industry byproducts are utilized, thereby enhancing the circular economy within this industry. Furthermore, a more thorough examination of fish oil markets is recommended, considering that, in light of new industrial technologies, fresh applications of fish oil with tremendous potential may develop (Rodrigues et al., 2024). Enzymatic hydrolysis, a very effective process for converting inedible fish protein into value-added compounds, has received a lot of attention. Hydrolysis of low-value fisheries sector by-products has grown in popularity as a result of the present global emphasis on maximizing resource usage. Fish protein hydrolysates have various nutritional advantages, including high digestibility, bioavailability, and functional qualities (Araujo et al., 2021). It has been noted that by-products from the marine industry have a substantial impact on overall by-products, as they contain a large volume of chitin-rich proteins. The creation and implementation of better and value-added uses are critical for expanding product markets (Venugopal, 2021). From a business standpoint, it is obvious that efforts to improve processes and goods should be increased. Several recent technological advancements in the fisheries industry offer valuable information and suggestions for current issues. Strengthening product recycling and incorporating organic and environmentally friendly ideas into equipment production and industrial operations are critical steps toward developing the food sector. Coordinate the post-treatment process, develop a processing technology system for final goods derived from marine resources, implement the ideal rolling design, and expand manufacturing equipment (Cooke et al., 2021).

The primary raw materials for gelatin production are fish skin and bone. Gelatin processing involved multiple processes, including soaking, washing, heating, demineralization, and the production of oxidative and hydrolytic compounds. Furthermore, the fish gelatin was assessed for proximate and quality analysis, with protein and fat content being measured. The fish gelatin had low protein and fat concentrations as a result of many washing and heating processes, and extended soaking was projected to result in 3.0%-3.5% fat content and 1.5%-2.0% ash. Fish gelatin, in instance, exhibited a larger molecular weight than bovine and pig gelatins across a broader range of processing conditions. The fish gelatin exhibited a high gel strength for a shorter period of time. The fish gelatin dispersions had a pH of 6.67-6.86 and were more transparent than bovine and pig gelatin gels by more than 82%. Fish gelatin is type A, with a PI of 8.36 (Nurilmala et al., 2022).

Application in Various Industries

Food, pharmaceutical, cosmetics, agricultural, and energy industries are all expressing interest in and expanding their usage of fish byproducts. These

industries are increasingly relying on the nutritional and functional qualities of fish by-products to improve product formulations and develop sustainable solutions. This tendency may be seen in industries such as food processing, cosmetics, and medicines, where fish meal, fish oil, and other derivatives are being used to boost nutritional value, improve sensory qualities, and promote health advantages (Lal et al.2023. Fish byproducts have become an essential part of the food sector. In the culinary world, fish byproducts such as heads, skins, and bones are widely utilized to make stocks, broths, and soups. These marine byproducts are well-known for increasing umami flavor characteristics and are presently used in a variety of food products (Siddiqui et al., 2023). Food product innovations based on seafood by-products are lowering waste and enhancing the efficiency with which seafood raw materials are used (Altintzoglou et al., 2021). Food from the global fisheries system is frequently devalued due to a focus on marketable protein from a limited number of species. Seafood by-products allow the culinary world to embrace neglected or underutilized things like jellyfish, arthropods, and pteropods, hence diversifying seafood commodities (Xia et al., 2024).

The pharmaceutical sector contains untapped potential for the use of fish byproducts. Fish contains active substances such as bioactive peptides and long-chain omega-3 polyunsaturated fatty acids, which are necessary for human health (Nikoo et al., 2023). Another novel way to use fish raw materials is to clean the skin with enzymes. The pharmaceutical sector has recognized the efficacy and safety of using fish skin and bones as collagen sources (Oslan et al., 2022). Beauty and health products derived from fish skin or bone collagen are projected to become increasingly popular in the market. A hydrolyzed fish skin collagen-based preparation in the form of a gel used as a pain reliever for locals and registered as a medicinal product is an example of a pharmaceutical product containing a fish-derived active component (Venkatesan et al., 2017). Fish-based phytopharmaceutical products are completely herbal mixture medications (hepatotonic and hyperlipidemia therapy). As the consumption of conventional medicines with western active agent content has declined in recent years, traditional, primarily herbal remedies in the form of dietary supplements, have gained popularity. These trends are expected to continue, providing pharmaceutical items including herbal preparations derived from fish a potentially fascinating piloting and economic niche for companies now developing fish-based pharmaceuticals. These products could have a significant economic impact, despite the fact that the scientific knowledge base for using fish as a raw material in pharmaceuticals and health products is still developing. The reduced administrative burden and inexpensive cost of the goods may make

the usage of fish active compounds appealing to pharmaceutical businesses (Al-Nimry et al., 2021).

The cosmetics industry is largely built on the promise of beauty. This promise has been turned into a more individualized pursuit for well-being. The business has spent years working with patients, dietitians, and biologists to establish settings that allow for chemical improvements to the skin, hair, and body. In recent years, the skin has been recognized as an essential component of a healthy lifestyle. Recent studies have begun to preserve and improve skin health through the creation of new technologies. Future research into novel anti-aging materials is predicted to benefit people's long-term health and welfare (Rizzi et al., 2021). In accordance with these findings, oil compounds and other marine-derived materials have lately been produced for cosmetic applications. The cosmetics sector is interested in this expansion because of its market potential and related to environmental factors (Fonseca et al., 2023). Using by-products from the fishing sector, especially from marine life, can create valuable items while also recycling and reducing waste (Šimat, 2021). In general, byproducts from the fish sector are heavy in proteins and lipids. They also have a high tolerance for bio-organic disposal, making them recyclable. The principal byproducts of fish processing are the head, backbone, skin, and viscera. Fish fats used to be thought of as low-value byproducts that were frequently discarded as trash. However, fish fats include a wide range of beneficial components. Biodiesel is produced from vegetable oils using natural enzymes. However, omega-3 fatty acids from fish oil are fragile and easily attacked by enzymes. As a result, many fish derivates are unsuitable for use as edible fish oils, necessitating the development of alternate therapies. Animal-derived substances can spark debate and raise ethical concerns, but creams, lotions, and other formulas can contain fish derivatives. Talent from these cosmetics has been studied, but a surge in the usage of fish derivatives as essences in soap, shampoo, and other products has prompted fresh studies on the efficacy and acceptance of fish derivatives as an ingredient in these sorts of cosmetics. Despite the restricted reach, interest in producing this type of product has been proven (Siahaan et al., 2022).

The growing global population and continued fight against poverty have created sustainability difficulties in a variety of fields, including agriculture. Agriculture necessitates the production of food and high-value substances, as well as the management of land, water, and crops, and the control of erosion and pests. Using fish by-products in agriculture can help achieve sustainable agriculture, promote public well-being, and maintain environmental balance (Šimat, 2021). They have the potential to improve soil quality while also

promoting plant development. Compounds generated from fish by-products can be effective antagonists to the most common agricultural illnesses due to their chemical structure. Chitins and chitosans, for example, have been shown to have significant potential as natural fungicides. This is good news for organic agriculture, which is thriving in the pursuit of environmental sustainability (Elgendy et al., 2024).

Future Trends and Innovations

After removing edible sections, fish by-products still account for almost two-thirds of the total. In recent years, there has been significant progress in the use of fish byproducts for industrial uses, although a large amount continues to be wasted. Because fish byproducts have a great potential for value-added products, awareness will continue to fuel market expansion in the fish processing industry (Tahergorabi and Adegoke, 2021).

The primary developments in processing technology have been focused on getting ingredients from fish byproducts, which improves the efficiency of extraction procedures and the quality of the finished goods. This means that the application of new green sustainable technologies will be determined by the byproduct (e.g., skull, bones, and skin) and the intended high-value ingredient to be recovered (e.g., collagen, enzymes, or peptides) (Al Khawli et al., 2019).

Consumers are increasingly demanding more novel fish by-product foods generated from relevant biomolecules, necessitating the application of new strategies and increased investment in the creation of fish by-product-based products (McKenzie et al., 2022). However, what is currently driving interest in the use of fish byproducts is the anticipation of major future developments. A growing number of surveys and research are being conducted to analyze the future market for fish byproducts (Coppola et al., 2021). This research has demonstrated the growing importance of fish byproducts and their related chemicals. Here, fish byproducts are used to make feed, food, crops, or other added-value goods, primarily in accordance with the concepts of sustainability and the circular economy. Furthermore, as people become more aware of the importance of exploitation of fish byproducts, there has been an increase in collaborations between enterprises, research institutes, and universities. Collaboration is resulting in tangible projects such as product development, pilot plants, and experimental systems. These projects can serve as models for future by-product development (Šimat, 2021).

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