



# Enhancing Cotton Fabric Morphology and Tearing Strength with Fish Scale Collagen Coating

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## Abstract

Fish scales from marine are the most significant waste. It contains a lot of collagen components, proteins. Collagen was extracted in this experiment using the hydro-extraction method. After the isolation of collagen from the emperor scale of marine fish species, SEM and FTIR analysis were employed to examine the confirmation of collagen's structure, elements functional groups and bonds. Cotton fabric was coated with the isolated collagen solution in various concentrations of 5% and 10%. Both the warp and weft directions were used to determine the tearing strength of the coated and uncoated cotton fabric. Then, SEM examination was used to examine the coated fabric's morphology. A one-way ANOVA statistical method was performed in this study for analyzing the improvements in tearing strength in both warp and weft directions. In terms of tearing strength, the coated cotton fabric outperformed the uncoated cotton fabric in both warp and weft directions. Overall, the morphology and tearing strength of the 5% collagen-coated cotton fabric evolved.

**Key Words:** Marine Fish Scale, Collagen Extraction, Coating, Morphology, Tearing Strength

## 1. Introduction

Several amount of fish wastes dumped on the sea lands (Navarro-Peraza et al., 2020). In particular, the waste from fish scale is never used for anything. Collagen is abundant component in the wastes of marine fish (Zhang et al., 2011). The most crucial protein in all human parts is collagen (Karsdal, 2016). Collagen was mostly utilized in pharmaceuticals and medical textiles (Xu et al., 2019). It is then utilized in the nutritional value (Bhagwat & Dandge, 2016) and cosmetic industries (Avila Rodríguez et al., 2018). The amino acid group in collagen is abundant. Glycine, proline and hydroxyproline are among the amino acids that make up the triple helix structure of collagen, a fibrous protein (Brodsky & Persikov, 2005). Collagen dressings and scaffolds support natural healing by attracting cells that repair tissue and controlling bleeding. It is a natural protein with biocompatibility and biodegradability. It is used in both implantable and non-implantable textile applications to support wound healing and tissue regeneration (Kennedy & Knill, 2006).

## 2. Materials and methods

The following methods was used in this study for collagen extraction and improving morphology and tearing strength of the cotton fabric by coating process.

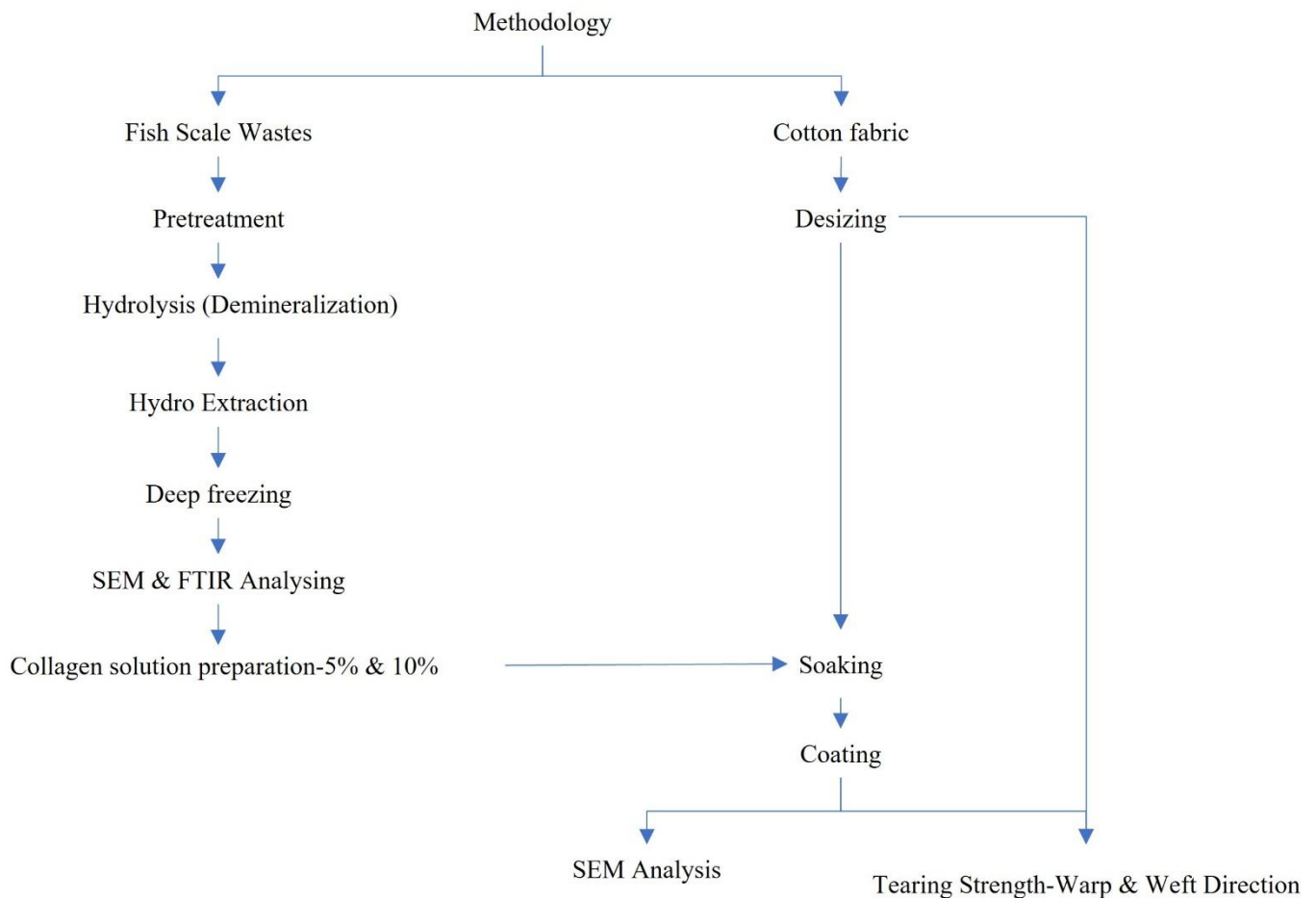


figure: 1 flow chart of collagen extraction and coating process

### 2.1 Materials and Equipment

Emperor fish scale waste was collected from the fish market. The other materials are Sodium hydroxide (NaOH) pellets, Hydrochloric acid (HCl), Single distilled water, Double distilled water, and Cotton fabric.

The collagen extraction process was carried out using water bath shaker instrument. The microstructure and elements were identified by the Scanning Electron Microscope (SEM) Instrument and the Functional groups and bonds were identified by the Fourier Transform Infrared Spectroscopy (FTIR). The padding mangle instrument was used for the coating process. Tearing strength of the coated and uncoated fabrics were tested by Tear strength tester.

### 3. Preprocessing

The scale of the emperor fish breed was chosen for the collagen extraction according to the large amount of fish scales and the majority of fishing breeds. The fresh fish scale wastes were collected from the South Indian side of Thoothukudi fish market and fish processing areas. Rinse the fresh fish scales with tap water three times for removing the blood, sand and unwanted dirt. And the fish scale was allowed to dry at ambient temperature after that, it was frozen until it was required.

A 0.1 N NaOH solution was used to pretreat 5 grams of fish scales for three days (Sun et al., 2017). It was beneficial in clearing the fish scales of extra dirt. The fish scales that had been pretreated were then thoroughly rinsed three times using single distilled water. The mild chemical process of hydrolysis was carried out with 0.5M HCl solution for three days with pretreated fish scales (Matinong et al., 2022). Then the hydrolyzed fish scale was rinsed thoroughly three times with single distilled water. The hydrolysis process helps to eliminate the inorganic components from the fish scales.

#### 4. Hydro extraction method

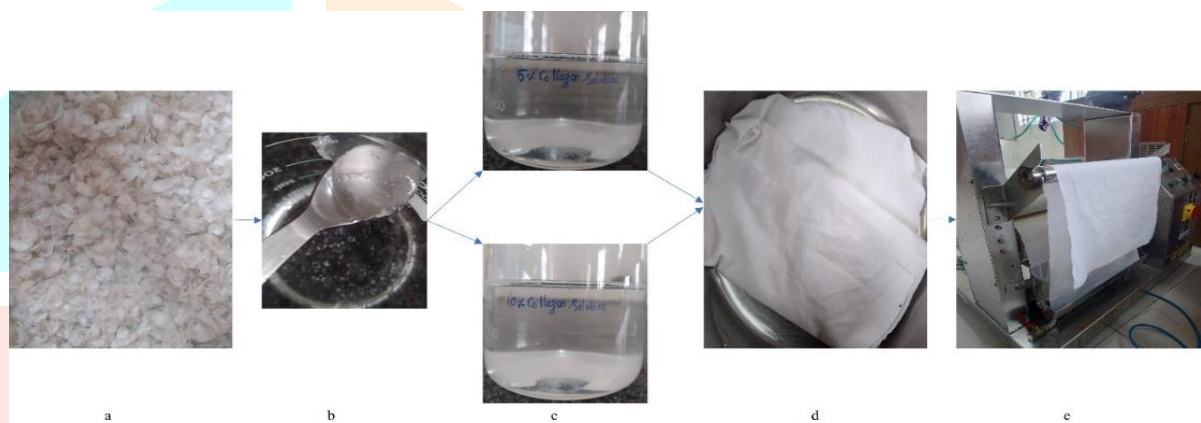
Based on the less chemical usage, low cost, time consumption and high quantity extraction, the hydro extraction method was carried out for this research (Huang et al., 2016). Following hydrolysis, fish scales and double distilled water were combined in a 1:10 material to liquid ratio in order to extract collagen. The water bath shaker instrument was used for this method (Suparno & Prasetyo, 2019). The collagen components broken away from the fish scales and merged with the double distilled water at a temperature of 80°C for 2 hours during the extraction process. After extraction, the collagen solution was filtered with fine mesh cloth and stored it deep freezing until further use.

#### 5. Desizing

Cotton fabric was selected for this study because it is the most practical and in-demand fabric for a wide range of uses. The sizing agent was removed from the cotton fabric by soaking it in a moderate soap solution for 2 hours. After that, washed well with the tap water to get rid of any soap residue. Then, the cotton fabric was allowed to air dry at room temperature so that it could be coated (Kabir & Haque, 2022).

#### 6. Coating

The extracted collagen solution was taken by 5 & 10 percentages separately with double distilled water for coating. For a smooth coating, the cotton fabric was submerged in the coating solution for 5 minutes prior to the coating process beginning.



**figure: 2 a) emperor fish scale wastes, b) extracted collagen solution, c) preparation of 5 & 10 percentages of collagen solution with double distilled water, d) immersing cotton fabric with collagen solution, e) coating process**

A padding mangle instrument was utilized for the coating process. The coating process was carried out at 500 rpm speed with top and bottom roller pressure ranges of 20. For a fine coating, the collagen solution was coated to the cotton fabric 5 times. The coated fabric was then allowed to air dry at ambient temperature.

## 7. Results and Discussion

### 7.1 SEM Analysis

#### 7.1.1 Collagen confirmation

The raw collagen solution was dried at room temperature for 2-3 days in order to produce a powder for collagen confirmation.

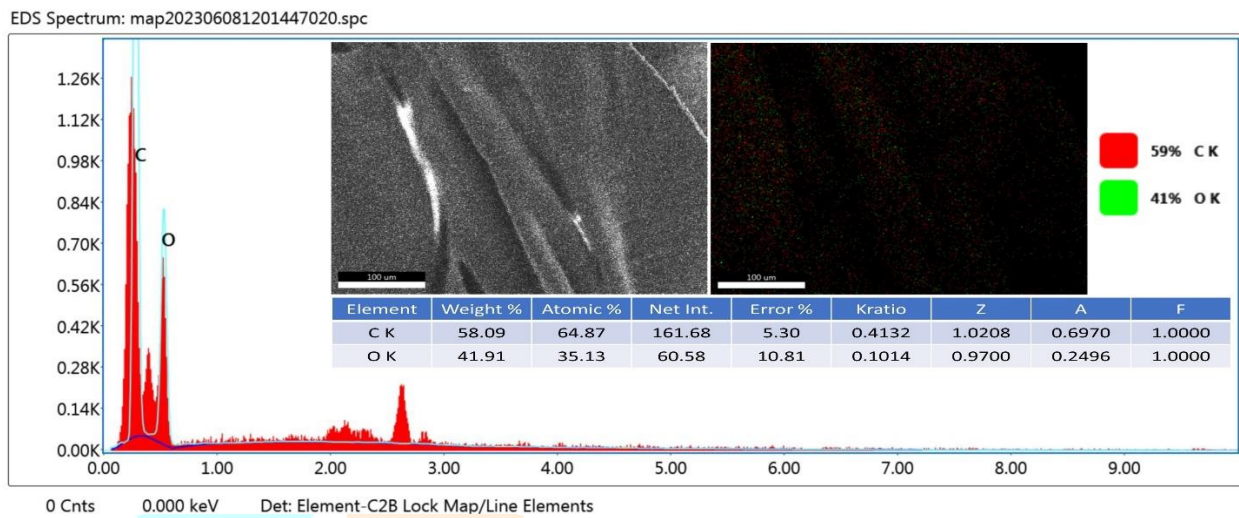


figure: 3 SEM analysis of emperor fish scale collagen powder

Figure 3 demonstrated the collagen powder’s percentages of carbon (C) & oxygen (O). It shows that there are more O and C groups in it (Matinong et al., 2022). It stood for the abundant collagen substance found in the collagen that was extracted. More importantly, the isolated collagen powder exhibits a fine structure at 100 μm.

#### 7.1.2 Morphology of the coated fabric

The following figures 4, 5 & 6 represented the collagen elements and morphology of the both 5% & 10 % collagen coated cotton fabrics by SEM analyzed.

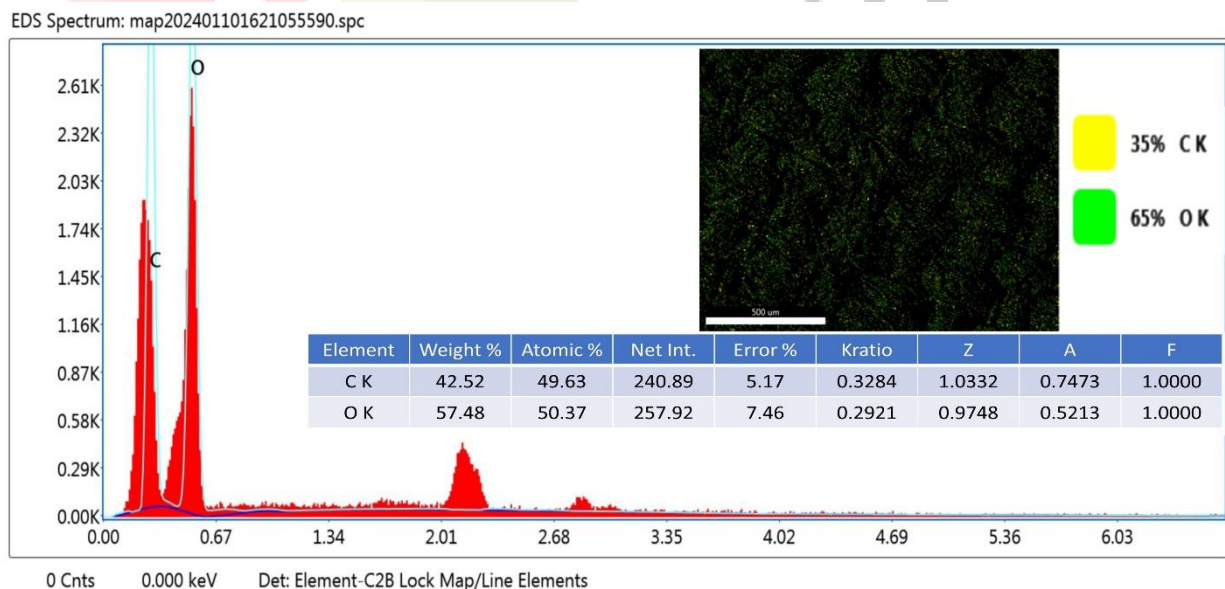


figure: 4 SEM analysis of 5% collagen coated cotton fabric

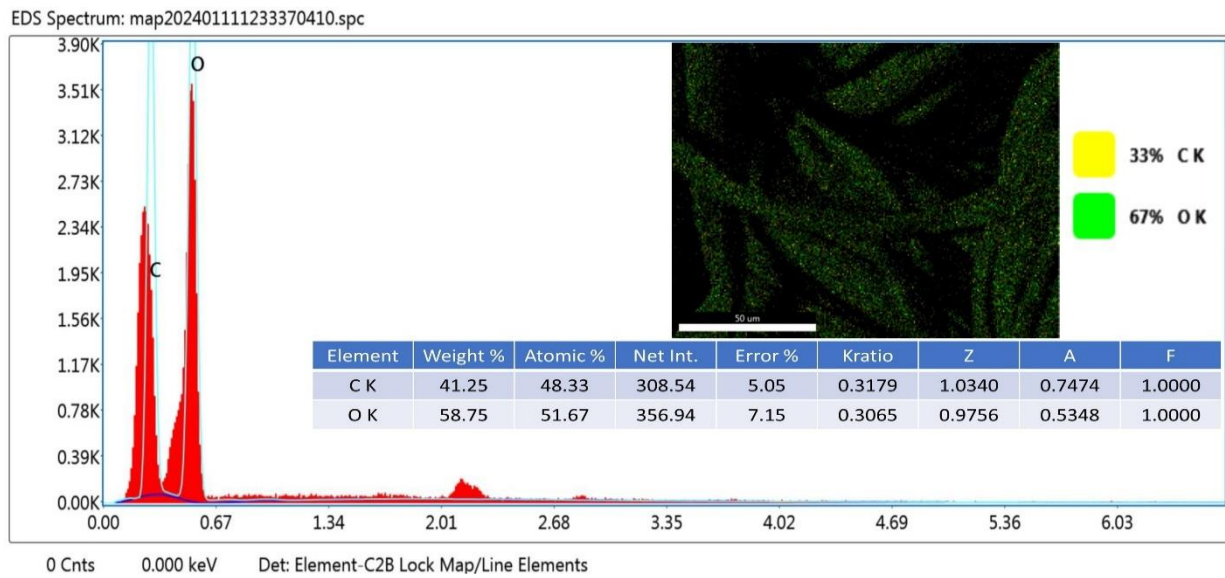


figure: 5 SEM analysis of 10% collagen coated cotton fabric

The maximum C & O level of collagen was found in the cotton fabrics cotted with 5 and 10 % collagen, as shown in figure 4 & 5. The collagen components were clearly visible on both coated cotton fabrics. Compared to that, 5% coated fabric has a higher C than the 10% coated fabric, and 10% coated fabric has a higher O level than the 5% coated fabric (Matinong et al., 2022).

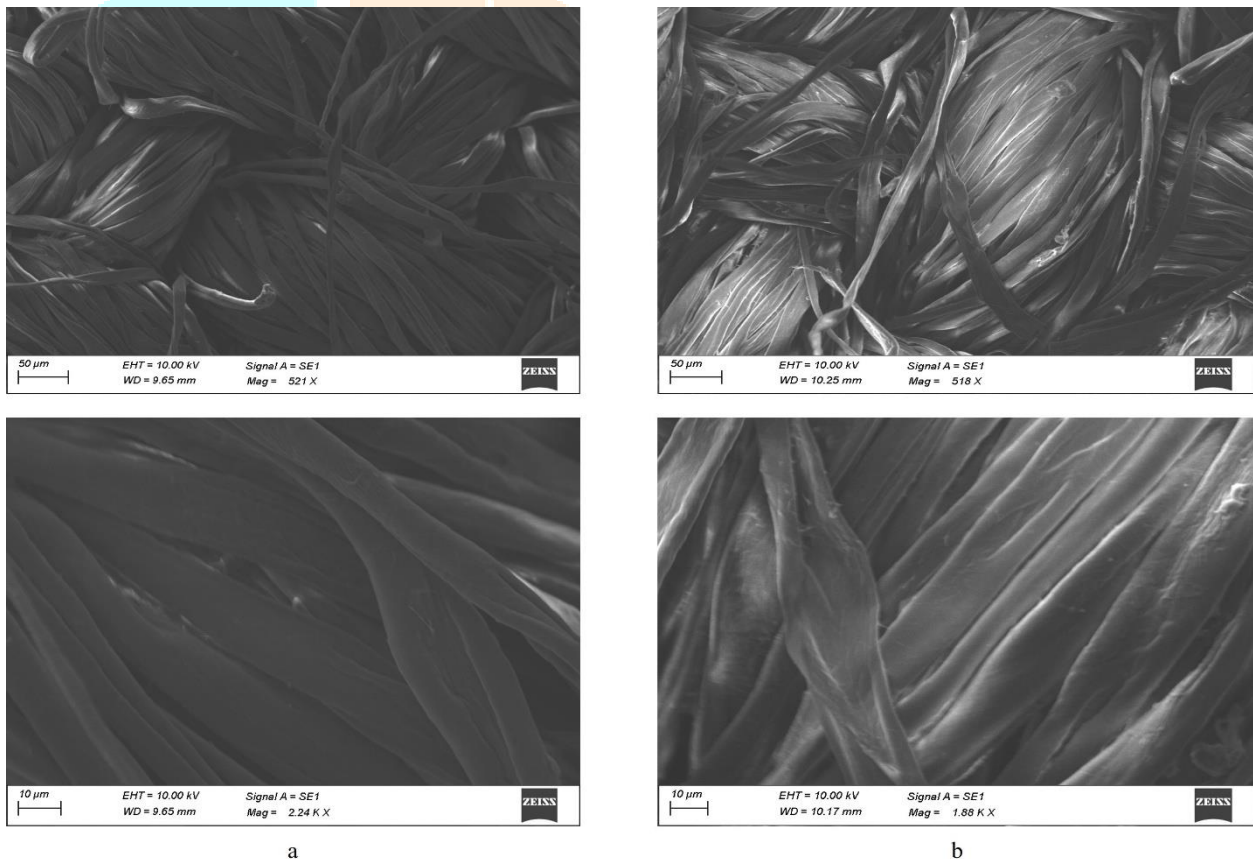
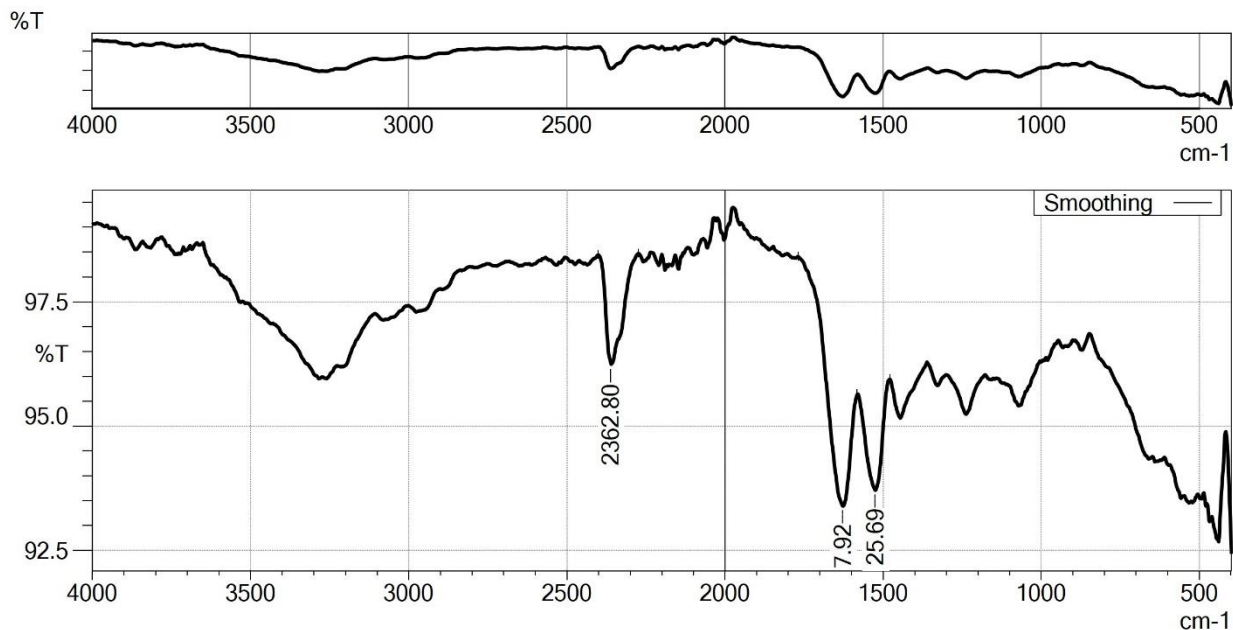


figure: 6 SEM analysis: morphology of a) 5% & b) 10% collagen coated cotton fabrics

The morphology of the cotton fabrics coated with 5% and 10% collagen shown in figure-6. The surfaces of both coated fabrics are smooth and fine. The cotton fabric with a 5% collagen coating has a fine structure in every corner on the both 50 & 10 μm (Rafikov et al., 2020).

## 7.2 FTIR Analysis

Using 25 scans with a resolution of  $4\text{ cm}^{-1}$ , the signals were collected over the  $4000\text{--}400\text{ cm}^{-1}$  range. FTIR analysis was used to identify the collagen powder's functional groups and bonds in order to confirm the collagen.



**figure: 7 FTIR analysis of the emperor fish scale collagen powder**

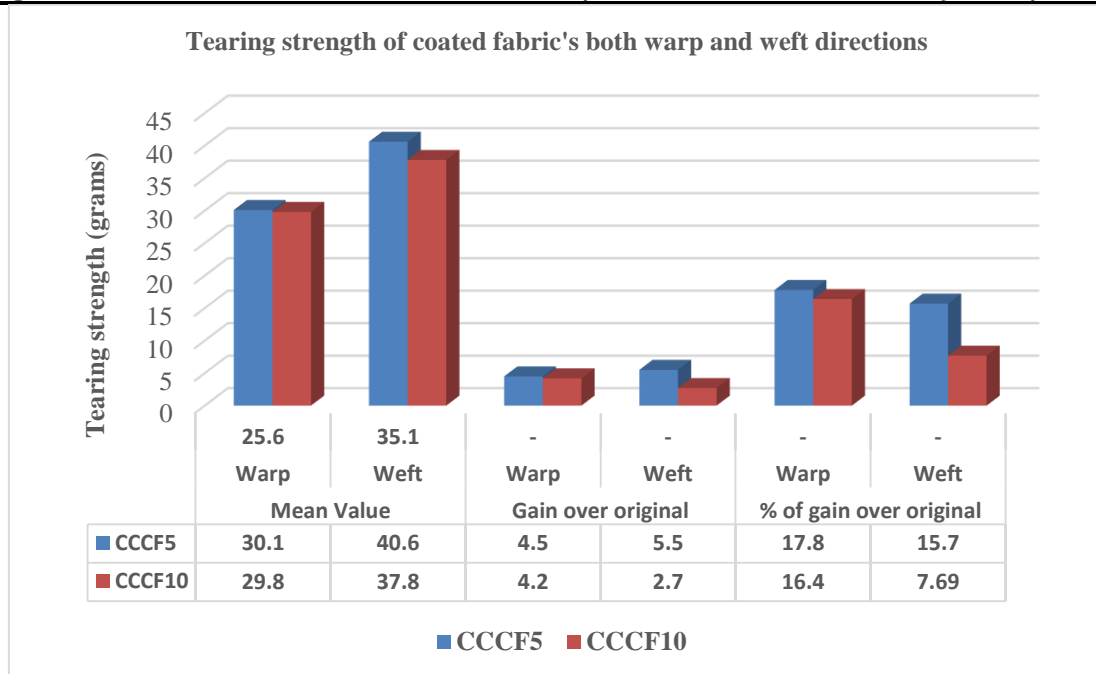
Fig: 7 represented the collagen confirmation of fish scale extracted collagen powder. The various functional groups and secondary structure in the collagen were identified and described by extracting the collagen from emperor fish scales and analyzing it using FTIR. This includes amides A, B, I, II, and III's primary absorption band. Amide A band was observed at  $3300\text{ cm}^{-1}$ . Amide B band was observed at  $2920\text{ cm}^{-1}$ . The amide I band is linked to the asymmetric stretch of the  $\text{CH}_2$  stretching vibration. Stretching ( $1600\text{--}1700\text{ cm}^{-1}$ ), hydrogen bond interaction with  $\text{COO}^-$ , or  $\text{C=O}$  stretching vibrations are all associated with the amide I peak. Amide I band was observed at  $1647\text{ cm}^{-1}$ . Amide II band was observed at  $1525\text{ cm}^{-1}$ . The interaction between amide II band and the N-H bending vibration combined with the C-N stretch indicates that the N-H group is involved in hydrogen bonding. Amide III band was observed at  $1230\text{ cm}^{-1}$ . The C-O, N-H, and C-N stretching vibrations are all included in amide III. Amide III depth and peak is a crucial collagen characteristic (Riaz et al., 2018).

## 7.3 Tearing Strength (Warp and Weft Direction)

ASTM D1424 Elmendorf based tear test was performed in this study. Tearing strength of the both 5% & 10% collagen coated and uncoated cotton fabric were determined in this study. Ten samples of the coated and uncoated cotton fabrics in both warp and weft direction were implemented for the test. Following table 1 was represented the tearing strength in warp and weft direction of both coated and uncoated cotton fabrics.

**table: 1 tearing strength of coated & uncoated fabrics in both warp and weft directions**

S. No	Samples	Mean Value		Gain over original		% of gain over original	
		Warp	Weft	Warp	Weft	Warp	Weft
1	CF	25.6	35.1	-	-	-	-
2	CCCF5	30.1	40.6	4.5	5.5	17.8	15.7
3	CCCF10	29.8	37.8	4.2	2.7	16.4	7.69



**figure: 8 tearing strengths of coated fabrics in both warp and weft directions**

Table 1 and Figure 8 showed the both collagen coating (5 & 10%) were increased the mean values of both warp & weft directions compared to uncoated cotton fabric. 5% collagen coating (CCCF5) showed larger improvements in mean values (17.8% in warp and 15.7% in weft) than 10% (CCCF10) collagen coating in both warp and weft directions (16.4% in warp and 7.69%).

### 7.3.1 ANOVA test

A one-way ANOVA (Analysis of variance) test checks whether the mean values of groups are statistically different from each other.

**table: 2 groups & samples**

S. No	Groups	Samples
1	1	Cotton fabric (CF)
2	2	Collagen coated cotton fabric 5% (CCCF5)
3	3	Collagen coated cotton fabric 10 (CCCF10)

### 7.3.2 Hypotheses: For each direction (warp & weft)

- Null hypotheses ( $H_0$ ): The mean is equal across all three groups
- Alternative hypotheses ( $H_1$ ): At least one group mean is different

**table: 3 warp direction ANOVA**

S. No	Statistic	Value
1	F-Statistic	5.83
2	P-Value	0.009

Table 3 showed the  $p < 0.05$ , it rejects the null hypotheses and conclude that there is a statistically significant difference in mean warp values among the three fabric groups.

**table: 4 weft direction ANOVA**

S. No	Statistic	Value
1	F-Statistic	8.42
2	P-Value	0.002

Again table 4 represented the  $p < 0.05$ , so it rejects the null hypotheses and there is a significant difference in mean weft values among the groups. However, both ANOVA test showed the significant differences and it can conclude that the collagen coating affects warp and weft values differently compared to the uncoated cotton fabric.

## Conclusion

In this study, collagen was successfully extracted from marine fish scale wastes, using a hydro-extraction method, and its presence was confirmed through SEM and FTIR analysis. The extracted collagen was coated on cotton fabric at 5% & 10% concentrations, significant improvements in material properties were observed. SEM analysis of the coated fabrics revealed well distributed collagen elements and smoothed surface morphology, particularly in the 5% collagen coated fabric. The one-way ANOVA analysis confirmed statistically significant differences in mean tearing strengths across the three fabric groups for both warp and weft directions. These results clearly indicate that collagen coating enhance the mechanical properties of cotton fabric, and that the type of treatment (5% vs 10% collagen) has a measurable effect on performance. Overall, this research highlights the potential of using fish scale waste-derived collagen to improve textile properties sustainably. The findings suggest that low concentration collagen coating not only enhance functional performance but also contribute to value added utilization of marine waste.

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