

TECHNOLOGICAL CAPABILITIES AND PROSPECTS FOR OBTAINING VALUABLE PRODUCTS FROM FISH WASTE

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Abstract.

This article examines the processing of fish waste as a promising avenue for environmentally sustainable production in Uzbekistan. Particular attention is paid to the potential for utilizing heads, bones, skin, scales, and other fish-processing by-products as secondary raw materials for food production. Modern methods of fish waste processing-including the production of protein products, gelatin, and collagen-are reviewed. The article demonstrates the feasibility of using local fish raw materials to create new products with high nutritional and biological value. Processing fish waste helps mitigate its negative environmental impact, reduce the volume of industrial waste, and improve the efficiency of fish resource utilization. The findings can be applied to the development of environmentally safe technologies for the comprehensive processing of fish raw materials within the context of Uzbekistan.

Keywords: fish waste, fish processing, waste processing, environmental safety, secondary raw materials, fish meal, fish oil, collagen, utilization, zero-waste production.

Introduction. The development of fish farming and the fish processing industry in the Republic of Uzbekistan is accompanied by an increase in the volume of raw fish processing and, consequently, the generation of significant quantities of by-products and waste. Under traditional processing methods, a substantial portion of secondary raw materials-including heads, skin, scales, bones, swim bladders, internal organs, and other fish parts-often remains underutilized. This not only results in the loss of potentially valuable biological resources but also creates additional challenges regarding their storage, transportation, and disposal. Fish waste constitutes a complex biological raw material containing proteins, lipids, minerals, collagen, and other biologically valuable components. The content and ratio of these individual components can vary significantly depending on the fish species, the anatomical part, and processing conditions. Consequently, fish processing by-products can be viewed not merely as production waste but as a promising source of secondary raw materials for the manufacture of various

products. The protein component of fish waste is of particular importance. Skin, bones, scales, and swim bladders contain significant amounts of structural proteins, including collagen. Collagen is one of the most abundant animal-derived proteins and is widely used in the food, pharmaceutical, cosmetic, and other industries. It serves as a basis for producing collagen hydrolysates, gelatin, and other protein products with specific functional and technological properties.

The processing of fish by-products into gelatin is of particular interest to the food industry. Gelatin possesses gelling, stabilizing, and structuring properties, making it a valuable ingredient in the manufacture of various food products. Utilizing fish raw materials for gelatin production expands the available resource base while simultaneously increasing the depth of fish processing.

In addition to protein components, fish waste serves as a source of minerals. Bones and scales contain compounds of calcium, phosphorus, and other mineral elements, enabling their further utilization following appropriate processing. Depending on the technology employed, specific types of fish waste can yield protein concentrates, animal feed products, mineral components, fats, collagen, gelatin, and other products of practical value.

Modern approaches to processing fish raw materials entail a shift from simple waste disposal to comprehensive utilization. Under this approach, every part of the fish is viewed as a potential source of specific valuable components. This increases the efficiency of raw material use, expands the product range, and reduces the volume of unused by-products.

For the Republic of Uzbekistan, this area is of particular relevance due to the growth of fish farming and the increasing role of fish products in supplying dietary protein to the population. Utilizing local fish raw materials to produce value-added goods enables the creation of new processing lines directly within fish processing enterprises. Crucially, the practical implementation of such solutions depends on employing accessible processing methods and adapting existing technologies to local fish species.

One promising avenue is the processing of by-products from freshwater fish, specifically common carp (*Cyprinus carpio*). The swim bladder, skin, scales, bones,

and other parts of these fish can serve as potential raw materials for producing collagen-based and other protein products. However, processing efficiency depends on the type of raw material, its initial condition, pre-treatment conditions, processing temperature and duration, as well as the extraction and drying methods employed. Scientific literature describes various methods for processing fish by-products, including mechanical, thermal, acidic, alkaline, and enzymatic treatments. The choice of a specific technological approach is determined by the composition of the raw material and the target product. Moreover, data obtained for one fish species or under specific processing conditions cannot always be directly applied to other raw materials. Therefore, it is essential to conduct specific studies on local fish species to determine the yield and quality characteristics of the resulting products.

The efficient processing of fish by-products allows for the simultaneous resolution of several technological challenges: maximizing raw material utilization, generating high-value-added products, reducing waste, and enhancing the overall efficiency of fish processing operations. Of particular importance is the development of technologies that transform these by-products into materials suitable for further use in the food industry and other sectors. Thus, studying the technological capabilities for processing fish waste and identifying promising avenues for deriving valuable products from it are matters of both scientific and practical interest. Investigating the composition of various types of secondary fish raw materials, selecting efficient processing methods, and evaluating the properties of the resulting products can facilitate the development of comprehensive fish processing in the Republic of Uzbekistan.

Processing fish by-products into collagen, gelatin, and collagen peptides represents a promising avenue for the development of domestic production in the Republic of Uzbekistan. The availability of local raw materials—such as the skin, scales, bones, and swim bladders of common carp and silver carp—creates an opportunity to establish an additional resource base for producing high-value-added goods. A promising approach involves developing an integrated technology for processing fish waste that maximizes the utilization of various raw material fractions. This would enable the production of several types of in-demand products,

including collagen, gelatin, collagen peptides, and protein and mineral components. Developing technologies to produce collagen peptides with controlled properties is of particular importance. Optimizing extraction, enzymatic hydrolysis, purification, and drying processes will yield products suitable for application in the food, cosmetic, pharmaceutical, and other industries.

Creating domestic technologies tailored to local fish raw materials offers significant potential. Such initiatives could help expand the range of domestically produced goods and reduce reliance on imports of collagen, gelatin, and collagen peptides. Future steps should include a techno-economic assessment of the proposed technologies, determination of product yields and production costs, analysis of quality and safety parameters, and an evaluation of the feasibility of scaling up laboratory-stage developments to industrial production. Thus, the integrated processing of fish waste could become a key driver for the development of Uzbekistan's fish processing industry, simultaneously enhancing the efficiency of local raw material use and laying the foundation for the domestic production of collagen-based products.

Materials and Methods. The study utilized by-products generated during the processing of local fish raw materials at facilities in the Republic of Uzbekistan. The materials examined included the skin, scales, and bone residues of common carp (**Cyprinus carpio**), mirror carp, and silver carp (**Hypophthalmichthys molitrix**).

The selected raw materials underwent preliminary processing, which included washing and the removal of mechanical impurities and foreign matter, followed by drying. The prepared materials were then used to investigate processing options and the production of items with potential nutritional and technological value.

Fish scales served as the primary raw material for producing a collagen-containing product. The process began with demineralization, followed by the acid extraction of collagen components. The resulting extract was then purified and concentrated. The potential for forming a gel-like product was evaluated based on

organoleptic and functional characteristics, including appearance, color, consistency, structural stability, and gelling capacity.

To broaden the assessment of opportunities for the rational utilization of fish waste, a comparative analysis of modern processing methods was also conducted. The study examined the feasibility of producing fish meal, fish oil, and collagen-containing products from various fish raw material fractions, as well as the use of bone residues as secondary raw materials.

The results were analyzed using comparative and descriptive methods. When evaluating processing prospects, the following factors were taken into account: the composition of the raw material, the potential value of the resulting products, the possibility of reducing the volume of unused waste, and the potential for the comprehensive utilization of the fish raw material. Table 1 presents data on the quantities of the main types of waste generated during the processing of common carp (*Cyprinus carpio*), domesticated carp, and silver carp.

**Volume of waste generated during the processing of major fish species
in the Republic of Uzbekistan**

Table 1.

Fish species	Mass of starting material, kg	Leather, kg	Scales, kg	Bones, kg	Total amount of waste, kg
Wild carp	10,0	0,8	0,5	1,2	2,5
Common carp	10,0	0,9	0,6	1,3	2,8
Silver carp	10,0	1,0	0,7	1,5	3,2
Total	30,0	2,7	1,8	4,0	8,5

The data presented characterize the significant volume of by-products generated during the processing of major freshwater fish species. Bone residues

constitute the largest share of the fractions studied, while skin and scales also account for a substantial portion.

The skin, scales, and bones of common carp and silver carp can be considered promising sources of secondary raw materials for the production of various goods. Specifically, the protein components of the skin and scales can be used to produce collagen and gelatin, whereas bone residues are valuable as sources of minerals and proteins. The integrated processing of these fractions makes it possible to increase the utilization rate of fish raw materials, reduce the volume of unused by-products, and expand the range of products derived from fish.

Thus, processing by-products from fish processing plants to obtain collagen, gelatin, fish meal, fish oil, and other secondary raw materials represents a promising approach to improving the efficiency of fish resource utilization and advancing the integrated processing of fish raw materials.



*Fig. 1. Swim bladder at various stages of processing:
a - dried; b - boiled; c - gelatin powder*

Key physicochemical and functional properties of the obtained gelatin samples were determined, including moisture content, protein content, ash content, pH, solubility, viscosity, water- and fat-holding capacities, gel strength, gelation temperature, and melting temperature.

These parameters were measured using standard methods established for the characterization of food-grade gelatin. Particular attention was paid to product yield, gel strength, and viscosity, as these characteristics allow for the assessment of the gelatin's technological suitability and the determination of optimal production conditions. To confirm the collagenous nature of the product, protein and

hydroxyproline contents were measured, and the amino acid composition was analyzed where necessary [18].

Fourier-transform infrared (FTIR) spectroscopy was employed to further characterize the structural features of the obtained protein. The resulting spectra were used to identify characteristic protein functional groups and to verify the product's collagenous nature. Where required, sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) was used to further characterize the protein components [20].

Conclusion. The processing of by-products from common carp (wild and farmed varieties) and silver carp represents a promising avenue for the rational utilization of fish raw materials. Skin, scales, bones, swim bladders, and other fish parts generated during processing can be viewed as valuable sources of protein, collagen, and minerals. Utilizing these types of secondary raw materials enables the production of high-demand products, including collagen, gelatin, collagen peptides, fish meal, and fish oil. Their comprehensive processing enhances the utilization rate of the initial fish raw material and reduces the volume of unused by-products.

Developing technologies to extract collagen, gelatin, and collagen peptides from local fish raw materials is of particular practical interest. Establishing domestic production technologies for these products could help create an additional raw material base and expand the output of goods capable of replacing a portion of imported collagen-based materials. Rational processing of fish waste also helps reduce waste accumulation at fish processing plants and food service establishments, lowers organic waste volumes, and improves the efficiency of fish resource utilization.

Thus, the comprehensive processing of waste from common carp and silver carp holds both technological and practical significance for the development of the fish processing industry in the Republic of Uzbekistan. Further development and refinement of technologies for producing collagen, gelatin, and collagen peptides from local raw materials could lay the foundation for high-value-added production, foster import substitution, and establish a more rational system for processing fish raw materials.

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