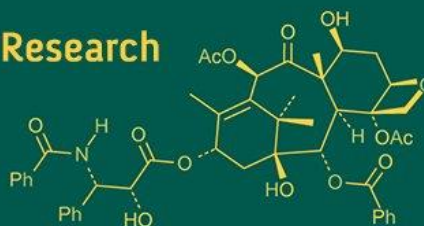


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Biochemical composition and collagen content of Bullseye fish skin: Potential for sustainable non-chrome leather production

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Abstract

The growing demand for eco-friendly biomaterials and circular bioeconomy has increased the interest in sustainable utilization of fish processing by-products. Fish skin is a collagen-rich by-product produced during seafood processing. It has great potential to be converted into value added products such as leather. The current study analyzed the biochemical composition and collagen content of Bullseye fish (*Priacanthus hamrur*) skin for its suitability in sustainable fish leather applications. The average total length and body width of the fish were 19.55 ± 0.96 cm and 5.28 ± 0.38 cm, respectively. The skin contained $65.03 \pm 2.58\%$ moisture, $33.47 \pm 2.09\%$ crude protein, $2.00 \pm 0.33\%$ crude fat, $3.41 \pm 0.29\%$ ash and $22.32 \pm 1.08\%$ collagen. The relatively high protein content, high concentration of collagen and low lipid content revealed that Bullseye skin had favourable biochemical characteristics for leather making.

Keywords: Bullseye fish, fish leather, collagen, biochemical composition, non-chrome

1. Introduction

Global fisheries and aquaculture have an important role in providing food security and supporting livelihoods of millions of people. Over the past decade, global production of aquatic animals has increased steadily (Food and Agriculture Organization, 2024) [1]. Consequently, seafood processing activities have also been increasing in parallel. Fish processing enhances product quality and market value, but also generates large amount of waste, such as heads, bones, scales, fins, viscera and skin. It can be 30-70% of the whole fish, depending on the species and the processing method (FAO, 2024) [1]. Normally these waste materials are used in the preparation of value added products like fish meal or discarded as waste which leads to economic losses and also to environmental concerns. The efficient use of fish processing by-products is therefore very important for a sustainable fisheries management and the circular bioeconomy (Caruso *et al.*, 2020) [2]. Skin is one of the fish processing by-products considered as valuable raw materials, due to its high collagen content. Fish skin collagen has good biocompatibility, biodegradability and unique structural organization. It has many applications in food, pharmaceutical, cosmetic, tissue engineering and biomaterials industries (Jafari *et al.*, 2020; Rajabimashhadi *et al.*, 2023) [3, 4].

Fish skin is increasingly being seen in recent years as a potential alternative raw material for leather making. It has multidirectional arrangement of collagen fibres which gives the skin remarkable flexibility, tear resistance and distinctive natural grain patterns (Kotian *et al.*, 2025; Krishnamurthy *et al.*, 2026) [5, 6]. These characteristics have made fish leather a viable eco-friendly alternative to traditional leather, especially for shoes, purses, handbags, clothing and fashion accessories (Covington and Wise, 2019) [7]. The growing environmental concerns regarding the traditional leather industry have stimulated the search for new and eco-friendly alternatives. Conventional leather production from hides of cattle and sheep is usually based on chrome tanning which produces chromium containing effluents that need careful treatment before disposal. Demand for environmentally sustainable alternatives has stimulated research on underutilized fish species and eco-friendly tanning technologies. Fish skin also offers an opportunity for value addition and aids in reducing the waste generated

from seafood processing industries (Kanagaraj *et al.*, 2006; Gaikwad *et al.*, 2024) [8, 9]. The biochemical composition of fish skin is very important for its suitability in leather production. Moisture content affects preservation and chemical penetration during processing, while crude fat is important in the degreasing process and in leather finishing. Ash content is a measure of the mineral content of the dermal tissue and can affect fibre opening during tanning process. Among these components, the most important is collagen. Fish skin leather with higher collagen and protein contents has better mechanical strength and durability (Muyonga *et al.*, 2004; Jafari *et al.*, 2020) [10, 3]. Therefore, the study of biochemical parameters and collagen content of fish skin is an important source of basic information for the assessment of its industrial potential.

Bullseye (*Priacanthus hamrur*) fish is a valuable demersal species distributed across the Indo-West Pacific region. It represents a major share of the Priacanthidae catch along southwest coast of India (Sivakami *et al.*, 2001; Seetha *et al.*, 2018) [11, 12]. The present study was aimed to determine the biochemical composition and collagen content of Bullseye skin and to investigate its potential as a sustainable raw material for fish leather applications.

2. Materials and Methods

2.1 Sample collection and preparation

Fresh Bullseye fish skin was collected from Mangaluru Fishing Harbour, Karnataka, India and transported in insulated containers to the Department of Fish Processing Technology, College of Fisheries, Mangaluru. The study used randomly selected thirty fish skins ($n = 30$). The total length and the maximum width of the body of each fish skin were measured (Fig. 1). The skins were manually separated from muscle tissue and thoroughly washed with ice-cold distilled water after removal of adhering flesh, blood and scales. The skins were then packed in polyethylene bags and stored at -20°C for further analysis.



Fig 1: Morphometric Analysis of Bullseye Skin

2.2 Biochemical composition

The composition of the fish skin was analyzed following AOAC (2019) [15] guidelines. Moisture content was obtained by drying homogenized skin samples in a hot air oven at 100°C until a constant weight achieved. Protein content was determined by the Kjeldahl method and nitrogen values were converted to protein by a factor of 6.25. Crude fat was estimated through Soxhlet extraction with petroleum ether as the solvent. Finally, ash content was measured by incinerating the dried samples in a muffle furnace at 550°C until a stable weight of light grey ash was obtained.

2.3 Collagen extraction and estimation

Acid soluble collagen (ASC) was extracted as per the method of Muyonga *et al.* (2004) [10] and Sasidharan *et al.* (2020) [14] with minor modification. The frozen skin samples were thawed in a refrigerator and then treated with 0.1 M sodium hydroxide (NaOH) with a sample to solution ratio of 1:10 (w/v) for 24 h at 4°C to remove non-collagenous proteins. The alkali was changed at 12 h intervals during treatment. The skins were then washed in cold distilled water until neutral pH was reached.

The pre-treated skins were defatted with 10% butyl alcohol (1:10, w/v) for 24 h at 4°C and washed thoroughly to remove the solvent residues. The collagen was extracted with 0.5 M acetic acid (1:15, w/v) and stirred continuously at 4°C for 48 h. The extract was passed through double layered cheesecloth and centrifuged at $10,000 \times g$ for 30 min. Collagen was precipitated in the final concentration of 2.5 M NaCl in 0.05 M Tris-HCl buffer (pH 7.5). The precipitated collagen was collected by centrifugation, dissolved in minimum volume of 0.5 M acetic acid, sequentially dialyzed against 0.1 M acetic acid and distilled water, freeze dried and stored at -20°C for further analysis (Jafari *et al.*, 2020; John Kumar *et al.* 2025) [5, 15].

2.4 Statistical Analysis

All analyses were performed in triplicates ($n = 3$) and the results were expressed as mean $\pm$ standard deviation (SD).

3. Result and Discussion

3.1 Morphometric measurement of Bullseye Fish skin

The morphometric features of Bullseye fish skin are presented in Table 1. The fish used in the present study had a mean total length of 19.55 ± 0.96 cm and a mean body width of 5.28 ± 0.38 cm. Morphometric parameters influence the commercial feasibility of fish leather because they determine the available skin area and therefore, the leather yield. Although *P. hamrur* is relatively smaller than freshwater species such as Nile tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*), the species contributes significantly to commercial trawl landings along the Indian coast (Sivakami *et al.*, 2001; Seetha *et al.*, 2018) [11, 12]. Therefore, this species is attractive for leather production based on the continuous availability rather than the size of the individual skin. Marine fish skins usually have a compact collagen fibre architecture, which gives a better mechanical performance of the leather despite the relatively small skin size (Covington and Wise, 2019) [7].

Table 1: Morphometric parameters of Bullseye Skin

Parameter	Value
Total length (cm)	19.55 ± 0.96
Body width (cm)	5.28 ± 0.38

3.2 Biochemical Composition and Collagen Content of Bullseye Fish Skin

The biochemical composition of fish skin is of great importance for its suitability for leather manufacture affecting preservation, processing efficiency, stability of collagen and physical properties of the final leather. Fish skin is rich in structural proteins, especially collagen and relatively low lipid content and generally considered an ideal raw material for leather production. The biochemical composition of Bullseye fish skin is presented in Table 2.

Table 2: Biochemical Composition and Collagen Content of Bullseye Skin

Parameter	Value (%)
Moisture	65.03 ± 2.58
Crude protein	33.47 ± 2.09
Crude fat	2.00 ± 0.33
Ash	3.41 ± 0.29
Collagen	22.32 ± 1.08

3.2.1 Moisture Contents

The moisture content of Bullseye skin was 65.03 ± 2.58%, showing that water was the main component of the fresh skin. Moisture is important for the maintenance of the native conformation of collagen fibres and for the provision of flexibility of the dermal matrix before tanning. It also affects microbial stability during storage, curing efficiency and diffusion of chemicals during soaking and liming (Covington and Wise, 2019) [7].

The moisture content of bullseye skin was found to be lower than those of Nile perch (*Lates niloticus*) skin (about 69-72%) and tilapia skin (68 and 73%) (Muyonga *et al.*, 2004; Costa *et al.*, 2022) [10, 16]. Similarly, Silva *et al.*, 2014 [17] reported 70% moisture content in Atlantic salmon skin. This variation is mainly due to the differences in the habitat, connective tissue organization and lipid deposition. Lower moisture content means a more compact collagen matrix, which improve shelf life of the leather. If moisture is very low, it may reduce the flexibility and penetration of chemicals used during processing treatment (Fadda *et al.*, 2024) [18]. So the water content in Bullseye was considered to be best for leather making. Similar findings have been reported for the collagen-rich skins of marine fish used in leather manufacturing (Jafari *et al.*, 2020; Rajabimashhadi *et al.*, 2023) [3, 4].

3.2.2 Crude protein content

The skin of Bullseye contained 33.47 ± 2.09% crude protein which suggests that structural proteins are a considerable part of the dermal tissue. Protein content is a major indicator of leather quality since the main structural protein of the skin, collagen, forms the fibrous framework that is stabilized during the tanning process. Fish skins with higher protein concentrations were found to have greater tensile strength, flexibility, tear resistance and durability after tanning (Covington and Wise, 2019) [7].

The protein content obtained in the present study was higher than that reported for several commercially important freshwater species such as Nile tilapia where skin protein typically ranges between 24 and 30% and was comparable to values reported for collagen rich marine fish species (Muyonga *et al.*, 2004; Jafari *et al.*, 2020) [10, 3]. Differences in protein concentration may be due to differences in age, habitat, nutritional status, connective tissue development and analytical procedures. The high protein content of Bullseye fish skin indicates a rich extracellular collagen network, which is useful in leather production because tanning agents mainly react with collagen molecules via cross-link formation.

3.2.3 Crude fat content

The crude fat content of Bullseye fish skin was 2.00 ± 0.33%, which indicates a relatively low deposition of lipids in the dermal tissue. Lipids are biologically important but from the leather processing point of view excessive fat is undesirable as it prevents the penetration of tanning

chemicals, causes uneven dye uptake and causes oxidative rancidity during storage (Covington and Wise, 2019) [7]. Lipid content in the present study was similar to lean fish species like tilapia and cod but significantly lower than fatty marine fishes such as salmon (Muyonga *et al.*, 2004, Silva *et al.*, 2014) [10, 17].

This low-fat content has several practical advantages in leather manufacture. It decreases the intensity of the degreasing treatments, decreases the solvent consumption, improves the penetration of the tanning agents and increases the uniformity of the dyeing and finishing.

3.2.4 Ash content

The ash content of Bullseye fish skin was 3.41 ± 0.29%, which is within the range commonly reported for fish skins used in collagen extraction and leather production (Muyonga *et al.*, 2004; Costa *et al.*, 2022) [10, 16]. Mineral constituents such as calcium, phosphorus, magnesium, sodium and potassium are involved in tissue integrity and affect the behaviour of collagen fibres during processing. A moderate ash content is an advantage, as too much mineral deposit may limit the opening of the fibre during liming and the penetration of tanning chemicals. Thus, the present study indicates that the Bullseye fish skin has a balanced mineral composition and is suitable for leather processing operations based on ash content.

3.2.5 Collagen content

Collagen is considered as the main structural protein of connective tissues and the most important factor in determining leather quality. Collagen content of bullseye skin was 22.32 ± 1.08% (Fig. 2). This validates the collagen-rich nature of the skin and its potential for leather making. The collagen content was lower than Nile perch and tilapia but is within the range of several marine fish species and is sufficient for leather production (Muyonga *et al.*, 2004; Jafari *et al.*, 2020) [10, 3]. The physical properties of leather are primarily determined by the quantity and arrangement of collagen (Muralidharan *et al.*, 2013; Sasidharan *et al.*, 2020) [19, 14]. During the tanning process the tanning agents form cross-links between the collagen molecules. This increases the hydrothermal stability, tensile strength, flexibility and microbial resistance of final leather (Souza *et al.*, 2017, Covington and Wise, 2019) [20, 7]. Therefore, skins containing a large amount of collagen generally produce leather with high mechanical properties.

**Fig 2:** Collagen extracted from Bullseye fish skin

4. Conclusion

The biochemical composition and collagen content of *Priacanthus hamrur* skin were analysed in the present study

determine its suitability as a sustainable raw material for leather production. The skin had good biochemical properties for leather processing. The relatively high protein and collagen contents suggest the presence of a well-developed connective tissue matrix that has the potential to produce leather with desirable mechanical properties. The advantage of low lipid content is that the degreasing requirement can be reduced and tanning chemicals can penetrate well. This shows the potential of this underutilized marine fish as an alternative source of collagen. The use of Bullseye fish skin would reduce organic waste from seafood processing industries and would promote circular bioeconomy principles by producing high-value products.

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