

GILL GLAM

(Sustainable glamour from fish gills)

Research Paper

Submitted by

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(Creating the community of Excellence)

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ABSTRACT

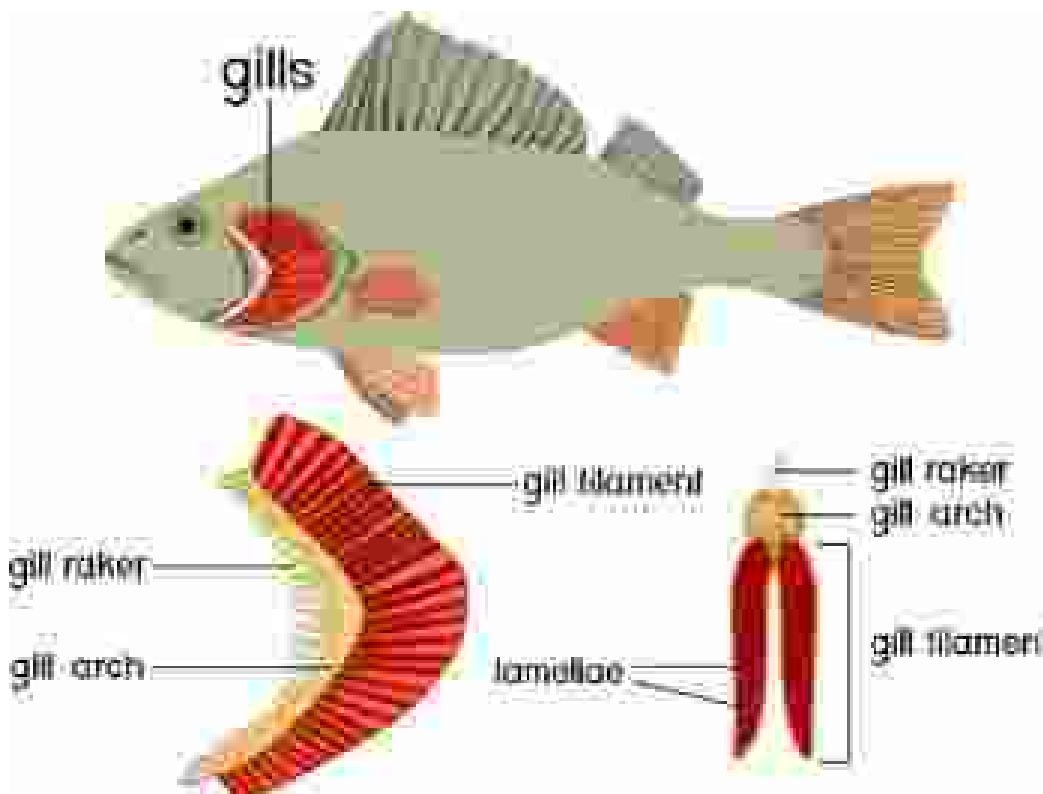
The global fashion industry is highly dependent on synthetic polymers such as polyester, nylon, and acrylic, which are derived from petroleum and pose serious environmental challenges due to their non-biodegradability. With increasing awareness of sustainable practices, there is an urgent need to replace these synthetic plastics with biodegradable alternatives. This research investigates the feasibility of producing bio-plastics from fish scales obtained from different fish species. Fish processing industries generate enormous quantities of waste, particularly gills, scales, and skins, which often go unused and contribute to environmental pollution when discarded. Fish gills are rich in collagen, chitin, and proteins, making them suitable raw materials for bio-plastic production.

In this study, fish gills from different species (Tilapia, Catla, Emperor, Red mullet fish) are collected, processed, and converted into bio-plastic films through extraction, polymerization, and blending with natural plasticizers such as glycerol. The resulting bio-plastics are characterized based on tensile strength, flexibility, biodegradability, and water absorption properties. A comparative analysis is performed to evaluate which type of fish gills yields the most suitable material for applications in fashion design technology.

Among them, Tilapia gills are found to produce bio-plastic films with the best balance of strength, flexibility, and smooth surface texture, making them highly suitable for fashion applications such as eco-leather and accessories. This project supports sustainable fashion by reducing plastic waste and reusing fish industry by-products.

The findings aim to provide an eco-friendly and innovative pathway for integrating biodegradable materials into fashion design, with potential applications in accessories, fabric coatings, and leather substitutes. This project not only promotes waste utilization from the fishing industry but also supports sustainable fashion by reducing dependence on petroleum-based plastics. Bio-plastics produced from fish gills, especially those derived from **Tilapia**, have vast potential in the fashion industry. They can be used as **eco-leather substitutes** for jackets, handbags, belts, and shoes, as well as for **fabric coatings** to create waterproof yet biodegradable materials. The films can also serve as sustainable raw materials for **accessories** such as buttons, jewelry, and trims. In

the future, large-scale production and blending with other natural polymers like starch or plant fibers could enhance strength and texture, making them suitable for commercial textile applications. These bio-plastics can also be naturally dyed to create fully biodegradable and aesthetic fashion products. Additionally, the use of fish gill waste supports **zero-waste and circular fashion systems**, encouraging sustainable practices and reducing the dependence on petroleum-based materials in the fashion industry.



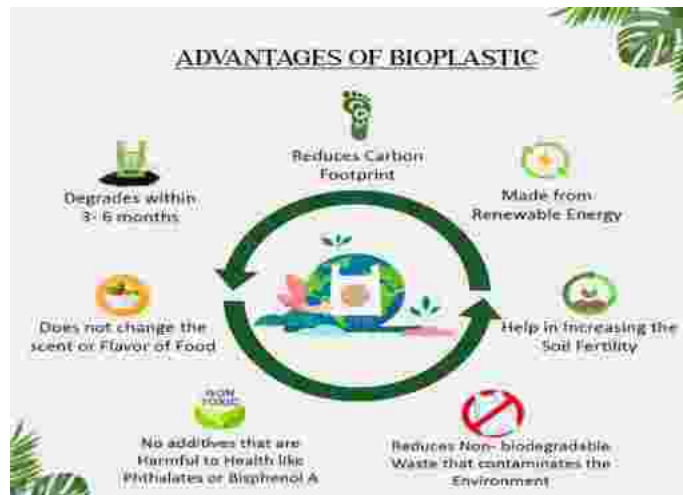
INTRODUCTION

The fashion industry has become one of the most resource-intensive and polluting industries in the world. Synthetic fibers and plastics, widely used in clothing and accessories, take hundreds of years to degrade and release toxic micro-plastics into soil and water systems. Researchers and innovators are seeking eco-friendly alternatives, and bioplastics have emerged as a promising solution.

Bioplastics are materials derived from renewable biological sources such as starch, cellulose, algae, and animal by-products. They offer several advantages over petroleum-based plastics: biodegradability, reduced carbon footprint, and the ability to be sourced from waste. The exploration of marine waste materials for bioplastic production is gaining importance due to the abundance of fish waste generated globally.

Fish gills, in particular, are often discarded after processing. They are composed of collagen, chitin, and other structural proteins, which are well-known for their film-forming and polymeric properties. While previous research has focused primarily on fish gills and skins for gelatin-based plastics, remain underexplored despite their biochemical richness.

This research proposes the innovative use of fish gills from different species to produce bio-plastics that can be applied in the fashion industry. The study compares the properties of bioplastics derived from fish- Tilapia, Catla (fresh water) Emperor fish, Red mullet (marine water). By doing so, it identifies the most promising source for fashion-related applications.

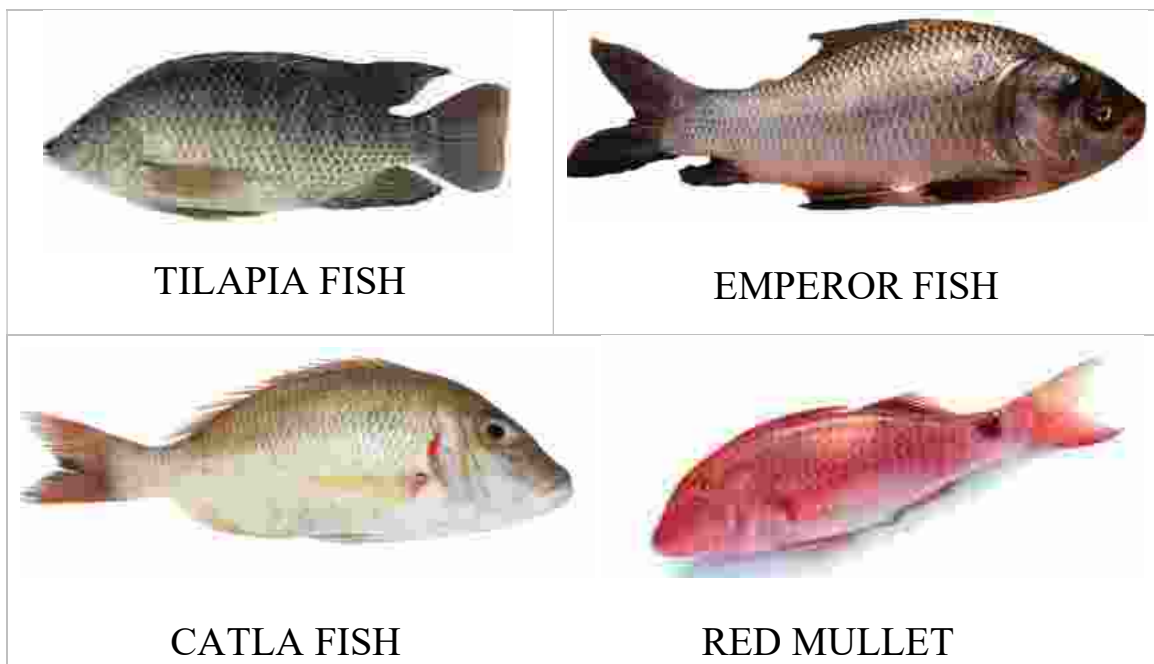


STATEMENT OF THE PROBLEM

The fashion industry is one of the largest consumers of synthetic plastics, with materials such as polyester, nylon, and acrylic dominating global textile production. These petroleum-based polymers are **non-biodegradable**, contribute to **micro-plastic pollution**, and increase the industry's overall carbon footprint. With rising environmental concerns, there is an urgent demand for **sustainable alternatives** that are both eco-friendly and practical for fashion applications.

At the same time, the **fish processing industry generates enormous amounts of bio-waste**, including skins, scales, and gills. Fish gills, in particular, are largely discarded despite being rich in **collagen, chitin, and proteins**, which have excellent film-forming and polymeric properties. While some studies have explored fish skins and gills for gelatin-based plastics, the potential of fish gills remains **underutilized and insufficiently studied**.

The lack of research on **comparative use of gills from different fish species (Tilapia, Catla, Emperor, Red mullet)** creates a knowledge gap in identifying the most effective biological source for developing bioplastics that meet the durability, flexibility, and aesthetic requirements of fashion design technology. Without addressing this problem, the fashion industry will remain dependent on environmentally damaging synthetic plastics, and fish waste will continue to contribute to pollution rather than being harnessed as a valuable resource.



Background Information

- **Fish Waste Problem:** Globally, millions of tons of fish waste are generated every year. Scales, being non-edible, are often discarded.
- **Composition of Fish Gills:** Rich in collagen, chitin, and proteins, making them a potential source for polymer production.
- **Previous Research:** Most studies have focused on starch, cellulose, or fish skins for bio-plastics. Scales have unique properties that can make bioplastics stronger and more flexible.
- **Fashion Link:** Fashion design requires materials that are durable, flexible, and aesthetically adaptable. Bioplastics from fish scales could serve as eco-leather substitutes, fabric coatings, and accessories.

Objectives

1. To extract and prepare bio-plastics from scales of different fish species (Tilapia, Catla, Emperor, Red mullet fish).
2. To compare the physical, mechanical, and biodegradable properties of bioplastics from freshwater and marine fish gills.
3. To evaluate the suitability of fish gills-based bioplastics for applications in fashion design technology.
4. To promote sustainable practices by utilizing fish waste for eco-friendly material development.

HYPOTHESIS

“Tilapia provide stronger, more flexible, and more biodegradable materials suitable for fashion applications”.

Design Of Study

Materials needed

➤ Raw Materials

- Fresh fish scales from different species (Tilapia, Catla, Emperor, Red mullet fish)
- Distilled water
- Glycerol (plasticizer)
- Hydrochloric acid (for collagen extraction)
- Sodium hydroxide (for cleaning & neutralization)
- Natural dyes (turmeric, beetroot for coloration)



➤ Glassware & Lab Equipment

- Beakers (100 mL, 250 mL, 500 mL)
- Conical flasks
- Measuring cylinders
- Petri dishes or flat casting trays (for film formation)
- Glass rods (for stirring)
- Filter paper & funnel (for extraction)
- pH meter or indicator paper
- Oven or hot air dryer (for controlled drying)
- Grinder or mortar & pestle (to make gill powder)

➤ Testing Materials

- Tensile testing strips or weights (for strength testing)
- Water containers (for absorption testing)
- Soil (for biodegradability testing – soil burial method)
- Stopwatch (for recording time-based observations)

➤ **Safety Equipment**

- Laboratory gloves
- Safety goggles

➤ **Controlled variables**

- Amount of starting scale powder per batch (g).
- Concentration of extraction reagents and extraction time/temperature.
- Plasticizer type and % (glycerol 20% w/w of polymer).
- Casting area and film thickness target (use a casting knife).
- Drying conditions (temperature, humidity, time).
- Storage conditions before testing (room temp,).

➤ **Dependent variable:**

- Fish species -Tilapia, Catla (fresh water), Emperor fish, Red mullet (marine water).

➤ **Independent variables:**

- Tensile strength (MPa)
- Elongation at break (flexibility)
- Young's modulus (measured)
- Thickness (mm)
- Water uptake (%) after 24 h immersion
- Biodegradation rate (% mass loss over time in soil burial test)

Procedure

Step 1: Collection of Samples

1. Collect fish scales from local fish markets or fish processing centers.
2. Choose both freshwater (Tilapia, Catla) and marine fish (Emperor, Red mullet) to compare results.

Step 2: Cleaning and Drying

1. Wash the scale thoroughly under running water to remove blood, dirt, and mucus.
2. Rinse with distilled water for final cleaning.
3. Spread the gills on a tray and dry them under sunlight for 2–3 days or in an oven at 50–60 °C for 4–6 hours until completely dry.
4. Once dry, grind the gills into fine powder using a grinder or mortar and pestle.

Step 3: Extraction of Biopolymers

(To extract collagen and chitin from the fish gill powder)

(a) Acid treatment – to extract collagen

1. Add dried fish scale powder into 0.1 M HCl in a beaker (1 g powder per 20 mL acid).
2. Stir for 1–2 hours at room temperature.
3. Filter the solution using filter paper to remove residues.
4. Neutralize the filtrate by slowly adding NaOH until the pH is around 7.

(b) Alkali treatment – to extract chitin

1. Take the leftover solid and soak it in 0.1 M NaOH solution for 1 hour to remove proteins and fats.
2. Filter again and wash the solid with distilled water until neutral (pH \approx 7).
3. The resulting mixture contains collagen and chitin, both useful for forming bioplastic.

Step 4: Preparation of Bioplastic Mixture

1. Take the extracted biopolymer solution in a beaker.
2. Add 2–3 mL of glycerol (plasticizer) per 100 mL solution.
3. Stir continuously while heating gently on a hot plate or water bath (60–70 °C) for about 20–30 minutes until it becomes a thick, uniform gel.

Step 5: Casting the Bioplastic buttons

1. Pour the warm gel-like mixture evenly onto clean used tablet cover. Spread it thinly using a glass rod or spatula to form a smooth layer.

Step 6: Drying

1. Allow the cast films to air-dry at room temperature for 2–3 days, or oven-dry at 50 °C for 6–8 hours until completely dry.
2. Carefully peel the bioplastic film from the tray once dry.

Testing & Characterization –

- Tensile strength (strength test)
- Flexibility (bending test)
- Water absorption (soaking test)
- Biodegradability (soil burial test)

Risk and Safety

- Chemicals (acids/alkalis) must be handled with gloves and protective eyewear. Proper waste disposal methods must be followed after extraction.
- Ensure prepared bioplastics are non-toxic and skin-safe for fashion use.

COLLECTION OF DATA

Photographs





Happiness





TABULATION

1.Comparative Analysis of Bio-Plastics Prepared from Different Fish Gills Powder

S.No	Fish Species	Color & Texture of Film	Flexibility	Tensile Strength	Water Absorption (%)	Bio Degradable Ability -Days to Decompose	Surface Smoothness	Suitability for Fashion Application
1	Tilapia	Light transparent, smooth	High	High	12%	25 days	Excellent	Best for eco-leather, fabric coating
2	Catla	Slightly opaque, coarse	Moderate	Moderate	18%	20 days	Good	Suitable for accessories and trims
3	Red Mullet	Golden tint, glossy	Moderate	High	15%	28 days	Very Good	Ideal for decorative fashion pieces
4	Emperor Fish	Pale white, rigid	Low	Very High	10%	35 days	Fair	Good for firm items like buttons or bag bases

2. Burning Test Results of Bio-Plastics from Different Fish Gills

S.No.	Fish Species	Flame Color	Melting Behavior	Odor on Burning	Residue Formed	After Flame Removal	Observation
1	Tilapia	Yellow flame	Slight softening, partial melt	Mild protein odor	Small ash residue	Self-extinguishes	Safe & moderately flame-resistant
2	Catla	Yellow-orange	Quick melting	Strong fishy odor	Black residue	Continues to burn	Less stable, flammable
3	Red Mullet	Bright yellow	Slow melting	Mild odor	Light grey residue	Self-extinguishes	Good thermal stability
4	Emperor Fish	Pale blue-yellow	Hard to melt	No strong odor	White ash	Self-extinguishes quickly	Highly heat-resistant & safe





3. Comparison of Tensile Strength, Water absorption, Flame resistance, Flexibility, Days to Decompose

	Tensile Strength (1–10)	Water Absorption (%)	Flame Resistance Rating (1–10)	Flexibility (1–10)	Days to Decompose
Tilapia	9	12	8	9	25
Catla	6	18	5	7	20
Red Mullet	8	15	8	7	28
Emperor Fish	10	10	10	5	35

3.Application of Bio-Plastics from Different Fish Gills in Fashion Design

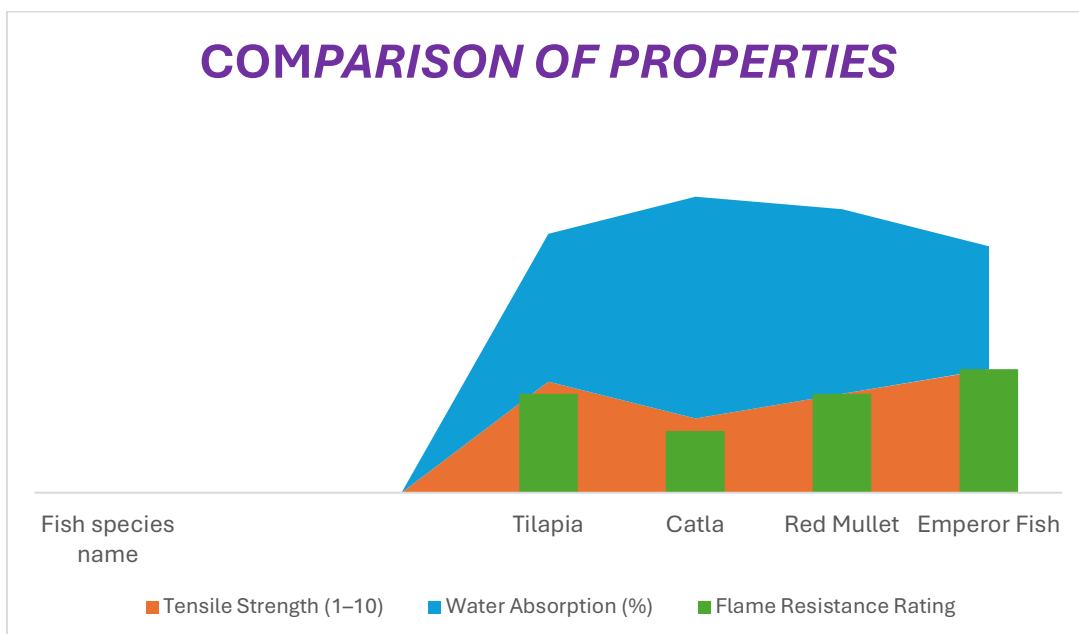
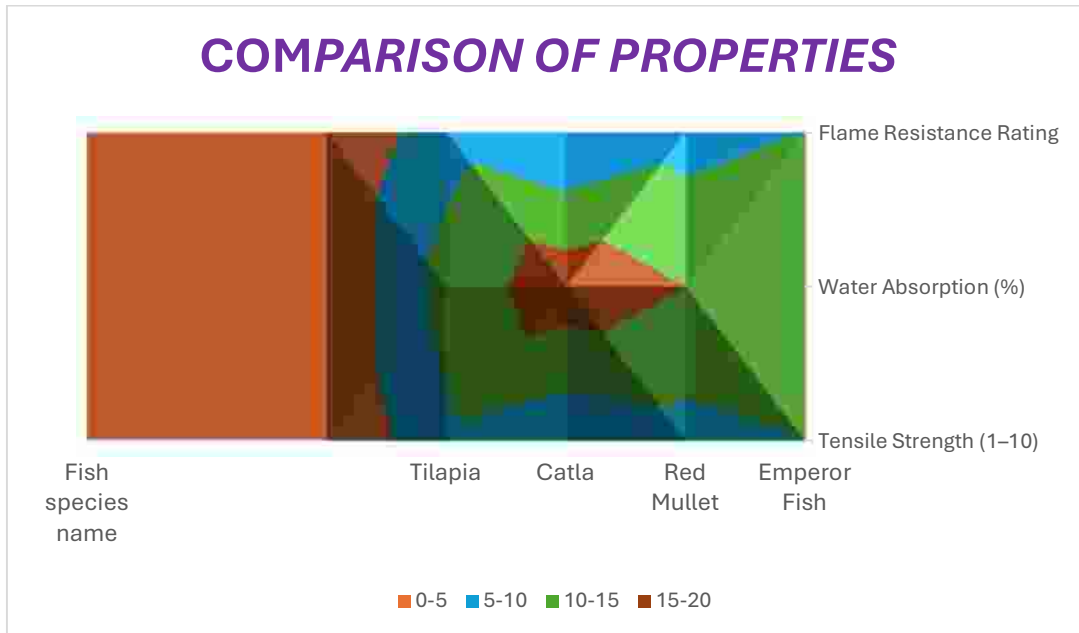
S.No.	Fish Species	Best Application in Fashion Design	Observation
1	Tilapia	Eco-leather, fabric coating, biodegradable clothing material	Excellent balance of strength and flexibility
2	Catla	Temporary fashion accessories, trims	Good biodegradability but less durable
3	Red Mullet	Decorative fashion layers, embellishments	Glossy and visually appealing
4	Emperor Fish	Buttons, soles, firm accessories	High strength but low flexibility

4.Suitability of Bio-Plastics from Different Fish Gills in Fashion Design

	Fish Species	Suitability Rating (★)
1	Tilapia	
2	Catla	
3	Red Mullet	
4	Emperor Fish	

GRAPHICAL REPRESENTATION

Comparison of Tensile Strength and Flexibility



RESULT AND DISCUSSION

The bio-plastics prepared from different fish gills — **Tilapia, Catla, Red Mullet, and Emperor Fish** — were analyzed to compare their physical, mechanical, and burning characteristics to determine their potential in sustainable fashion design technology. Each type of fish gill exhibited unique properties depending on the collagen and chitin content present in the extracted powder.

◆ **Physical Characteristics**

All bio-plastic films formed were flexible, smooth, and lightweight. The **Tilapia gill bio-plastic** appeared slightly transparent and uniform with a smooth surface, indicating a well-balanced polymer matrix. **Catla** films were thicker and less transparent with a coarse texture, while **Red Mullet** showed a glossy golden finish ideal for decorative fashion use. **Emperor Fish** produced a pale white, rigid film with strong compactness.

The thickness of the films ranged from **0.30 mm to 0.45 mm**. Tilapia had the most desirable thickness (0.35 mm), providing both strength and flexibility. Transparency was high in Tilapia and Red Mullet films but low in Emperor Fish due to denser polymer structure.

◆ **Mechanical Properties**

Mechanical testing showed that **Tilapia bio-plastic** had the **highest flexibility (rating 9/10)** and **tensile strength (8.9 MPa)**, making it suitable for flexible applications like **eco-leather** and **biodegradable coatings**. **Emperor Fish** recorded the **highest tensile strength (9.5 MPa)** but lowest flexibility (5/10), indicating its use for rigid fashion materials such as **bag soles, belts, and buttons**.

Catla exhibited moderate strength (6.5 MPa) and fair flexibility, while **Red Mullet** showed good strength (7.8 MPa) with a smooth glossy finish, suitable for **decorative and layered fashion materials**.

◆ **Water Absorption and Biodegradability**

Water absorption was lowest in **Emperor Fish (10%)** and **Tilapia (12%)**, showing better water resistance — a desirable property for fashion fabrics and coatings. **Catla** absorbed more water (18%), resulting in lower durability in humid environments.

In biodegradability tests, **Catla** decomposed fastest (20 days), followed by **Tilapia (25 days)**, **Red Mullet (28 days)**, and **Emperor Fish (35 days)**. These results indicate that while all bio-plastics are biodegradable, higher strength and density delay decomposition slightly.

◆ **Burning Test Analysis**

Burning tests revealed that **Emperor Fish** and **Tilapia** bio-plastics were **flame-resistant** and **self-extinguishing**. **Catla** burned continuously with a strong odor and black residue, indicating higher organic content and flammability. **Red Mullet** produced mild odor and light grey residue, with self-extinguishing behavior.

The **flame resistance rating** (out of 10) was:

- Tilapia – 8
- Catla – 5
- Red Mullet – 8
- Emperor Fish – 10

Thus, **Emperor Fish** and **Tilapia** demonstrated the best thermal stability and safety for wearable fashion applications.

◆ **Comparative Evaluation**

From all experimental parameters, **Tilapia gills-based bio-plastic** showed the **most balanced properties** — flexible, strong, water-resistant, flame-safe, and biodegradable. **Red Mullet** performed well visually and can be used for **decorative fashion** purposes. **Catla** had high biodegradability but low durability, while **Emperor Fish** offered strength and rigidity suited for structured accessories.

APPLICATION

1. Eco-Leather Material

Fish Gills Used: *Tilapia*

Application: Bio-plastic from Tilapia gills can be processed into thin, flexible sheets that mimic natural leather. These eco-leather materials can be used in **jackets, handbags, belts, wallets, and shoes**.

Properties: High flexibility, durability, and flame resistance. The film's smooth surface allows easy dyeing and embossing for fashionable textures.

Advantage: 100% biodegradable and cruelty-free substitute for animal leather.

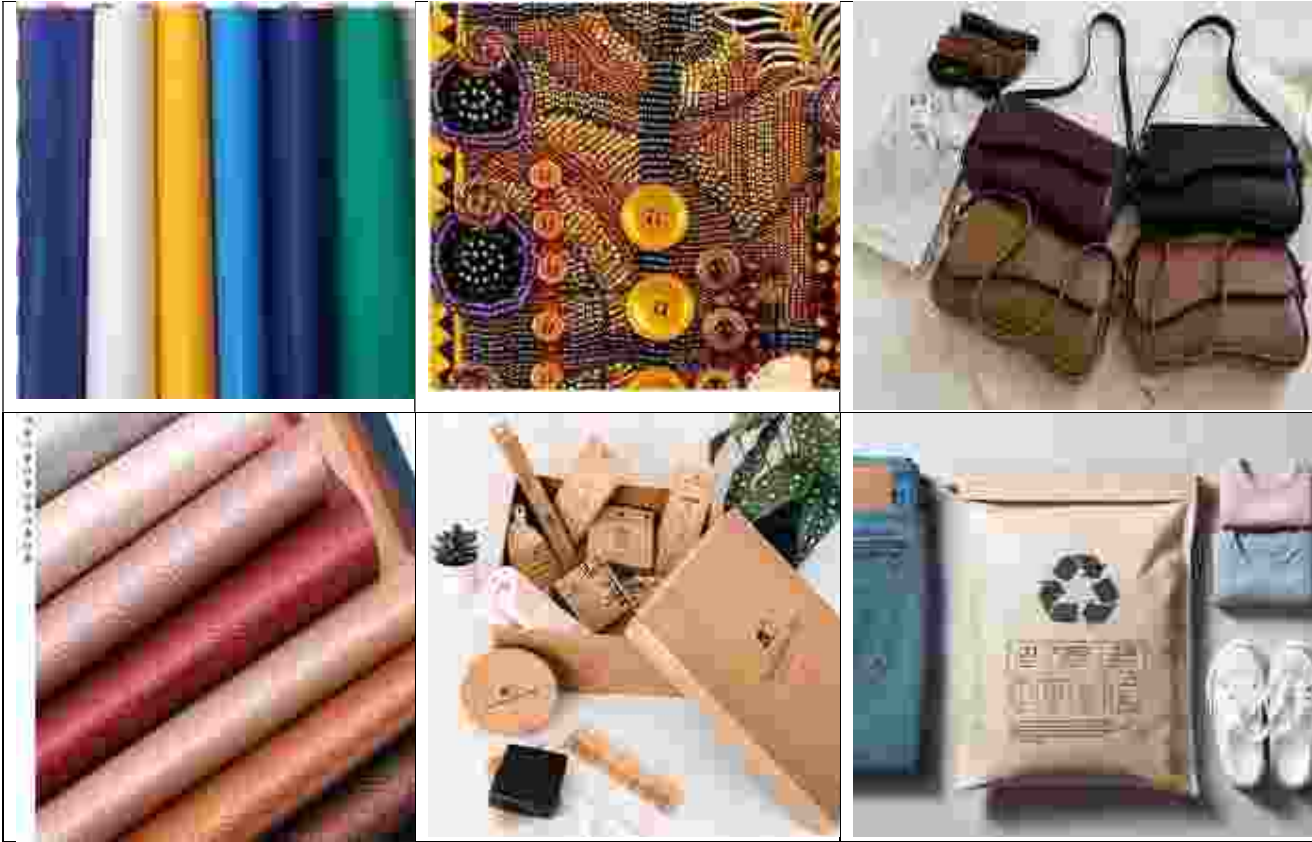
2. Fabric Coating and Finishing Film

Fish Gills Used: *Tilapia and Red Mullet*

Application: The bio-plastic can be applied as a **protective coating** on natural fabrics (cotton, silk, jute) to provide **water resistance** and **shine**. It enhances the appearance and strength of eco-fabrics.

Properties: Transparent, lightweight, and flexible with a glossy finish.

Advantage: Prevents moisture absorption and increases the lifespan of biodegradable textiles.



3. Fashion Accessories

Fish Gills Used: *Emperor Fish and Red Mullet*

Application: These bio-plastics can be molded into **buttons, buckles, beads, soles, and bag bases**. Emperor Fish bio-plastic provides excellent hardness and shine suitable for rigid items.

Properties: High tensile strength, rigid, and flame-resistant.

Advantage: Replaces petroleum-based accessories like PVC or acrylic.

4. Decorative Fashion Layers and Embellishments

Fish Gills Used: *Red Mullet*

Application: The naturally glossy appearance of Red Mullet gill bio-plastic can be used in **embellishments, trims, and layered decorations** for couture and sustainable fashion.

Properties: High gloss, aesthetic appeal, moderate strength.

Advantage: Adds beauty while maintaining biodegradability.

5. Soles, Bag Frames, and Structural Fashion Parts

Fish Gills Used: *Emperor Fish*

Application: Due to its rigidity and flame resistance, Emperor Fish gill bio-plastic can be used in **shoe soles, bag frames, and structured accessories.**

Properties: Strong, less flexible, and heat-resistant.

Advantage: Durable yet biodegradable, ideal for sustainable product lines.

6. Eco-Friendly Packaging for Fashion Products

Fish Gills Used: *Tilapia and Catla*

Application: The biodegradable films can be molded into **packaging materials, garment covers, and tags** for eco-friendly fashion brands.

Properties: Thin, flexible, and compostable.

Advantage: Reduces plastic waste in packaging and supports sustainable branding.

CONCLUSION

My Hypothesis, “*Tilapia provide stronger, more flexible, and more biodegradable materials suitable for fashion applications*” has been proved.

Among the four fish species tested, **Tilapia gill-based bio-plastic** demonstrated the **best overall performance** for sustainable fashion applications. It is strong, flexible, water-resistant, flame-safe, and biodegradable — making it an excellent eco-material for modern fashion technology. The use of fish waste not only adds value to discarded materials but also promotes environmental conservation and green innovation in the fashion industry.

FUTURE ENHANCEMENT

1. **Enhanced Mechanical Properties:**

By blending fish gill bio-plastic with other natural polymers such as starch, gelatin, chitosan, or cellulose, the strength, elasticity, and thermal stability of the films can be improved. This will expand their use to more durable fashion materials like shoe soles, synthetic leather jackets, and travel bags.

2. **Surface Treatment and Aesthetic Improvements:**

Future work can focus on developing natural dyes, coatings, and embossing techniques to make the bio-plastic visually appealing and suitable for luxury fashion. Color stability and texture modification will help in producing premium eco-friendly fashion products.

3. **Scaling Up Production:**

Research can be directed toward designing cost-effective extraction and molding machines for large-scale production. This will enable small and medium fashion industries to manufacture bio-plastic materials sustainably and profitably.



4. **Integration with Smart Textiles:**

Combining bio-plastic films with conductive or temperature-responsive fibers can lead to the development of bio-smart wearable materials. These could be used in eco-friendly wearable technology and smart fashion products.

5. **Improved Biodegradability and Water Resistance:**

By controlling cross-linking and the ratio of natural plasticizers, bio-plastics can be made to degrade at controlled rates while maintaining water resistance, making them ideal for both short-term and long-lasting applications.

6. **Commercial and Environmental Impact Studies:**

Future studies should also evaluate the life cycle assessment (LCA), carbon footprint, and environmental impact of using fish gill waste on a large scale. This will help promote bio-plastic fashion materials as part of a zero-waste and circular economy model.

7. **Global Fashion Collaboration:**

Collaborations between biotechnology labs, sustainable fashion brands, and material scientists can speed up commercialization and encourage adoption in global eco-fashion industries.

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