VALORIZATION OF ANIMAL BY-PRODUCTS OF THE AFRICAN CATFISH (*Clarias gariepinus*) TO GELATIN PREPARATION

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ABSTRACT

This study investigates using African catfish (*Clarias gariepinus*) by-products for gelatin extraction, promoting sustainability. Gelatin yield (32.0–43.1 %) exceeded literature values, but gel strength (79.4–99.0 Bloom), viscosity, and clarity were lower, potentially limiting applications. The melting point (23.1–23.2°C) aligns with typical fish gelatin. While promising, further optimization is needed to enhance functional properties.

Keywords: African catfish, animal by-products, gelatin extraction, gelatin yield, gelatin characterization

INTRODUCTION

Gelatin, a versatile biopolymer, is widely used in food, pharmaceuticals, cosmetics, and photography due to its unique functional properties (See et al., 2013). It is derived from the partial hydrolysis of collagen, primarily from bovine and porcine sources. However, health concerns and religious restrictions (Halal, Kosher) have increased interest in fish gelatin as a sustainable alternative. The African catfish (*Clarias gariepinus*) is a promising source, with its skin and bones rich in collagen (Alfaro et al., 2014; Sanaei et al., 2012).

African catfish are valued for their rapid growth, resilience, and high-quality meat (Gebremichael et al., 2023). Global production has surged from 6,000 to 248,000 tons, with Nigeria leading globally and Hungary and the Netherlands in Europe (FAO, 2025). Over 60% of the raw material—heads, skeletons, fins, skin, and viscera—remains unused for direct food consumption but holds potential for fish oil and gelatin extraction (Adejumo et al., 2022).

This study outlines a method for processing *Clarias gariepinus* by-products into gelatin, assessing efficiency and characterizing the final product, contributing to sustainability and the circular economy.

MATERIAL AND METHODS

Samples of African catfish by-products, mainly fish skeletons, were obtained in collaboration with Tilapia s.r.o., Radenín-Hroby. The raw material was analyzed for moisture, ash, protein, and lipid content. Moisture and ash content were measured gravimetrically (EN ISO 8534), with the ash content determined after incinerating the sample (ISO 6884), lipid content was determined using Soxhlet extraction (ISO 1443), and nitrogen was assessed by the Kjeldahl method (ISO 5983-1).

Raw material processing

African catfish bones were minced using a Braher P22/82 meat cutter (13 mm plate, double-sided knife; Braher, Spain), vacuum-sealed, and frozen (–85 ± 1 °C for 12 hours, then stored at –18 ± 1 °C). To obtain pure collagen, the thawed material was rinsed, treated with 0.2 M NaCl (1:6, 1.5 hours), and processed in 0.03 M NaOH (45-minute cycles, repeated three times) with cold water rinses. Finally, it was spread thin and dried at 35 ± 1 °C for 24–36 hours.

Defatting process

The raw material was defatted using a 1:6 hexane mixture, shaken for 1.5–2 days with two solvent changes, and then air-dried. The defatted collagen was milled to about 3 mm and stored in a sealed container in the dark.

Demineralization process

Demineralization, done due to the high-mineral raw material, uses 1.0 % HCl (1:10) at 10 ± 1 °C for 48 hours with mixing and an acid change after 24 hours, followed by rinsing and then dried thin at 35 ± 1 °C for 24–36 hours and milled to around 2 mm pieces. Its dry matter content is determined for subsequent enzymatic processing.

Gelatin extraction

Gelatin extraction followed optimized conditions, varying three factors: first and second extraction temperatures and second extraction duration. Four experiments were conducted: 1. experiment: 35 °C, 50 °C, 15 minutes; 2. experiment: 35 °C, 60 °C, 15 minutes; 3. experiment: 45 °C, 50 °C, 15 minutes; and 4. experiment: 45 °C, 60 °C, 35 minutes. The defatted, demineralized material was minced and treated with 0.1 % Protamex® (pH 6.5–7, 10 ± 1 °C) for 3 hours. Sequential extractions occurred first at 35–45 ± 1 °C (20 minutes), then at 50–60 ± 1 °C (15–35 minutes), followed by at 70 ± 1 °C (20 minutes), and finally at 90 ± 1 °C (30 minutes). After extractions, the gelatin solutions were filtered and centrifuged to separate the gelatin, fat, and residual pigment. The first and second extraction followed a quick heat to 85 ± 1 °C for 4 minutes. The gelatin fractions were dried in a stepwise manner, first at 40 ± 1 °C overnight, then at 65 ± 1 °C for 8 hours, ground to 1 mm.

Characterization methods

Gelatin properties were analyzed, including gel strength at 6.67 % concentration using a 0.5" cylinder probe (4 mm depression) with a Stevens LFRA Texture Analyser (GMIA, 2019), dynamic viscosity at 60 ± 0.5 °C based on flow time (GMIA, 2019), and yield as the percentage of gelatin weight relative to the demineralized dried raw material. The melting point was determined with 6.67% chilled gelatine samples drawn into glass capillaries (2–4 mm diameter, 5–10 mm height) and heated while the rising gelatine column indicated melting. The gelling point was determined as the temperature at which a solidified gelatine solution retained a defined weight ball on its surface without sinking. Clarity was measured via transmittance using a SPEKOL spectrophotometer (Thermo Spectronic, USA) on a 6.67 % gelatin solution at 45–50 °C and 640 nm (GMIA, 2019).

RESULTS AND DISCUSSION

Composition of the raw material

The chemical composition of *Clarias gariepinus* in this study was: moisture 65.8 ± 1.5 %, protein 15.4 ± 1.2 %, lipid 10.0 ± 1.1 %, and ash 5.2 ± 1.7 %. Compared to the literature on values for farmed and wild African catfish fillets, where the moisture content was 71.3–77.2 %, protein content 19.03–19.33%, lipid content 8.1–11.02 %, and ash content 1.05–1.7 %, it can be said that our raw material has lower moisture and protein content, while the lipid content is roughly the same (Abdel-Modby et al., 2021). However, the ash content is significantly higher, likely due to higher bone content in our raw material.

Characterization of the gelatin

The gelatin yield ranged from 31.9 to 40.4 %, higher than literature values (11.4–21.8 %). However, gel strength was weaker (79.4–99.0 Bloom) than the reported 142–266 Bloom, with only two fractions forming gels at 6.67% concentration; see Table 1. Dynamic viscosity (0.78–1.71 mPa.s) was also lower than in the literature (1.72–4.64 mPa.s), indicating reduced gel stability. Clarity was much lower (0.9–12.9 %) due to the presence of remaining fish pigments. The melting point (23.1–23.2 °C) was consistent with the literature (25.7 °C for catfish skin gelatin and between 11 and 28 °C for fish gelatins) (Alfaro et al., 2014; Sanaei et al., 2013; See et al., 2013). Despite high yield, the lower gel strength, viscosity, and clarity may limit its applications.

Table 1: The characterization results of the first two gelatin fractions

Experiments	Yield [%]						Gel strength [Bloom]		Melting point [°C]		Dynamic viscosity [mPa.s]		Gelling point [°C]		Clarity [%]	
	1. fraction	2. fraction	3. fraction	4. fraction	Hydrolyzate	Σ yield of all fractions	1. fraction	2. fraction	1. fraction	2. fraction	1. fraction	2. fraction	1. fraction	2. fraction	1. fraction	2. fraction
1.	10.7 ± 1.4	18.3 ± 1.0	8.5 ± 1.1	2.8 ± 0.9	8.9 ± 1.2	40.4 ± 1.1	–	–	–	–	0.80 ± 0.05	0.96 ± 0.04	–	–	5.1 ± 0.9	10.8 ± 1.3
2.	8.8 ± 0.7	21.0 ± 1.3	4.9 ± 0.8	3.1 ± 0.3	9.8 ± 2.2	37.9 ± 0.8	–	–	–	–	0.78 ± 0.04	0.95 ± 0.02	–	–	2.5 ± 0.7	8.0 ± 1.4
3.	20.1 ± 1.2	13.0 ± 1.2	1.6 ± 0.8	3.1 ± 0.6	10.1 ± 1.4	37.7 ± 1.0	–	99.0 ± 2.6	–	23.2 ± 2.3	1.07 ± 0.02	1.71 ± 0.05	–	12.2 ± 0.1	12.4 ± 1.2	2.0 ± 1.1
4.	18.9 ± 1.7	5.2 ± 1.0	3.5 ± 0.9	4.4 ± 1.1	13.3 ± 0.9	31.9 ± 1.2	–	79.4 ± 3.1	–	23.1 ± 2.2	1.14 ±0.06	1.68 ±0.01	–	12.9 ± 0.2	6.2 ± 1.0	0.9 ± 0.7

CONCLUSIONS

This study demonstrated that African catfish (*Clarias gariepinus*) by-products, particularly bones, can be a valuable raw material for gelatin production, aligning with sustainability goals. The gelatin yield was significantly higher than previously reported; however, the gel strength, viscosity, and clarity were lower than commercially available gelatins, which may limit its industrial applications. Future research should focus on refining the extraction process to enhance these properties.

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