Valorization of fish processing waste through enzymatic extraction: a short review

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The continuous growth of the world population and industrial development have led to a massive increase in the sale of products deriving from fishing. As a result, fish waste production has dramatically increased on a global scale: around two-thirds of the total amount of fish is wasted, raising serious economic and environmental issues (Coppola et al., 2021). In particular, the fish processing industry is the main responsible for the production of seafood waste, more than 60% of the catch is discarded during the production chain (Ideia et al., 2020).

These by-products, comprising carcass, head, skin, scales, tail, fins, bones and viscera (fig.1), usually discarded, have recently attracted the attention of researchers thanks to their potential to generate high-added-value compounds, such as proteins, fish oils, collagen, and gelatine etc. These high-added-value compounds show great potential for a variety of applications, from food ingredients to pharmaceuticals and cosmetic products (Ideia et al., 2020).

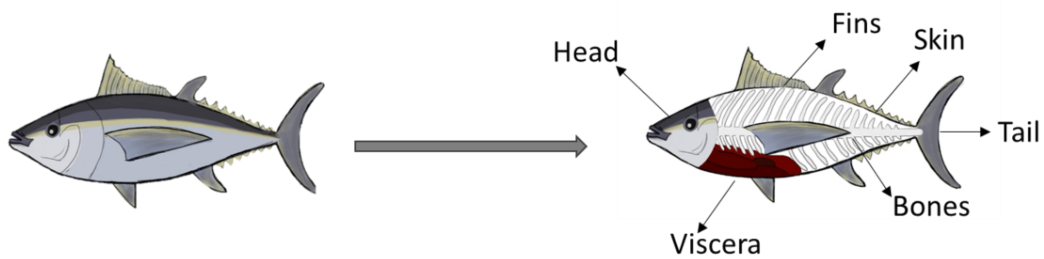

Figure 1. Main fish processing by-products

Usually, the extractions of these bioactive compounds are conducted following the traditional method. The main disadvantage of these methods is that they exploit toxic solvents which can remain in the final product but also the high temperatures applied can degrade heat-sensitive and labile natural compounds. Moreover, these methods have a huge impact on the environment because the extraction process requires a significant amount of heat and energy and there is a risk of solvents leaking into the environment (Ivanovs and Blumberga, 2017). One of the most promising innovative green extraction methods is represented by enzymatic hydrolysis. In enzymatic extraction, exogenous enzymes are added to the matrix to digest it and release the bioactive compounds of interest.

Enzymatic hydrolysis is an ideal way to recover bioproducts from fish and fishery processing waste. The enzymes must be of food quality, and in most cases, alkaline/neutral proteases are used for the hydrolysis because they produce better results than acidic proteases (Ivanovs and Blumberga, 2017).

The main products obtained from the fish waste materials are: fish protein hydrolysate (FPH), oil, gelatine and collagen. A protein is hydrolyzed when is broken into smaller peptides or amino acids. Bioactive peptides typically contain from 3 to 20 amino acid residues and their amino acid composition and sequence are responsible for their activity. These peptides present antioxidant and antihypertensive activities, regulate nutrient uptake and the immune system, and act as metabolic modulators (Yang et al., 2011). The oil percentage of fish waste materials can range from 1.4 to 40.1%, depending on the species and fish parts (Pudtikajorn and Benjakul, 2020). Wastes are often used to produce high-quality oil, rich in long-chain polyunsaturated fatty acids (PUFAs), in particular, omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Collagens are one of the most abundant proteins in animals and are intrinsically bioactive, biocompatible, and biodegradable. Collagens are one of the most commonly required and used biomaterials in many fields (Rajabimashhadi et al., 2023). Gelatin is a water-soluble biopolymer derived from the thermal denaturation of collagen and is extensively utilized in the food industry because of its physicochemical properties (Wang, 2022).

As reported in table 1, one of the most used enzymes in the production of bioactive peptides is alcalase. Alcalase is a protease initially obtained from Bacillus subtilis and is now produced by fed-batch fermentation using *Bacillus licheniformis.*

This review intends to analyze and discuss the methods available for the enzymatic extraction of selected high-added-value compounds from fish processing waste with a particular focus on FPH, fish oil, collagens, and gelatine.

Table 1: main species of fish valorised and the relative enzymes used

Fish waste	**Enzyme**
Catla and Rohu	Protease-P-Amano6
Mackerel	Alcalase
Ribbon fish	Alcalase
Mix Fish waste	Alcalase
Cobia	Papain
Tuna	Umamizyme
Cod and haddock	Papain
Small-spotted catshark	Esperase
Dagaa fish	Alcalase

1. Coppola, D., Lauritano, C., Esposito, F.P., Riccio, G., Rizzo, C., Pascale, D. De, 2021. Fish Waste : From Problem to Valuable Resource, Mar. Drugs 2021, 19, 116. https:// doi.org/10.3390/md19020116
2. Ideia, P., Pinto, J., Ferreira, R., Figueiredo, L., Spínola, V., Castilho, P.C., 2020. Fish Processing Industry Residues : A Review of Valuable Products Extraction and Characterization Methods. Waste and Biomass Valorization 11, 3223–3246. https://doi.org/10.1007/s12649-019-00739-1
3. Ivanovs, K., Blumberga, D., 2017. ScienceDirect ScienceDirect Extraction of fish oil using green extraction methods : a short review. Energy Procedia 128, 477–483. https://doi.org/10.1016/j.egypro.2017.09.033
4. Pudtikajorn, K., Benjakul, S., 2020. Simple Wet Rendering Method for Extraction of Prime Quality Oil from Skipjack Tuna Eyeballs. Eur. J. Lipid Sci. Technol. 122, 1–10. https://doi.org/10.1002/ejlt.202000077
5. Rajabimashhadi, Z., Gallo, N., Salvatore, L., Lionetto, F., 2023. Collagen Derived from Fish Industry Waste : Progresses and Challenges.
6. Wang, H., 2022. Repurposing fish waste into gelatin as a potential alternative for mammalian sources : A review 942–963. https://doi.org/10.1111/1541-4337.12920
7. Yang, P., Ke, H., Hong, P., Zeng, S., Cao, W., 2011. Antioxidant activity of bigeye tuna (Thunnus obesus) head protein hydrolysate prepared with Alcalase. Int. J. Food Sci. Technol. 46, 2460–2466. https://doi.org/10.1111/j.1365-2621.2011.02768.x