Development of Composite Material Using Human Hair and Chicken Feather Fiber Wastes

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Abstract- This study focused on developing a composite material using chicken feather waste and human hair waste. The utilization of these waste products helps to address the issue of waste management and contribute to sustainability. This composite material can have various applications in industries such as construction, automotive, and packaging. The study focused on the recycling of chicken feather waste and human hair waste, which are abundantly available from salons and poultry processing. The waste materials are processed and treated to extract the fibers, which are combined with a polymer matrix to create the composite material. The resulting composite materials were tested for their mechanical and physical properties to ensure their suitability for different applications. The testing involved evaluating the tensile strength, compression test, hardness properties, water absorption and density of the composite materials. For the manufacturing of composite materials, three different compositions were considered for this study. As a result, sample A exhibits higher tensile and compression strengths (20 MPa and 112.66 MPa), while at the same time, sample C obtained a higher hardness value (Shore D 82). Water absorption percentage increased by increasing chicken feather in the composites, meanwhile density decreased by increasing chicken feathers in the composites.

Indexed Terms- Chicken feather, Human hair, polymer matrix composites, waste products.

I. INTRODUCTION

Composites have been increasingly recognized as a valuable operational material in various industries [1]. Composites have gained significance in engineering due to their ability to improve mechanical properties. Use of composites offers many advantages, such as cost-effectiveness, recyclability, and biodegradability [2]. However, one of the challenges in composite development is the availability of suitable materials [3]. Typically, people consider chicken feathers and hairs from other animals and birds as worthless byproducts. The current disposal methods for these waste by-products include burial and incineration, both of which contribute to environmental pollution. Over the past few decades, there has been an increasing interest in investigating the potential of using waste materials, such as chicken feathers and human hair, to develop composite materials [4]. These natural fibers, which are often considered as waste products, possess unique structural properties that could enhance the mechanical and thermal properties of composites. These natural fibers offer unique properties, such as high strength-to-weight ratio, biodegradability, and renewability, making them attractive alternatives to synthetic fibers in composite material production [5].

The development of composites using human hair and chicken feather fibers could provide a sustainable and environmentally friendly solution, turning waste materials into valuable resources. The use of chicken feathers and human hair in composite materials not only addresses the issue of waste management but also offers the potential for cost-effective and sustainable production [6]. With a deeper understanding of the structural composition and properties of these natural fibers, researchers have been able to explore innovative approaches to incorporating them into composite materials. By harnessing the inherent strength and lightweight nature of these natural fibers, there is an opportunity to develop advanced composites with enhanced mechanical performance and environmental benefits.[7]. Furthermore, the biodegradability of these natural fibers offers a promising solution for reducing the environmental impact at the end of the composite material's life cycle [8].

The aim of this study was to fabricate a polymer matrix composite by reinforcing chicken feathers and human hair with the matrix, and then analyze its mechanical and physical properties. This was achieved by fabricating three different composite samples with varying composition ratios of human hair and chicken feathers. Standardized methods evaluated the physical and mechanical properties of the composite samples.

II. MATERIALS AND EXPERIMENTAL PROCEDURE

In this study, the raw materials used for the development of the composite material included human hair and chicken feathers. The human hair and chicken feathers were collected as waste products and underwent a series of preparation steps before being incorporated into the composite samples. The preparation steps involved thorough cleaning, drying, and cutting of the human hair and chicken feathers to obtain fibers of desired length and uniformity [4] which is shown in Fig.1.

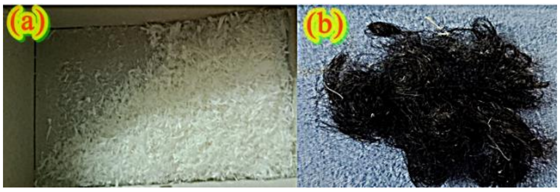


Fig.1(a) Chicken Feathers and (b) Human hair

In the composite fabrication process, epoxy resin and hardener were used as the matrix material to bind the human hair and chicken feathers together. The composite samples were prepared by mixing the epoxy resin and hardener with the human hair and chicken feathers in different composition ratios. The different composition ratios of the composite samples were as follows: Sample 1 - 10% human hair and 30% chicken feathers, Sample 2 - 20% human hair and 20% chicken feathers, Sample 3 - 30% human hair and 10% chicken feathers. For all three-composition epoxy resin maintained as constant volume of 60%. The mixture of epoxy resin, hardener, human hair, and chicken feathers was thoroughly mixed to ensure uniform distribution of the fibers within the matrix material. The epoxy mixture was then poured into molds (15×15 mm) and subjected to a curing process, which involved applying heat and pressure to promote the crosslinking of the epoxy resin and the reinforcement fibers. The curing process was carried out in a controlled environment to ensure the desired mechanical and physical properties of the composite material [5]. After the curing process, the composite samples were prepared for testing. Various composition of the prepared composites showed in Fig.2.

Fig.2 (a) Sample 1 - 10% human hair and 30% chicken feather, (b) Sample 2 - 20% human hair and 20% chicken feather, (c) Sample 3 - 30% human hair and 10% chicken feather.

The mechanical properties of composite samples are crucial for evaluating their overall performance and suitability for various applications. In this study, various mechanical tests were performed to assess the properties of the developed composite samples. These tests included hardness testing, compression testing, and tensile testing according to the ASTM standards D 2240 for hardness testing, D 695 for compression testing, and D 638 for tensile testing. The physical properties of the composite samples, such as density and water absorption content, were also measured.

III. RESULT AND DISCUSSIONS

This section investigates the impact of human hair and chicken feather reinforcement on the composites, as well as their hardness, tensile strength, and compression. This study additionally evaluated the physical properties of composite samples using standard procedures. These composite materials underwent analysis and testing using a Universal Testing Machine. The samples of composites reinforced with human hair and chicken feathers must be precisely cut into the appropriate dimensions to align with the testing procedures. However, these extracted samples were tested and their broken samples showed in Fig.3.

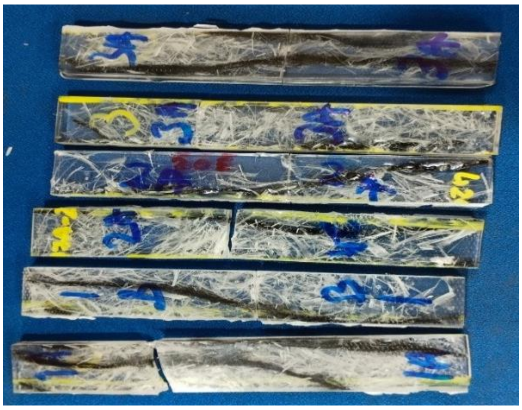


Fig.3 Composite samples after testing mechanical properties

A. Hardness Test

Hardness testing measures a material's resistance to permanent deformation at its surface by pressing a harder material into it. It is utilized in various industries for material comparison, selection, and quality control of manufacturing or hardening processes. The hardness test results for Sample A, B & C are as follows:

Table.1 Various composition and their Hardness property

Sample Code	Chicken feather (%)	Human Hair (%)	Epoxy resin & Hardener (%)	Shore D Hardness value
A	30	10	60	50
B	20	20	60	79
C	10	30	60	82

Table.1 demonstrates that Sample C has the greatest hardness among composite samples A, and B. In particular, it exhibits a hardness level of 82 (Shore D Hardness value) and consists of 10% chicken feather, 30% human hair, and 60% epoxy resin.

B. Compression Test

Compression testing is essential for analyzing composite materials. This process involves applying a load that can alter their mechanical properties. Compression test results between the samples A, B & C are as follows:

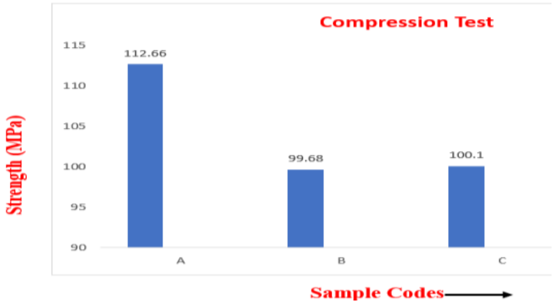
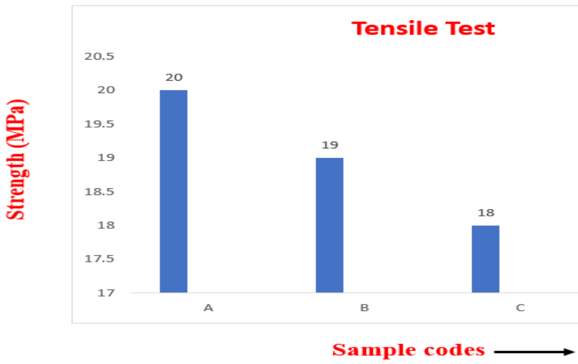


Fig.4 Compression test for various samples

The data presented in the graph indicates that Sample A exhibits a greater compressive strength compared to other composite samples. In particular, Composite Sample A demonstrates a compression strength of 112.66 MPa and comprises 10% Human hair, 30% Chicken feathers, and 60% Epoxy resin.

C. Tensile Test

The tensile strength of a material is the maximum amount of load it can withstand without breaking when stretched, divided by its original cross-sectional area. Tensile strength is typically expressed in terms of force per unit area and serves as a measure of the material's overall strength. Tensile strength between composite samples A, B & C are given below in Fig.5.



From Fig.5 clearly revealed that sample A has higher tensile strength compared to remaining composite samples. The composite sample A obtained tensile strength of 20 MPa.

D. Water absorption and Density Test

The water absorption and density tests are crucial for evaluating the performance of composites reinforced with chicken feathers, providing valuable insights into their ability to resist water penetration, structural integrity, durability, and long-term stability. Conducting these tests enables researchers to simulate different environmental conditions and assess the real-world applicability of the composites. Additionally, the density test determines the mass per unit volume of the materials, offering essential information about weight and strength. The results from these tests will provide valuable data for assessing suitability and performance in industries such as construction, automotive manufacturing, packaging applications.

Table.2 Various composition and their water absorption

S.No	Sample Code	Water absorption (%wt)
1	A	70
2	B	55
3	C	40

From the Table. 2 sample C demonstrates a lower water absorption capability compared to sample A, indicating that an increase in chicken feather content leads to increased water absorption behaviour. Conversely, an increase in human hair percentage results in reduced water absorption behaviour.

Table.3 Various composition and their density

S.No	Sample Code	Density (g/cm^3)
1	A	1.5
2	B	2.8
3	C	3.2

From the Table. 3 sample C demonstrates a higher density compared to sample A, indicating that an increase in chicken feather content leads to decreased density behaviour. Conversely, an increase in human hair percentage results in increased density of composites.

CONCLUSION

The composite material, consisting of diced human hair and chicken feathers reinforced with epoxy resin, exhibits advantageous physical and mechanical properties that make it appropriate for ultralight uses like roof boards. The research also indicates that altering the composition of reinforcements leads to significant changes in the properties of the composite material. The results of the testing revealed that the mechanical and physical properties of the composite material can be tailored by adjusting the composition ratio of human hair and chicken feather.

- The composite samples with higher percentages of chicken feather with lower percentage of human hair exhibited higher strength and stiffness, while the ones with higher percentages of human hair with lower chicken feather had lower strength and stiffness, but higher hardness value obtained.
- The study highlights that a combination of 30% chicken feather, 10% human hair, and 60% epoxy resin exhibits notably superior compression strength and tensile strength.
- Furthermore, the density of the composite samples decreased as the percentage of chicken feather increased. At the same time water absorption reduced as percentage of human hair increased.

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