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Physicochemical Evaluation of Gulfam (*Cyprinus Carpio*), Rohu (*Labeo Rohita*), and Tilapia (*Oreochromis Niloticus*) from Local Markets of District Larkana, Sindh, Pakistan

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ABSTRACT

Fish is widely recognized as an important component of the human diet due to its high nutritional value and well-documented health benefits.The physicochemical characteristics of fish e.g. pH, moisture content, water holding capacity (WHC), texture and color are key indicators used to assess overall quality. These properties do not only indictate consumer preference but also the shelf stability, processing ability and marketing value.The present study was conducted to evaluate the physicochemical properties of three commercially important freshwater fish species of Gulfam (*Cyprinus carpio*) Rohu (*Labeo rohita*) and Tilapia (*Oreochromis niloticus*) collected from the local markets of District Larkana, Sindh, Pakistan. Ten specimens of each species were analysed using standard laboratory procedures to determine species specific variations. The findings revealed that Rohu possessed firmer flesh and compratively lower moisture content, indicating better storage stability and meat quality. Whereas, Gulfam exhibited the highest WHC, suggesting its suitability for processing and the development of value added products. However, Tilapia exhibited higher moisture levels and lighter flesh traits, contributing to its juiceness and visual appeal but resulting in reduced shelf life under local market conditions in the District Larkana, which are useful in terms of food safety, consumer awareness, and post harvest management practices. This study is distinguished by its regional focus and comparative assessment of fish species that have not previously been evaluated together under similar laboratory conditions in district larkana. The outputs help in enhancing local fisheries administration and advancement in market limitations of freshwater fish in Sindh.

Keywords: Physicochemical properties; Gulfam; Rohu; Tilapia; Larkana; Freshwater Fish; Quality assessment.

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Introduction

Assessment of fish quality is a multidimensional procedure that embraces biochemical, nutritional, and physicochemical indicators to give a comprehensive view of what is whole in the product and what is acceptable to consumers (Duarte et al., 2020; Silva et al., 2020). The most common ones include physicochemical characteristics that include pH, moisture content, water-holding capacity (WHC), texture, and color, which are all recognized as very important freshness, safety, and market value indicators (Chan et al., 2021; Wang et al., 2020). These parameters do not only indicate the real time post harvesting of fish but also identify the acceptability of fish to be processed, stored, and consumed.

The study of alternative freshwater species has indicated the instability of physicochemical characteristics of body parts, manipulation habits, and post-harvest procedures. As an example, research on *Cyprinus carpio* has shown that there are substantial variations in physicochemical characteristics based on anatomical location and processing conditions, and it is crucial to have strategic assessment protocols (Dong et al., 2017; Talab et al., 2024). Equally, *Labeo rohita* has been examined broadly regarding gelatin extraction and physicochemical characteristics of processed products, and thus its potential in nutrition and industrial use (Kanwate et al., 2022; Zaman et al., 2024). One of the most common freshwater species is Tilapia (*Oreochromis niloticus*) whose physicochemical and microbiological properties of quality have been extensively investigated to highlight the significance of this type of fish in food security and preference by the consumer (Foh et al., 2011; Olaoye et al., 2018).

The consumption of freshwater fish in Pakistan has grown continuously, especially in Sindh province, where aquaculture and inland fisheries are the main sources of fish and livelihood to local communities (Ahmad et al., 2024). The local fish markets, especially in District Larkana are a large sourcing area of various fish species to the local areas. Although this has increased demand, there is scanty scientific information on the physicochemical analysis of majorly consumed species like the Gulfam, Rohu and Tilapia. Past literature has not explored physicochemical characteristics in detail on the regional level, with much emphasis being placed on proximate composition, biochemical variability, and nutritional profiles, which are still unrealized (Jabeen et al., 2020; Ahmed et al., 2023). This loophole limits the capability of the producers, the processors and the consumers in order to make informed choices concerning quality assurance and competitiveness in the market.

All the physicochemical parameters have a characteristic effect on fish quality: pH is the key indicator of freshness and safety, enzyme activities, and microbial growth, as well (Rahman et al., 2021). Juiciness, palatability, and storage stability are directly proportional to the percentage of moisture and higher percentages tend to be linked to shorter shelf life and a more susceptible environment to spoilage (Adeyemi et al., 2020). WHC is the most critical process in the processing since it defines yield and quality in the stages of filleting, cooking, and storage (Li et al., 2021). The texture, which includes the firmness and cohesiveness, is one of the major factors that determine the consumer preference, and can be associated with both intrinsic muscle traits and post-harvesting (Zhang et al., 2022; Diaz et al., 2024). Meanwhile, color is used as a visual indicator of freshness and marketability, and its influence on consumer purchasing behaviour and acceptance is so strong that it significantly affects it (Picardo et al., 2025; Ghosh et al., 2018).

Owing to the growing popularity of freshwater fish in Sindh and the scarcity of complete physicochemical evidence on the species sold in District Larkana, this paper will serve to overcome the gap in knowledge. The research uses the study of Gulfam, Rohu, and Tilapia to provide a stipulated base of physicochemical characteristics, which would direct the local

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producers, processors, and consumers. It is hoped that the findings will bring about better practices of quality assessment, increase the consumer confidence as well as contributing to sustainable development of fresh water fisheries in Pakistan.

Materials and Methods

Study Area

The research was conducted in District Larkana, Sindh, Pakistan. Larkana is also located on the bank of Indus River and has been reported to have the active freshwater fish markets which provide various species to the towns and villages. The district has semi-arid climate, and hot summers with mild winters, which affect the availability of fish, how it is handled, and its storage. Considering that it is a big fishing port in the region, Larkana offers a perfect environment to assess physicochemical characteristics of the typically consumed fish species.

Sample Collection

Fresh samples of Gulfam (*Cyprinus carpio*), Rohu (*Labeo rohita*) and Tilapia (*Oreochromis niloticus*) were collected from local fish markets in District Larkana. A representative sample of ten samples of each species was randomly taken to the various vendors to make it representative. The fish were carried in insulated boxes in hygienic conditions so as to have minimal changes in temperatures and microbes. Once the collection process was complete, all the specimens were processed within 4-6 hours to ensure that the sample remained fresh enough and was not affected by storage which leads to increased variability.

Physicochemical Analysis

Physicochemical parameters were analyzed using validated procedures for fish quality assessment (Rahman et al., 2021).

pH Measurement: Muscle pH was determined using a calibrated digital pH meter. Readings were taken from homogenized dorsal muscle samples immediately after collection.

Moisture Content: Moisture percentage was measured using the oven-drying method at 105 °C until constant weight was achieved.

Water-Holding Capacity (WHC): WHC was assessed by centrifugation of homogenized muscle samples, with expressed water quantified gravimetrically.

Texture Analysis: Texture was evaluated using a texture analyzer equipped with a compression probe, recording firmness and cohesiveness values.

Color Evaluation: Color parameters (L, a, b*) were measured using a digital colorimeter to provide objective indicators of visual appeal.

Statistical Analysis

All the measurements were made three times and the results were measured in terms of mean and standard deviation. The SPSS software (version XX) was applied in statistical analysis. An analysis of variance (ANOVA) was used to establish the significant differences between the species of each of the physicochemical parameters. Tests of post-hoc were conducted at a 95% confidence level ($p < 0.05$) with Tukey HSD test in cases where ANOVA provided meaningful

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significance. Prior to analysis, assumptions of homogeneity of variance and normality were tested. Such a statistical methodology guaranteed a high level of interspecies variability assessment.

Results

Table 1. Physicochemical Parameters of Gulfam, Rohu, and Tilapia (Mean ± SD)

Parameter	**Gulfam (*C. carpio*)**	**Rohu (*L. rohita*)**	**Tilapia (*O. niloticus*)**
pH	6.9 ± 0.1	6.8 ± 0.1	6.6 ± 0.2
Moisture (%)	76.2 ± 1.5	74.1 ± 1.2	78.3 ± 1.7
Water-Holding Capacity (%)	85.4 ± 2.1	79.2 ± 1.8	82.6 ± 2.0
Texture (Firmness, N)	12.8 ± 0.9	14.5 ± 1.0	11.2 ± 0.8
Color (L* value)	58.3 ± 2.0	54.6 ± 1.8	61.1 ± 2.2

Interpretation

pH: Gulfam and Rohu maintained comparable pH values, while Tilapia showed a significantly lower pH, suggesting reduced shelf stability.

Moisture: Tilapia recorded the highest moisture, enhancing juiciness but limiting storage; Rohu had the lowest, supporting longer shelf life.

WHC: Gulfam exhibited superior water-holding capacity, indicating better suitability for processing and cooking yield.

Texture: Rohu was the firmest species, a trait linked to consumer preference and extended storage potential.

Color: Tilapia displayed the lightest flesh, increasing market appeal, whereas Rohu showed darker muscle tones.

Discussion

The differences in physico-chemical parameters of Gulfam, Rohu and Tilapia in the context of the current study are similar to the findings elsewhere in the world and support the need to carry out specific analyses on species-related in freshwater fisheries (Hasan et al., 2025; Menon et al., 2023). The firmer texture of Rohu is also in line with previous findings that highlight consumer value on the firmness of the muscle imitating meat-like consistency to increase the acceptability in various markets (Yousesaf et al., 2021; Ahmed et al., 2023). This fact exemplifies the idea that Rohu is especially adjusted to those regions where storing and transportation conditions are not ideal since hardness will help to increase shelf life and decrease storage levels.

The high ability of Gulfam to retain water (WHC) also makes it more applicable in processing. Another study showed comparable results in carp species where high WHC leads to increased cooking yield and juiciness, which renders the species worth processing on large scales (Ghosh et al., 2018; Li et al., 2021). These current findings prove that Gulfam can be regarded as an effective alternative of processors in District Larkana where processed fish products are slowly becoming more and more in demand. Comparatively, Tilapia had a better moisture content that

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indicated the soft structure of its muscles. That characteristic is associated with short shelf life in the literature, because increased moisture promotes the growth of microbes and enzymatic activity (Adeyemi et al., 2020; El Sayed, 2019). Although Tilapia continues to enjoy its popularity because of its worldwide presence and fast characteristics in aquaculture sources, its physicochemical characteristics imply that it has constraints in its storage stability under a localized market resource.

The difference in color of the three species is also critical in the consumer perception and buying behavior. The light bilge flesh of Tilapia has been also linked to freshness and aesthetic appearance, and this has been in agreement with previous observations that preferably, lighter coloured fish are favoured by consumers in retail outlets (Olaoye et al., 2018). Nevertheless, this is compromised by its less capacity to store information. The darker tone of Rohu, despite the fact that it is nutritionally equivalent, might be restrictive in the urban markets where the consumers frequently equate the light flesh as high-quality (Khan et al., 2022). The moderate color index of Gulfam also makes it a species with high adaptability or a product that can attract both rural and urban-based consumers, which is also confirmed by the inquiry that moderately colored carp species are more widely accepted in the market (Picardo et al., 2025).

The current research has unique information of the District Larkana, where the consumption of freshwater fish has become an essential part of local meals and lifestyles. Most research activities have been done in the past in Pakistan focusing primarily on proximate composition and nutritional variability, but very little came out on physicochemical characteristics. By sealing this gap, the present study will have some baseline information that can guide the practice of handling post-harvest, consumer awareness, and fisheries management strategies. Such findings are especially pertinent considering the fact that, in the province of Sindh, there is a growing need to consume fish, and local markets are growing in size, yet typically do not use standardized procedures to evaluate the quality of food (Hasan et al., 2025; Menon et al., 2023).

Comparisons to the previous studies demonstrate existing similarities and differences. Although the extant literature in the world has affirmed the role of WHC and texture in establishing the suitability in processing, the current study reiterates the way the characteristics are disadvantaged according to the local climatic and market circumstances. In case of an example, the high WHC of gulfam is representative of other carp species, but its market performance in Larkana markets is unique due to an increase in the demand of processed fish. On the same note, the hardiness of Rohu is highly recorded; however, this property is useful in Sindh because Rohu can survive a long period of storage under conditions that have very minimal refrigeration. The softness of Tilapia because of moisture is always a challenge in Pakistan because facilities to store it are not always available with us and this is unlike the reports that are issued in the international market.

Overall, the study allows concluding that physicochemical characteristics are species-specific and also context-dependent, determined by the local ecological conditions and consumer demands. Combining the findings with those made in prior studies, the work furthers knowledge on the subject of fish quality assessment and offers practical recommendations to stakeholder in District Larkana. The findings in the research highlight that species-specific handling and marketing approaches are required to accommodate the species difference, which contributes to sustainable management of fisheries as well as increases consumer confidence in the local markets.

Conclusion

Physicochemical analysis of Gulfam, Rohu and Tilapia indicated that each species

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possess different quality characteristics that highlight the significance of specific assessment of species in the freshwater fishing industry. Rohu was the best in texture and exhibited low moisture content, which made it have a high probability of longer shelf life and consumer preference. Gulfam was found to be of better capacity of holding water and thus it is appropriate in processing where yield and juiciness are important factors to take into account. Tilapia on the other hand had attributes of greater moisture and lighter flesh, which are advantageous to the immediate consumer but decreased longevity to stored foods. With these differences, there is a need to have species specific handling and marketing approaches that will take into consideration the species specific characteristics. Notably, the results will facilitate the relevant baseline data on the District Larkana markets towards the enhanced food safety, consumer awareness, and sustainable fisheries management. This research, by filling a knowledge gap of physicochemical analysis in the province of Sindh, therefore, contributes to the knowledge base in the region and provides valuable information to producers, processors and policy makers.

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