CREATING INNOVATIVE ECO-FRIENDLY PRODUCTS BY BLENDING BANANA FIBRE WITH FABRIC WASTE

PROJECT SUBMITTED

In partial Fulfilment of the Requirement for the

award of the Degree

MASTER'S PROGRAMME IN FASHION DESIGNING

BY

NIVEDITHA AJITH

(Register No. SM22MFD011)

Under the guidance of

Dr. VINITHA PAULOSE

DEPARTMENT OF FASHION DESIGNING

WOMEN'S STUDY CENTRE

ST. TERESA'S COLLEGE (AUTONOMOUS)

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DECLARATION

I, Niveditha Ajith, hereby declare that the project entitled **"CREATING INNOVATIVE ECO-FRIENDLY PRODUCTS BY BLENDING BANANA FIBRE WITH FABRIC WASTE"** is submitted in partial fulfilment of the requirement for the award of the degree of Master's Programme in Fashion Designing. This record is original research done by me under supervision and guidance of Dr. Vinitha Paulose, Assistant Professor, Department of Fashion Designing, St. Teresa's College, Ernakulam. This work has not submitted in part of fill or any other Degree, Diploma, Associateship/Fellowship of this or any other university.

Name and signature of the Candidate Name and signature of the Guide

Place:

Date:

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ABSTRACT

The purpose of this research entitled **"CREATING INNOVATIVE ECO-FRIENDLY PRODUCTS BY BLENDING BANANA FIBRE WITH FABRIC WASTE"** is to investigate the feasibility and sustainability of utilizing these materials in product design and manufacturing and to reduce fabric wastage and deforestation. Through a combination of experimental methods and material analysis, it aims to identify optimal blends of banana fibre and fabric waste that enhance product performance while minimizing environmental impact. The study contribute to advancing eco friendly manufacturing processes and promoting circular economic principles within the textile and economic sectors.

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INTRODUCTION

"CREATING INNOVATIVE ECO-FRIENDLY PRODUCTS BY BLENDING BANANA FIBRE WITH FABRIC WASTE"

1. INTRODUCTION

Textiles and Apparel sector is considered as one of the most significant industrial sectors and it plays a vital role towards contribution to national economy, employment generation and exports in developing countries and most essential consumer goods industry. However, textile and fashion industry are also blamed for being one of the most polluting industries. It is not only restricted to production but also consumption of textiles also produces waste. To face this problem, textile industry has taken many measures for reducing its negative contribution towards environment and earth. One of such measures is textile recycling-the reuse as well as reproduction of fibres from textile waste. Recycling can be done through thermal, material, chemical and mechanical processes. Sustainability is a useful method for protecting environment.

Sustainability is a social goal for people to co-exist on Earth over a long time. Definitions of this term are disputed and have varied with literature, context, and time. In everyday use, sustainability often focuses on countering major environmental problems, including climate change, loss of biodiversity, loss of ecosystem services, land degradation, and air and water pollution. The idea of sustainability can guide decisions at the global, national, and individual levels.

Sustainable product development is a method for product development that incorporates a Framework for Strategic Sustainable Development, also known as The Natural Step framework. As the demand for products continues to increase around the world and environmental factors like climate change increasingly affect policies – and thus business – it becomes more and more of a competitive advantage for businesses to consider sustainability aspects early on

in the product development process. It is the process of creating products that use resources responsibly and reduce environmental and ecological impacts. It involves the integration of both environmental and economic considerations, such as energy efficiency, use of renewable materials and reduction of waste, into product design and development. It also takes into account social aspects such as labour standards, poverty, and health impact.

Sustainable product development is not limited to the actual product development, but also the product design. Green design which is a part of sustainable product development has two main goals: the prevention of waste and to minimize environmental impact. Environmental impact involves: deforestation, greenhouse gas emissions, and resource/material management, etc. Sustainable product development is a growing trend in the manufacturing and engineering industries and provides and provides numerous benefits. Not only does sustainable product development led to cost savings, but it also helps to reduce a business's environmental impact, increase customer satisfaction, and led to improve public reputation. Additionally, this practice encourages businesses to innovate, resulting in the creation of more efficient and sustainable products. Therefore, sustainable product development is an essential practice for businesses looking to improve their operations and become more eco-friendly

Today, there is a global increase in the utility of natural fibres. This is due to increased environmental concerns. Among the available natural cellulosic fibres derived from agriculture, banana fibres stand out for their high potential. They offer unquestionable sustainability and embrace promising and unexplored potential in the textile industry. India claims huge resources for extracting fibres from banana stems. The fibre extraction process involves obtaining fibres from the pseudo stem of banana trees. During extraction, non-cellulosic gummy substances are removed. Then the fibre is extracted using primarily three methods: they are, mechanical, chemical, and biological techniques.

Once farmers harvest the fruit, they regularly cut down the parent stem to enable regrowth. This is revealing that the banana plantations are rich in fibres and are basically considered as waste material after harvesting of banana fruit. Banana fibres are extremely strong and can blend effectively with other fibres to create mixtures. They are lightweight, biodegradable, quickly renewable, water-resistant, and flame-resistant.

Raw banana paper holds a rough surface due to the presence of hemicellulose, lignin, and other waxy components in the fibres. Hemicellulose is situated between cellulose fibrils, combined into the cellulose structure. Fibers or pulp with a high hemicellulose content generates high maximum tensile strength but a low maximum tear index. The cellulosic fibres enclose the cellulose fibres externally, serving as natural binders. Key to banana paper are long wrapped fibre bundles. Fiber length is a serious property; longer fibres contain more fibre joints, contributing to a stronger fibre network. Papers made from longer fibres generally exhibit superior strength properties compared to those made from shorter fibres.

Blending the waste threads and shreads in the making process of banana paper makes it more sustainable as it reduces waste from textile industry. Here in this project, I got inspiredd from these two concepts of sustainability and eco-friendly methods, which leads me to mix these two processes. The waste threads and shreds are cut into small pieces and mix it into the banana paper making process creates a new variety of sustainable product. And as a measure for finished surface of the products, natural gum coated over them. This makes the products to get more finished look.

This is a method to manage and reduce waste from textile industries and a scheme in which gets protection from deforestation. It is a biodegradable and cost- effective method in which various sustainable products can be developed.

1.1 OBJECTIVES OF THE STUDY

- To understand the process of extraction of banana fibre
- To recycle the fabric waste from the stitching units
- To blend the banana fibres with the fabric waste
- To make utility paper from the blended banana fibre and fabric waste
- To design and develop utility products from the ecofriendly paper made from banana fibre and fabric waste.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The review of the study pertaining to the title **"Creating Innovative Ecofriendly Products by Blending Banana Fibre with Fabric Waste"** is described under the following heads:

2.1 Textile industry

2.2 Sustainability

2.3 Recycling

2.4 Upcycling

2.5 Natural fibres

2.6 Banana stem

2.7 Banana fibre

2.8 Banana paper

2.1 Textile industry

The textile industry refers to the sectors mainly focused on designing, manufacturing, distributing, and utilizing clothing and textiles. The textile industry is a light manufacturing industry that produces a variety of fabrics, yarns, and related products using plant fibres, wool, and synthetic fibres. It involves the processing of raw materials such as yarn, flax, hemp, jute fibre, silk, wool, nonwovens, net weaving, textiles, knitwear, and felt printing. Textile industry products are used in clothing, footwear, furniture, engineering, and other sectors (Payziyevna , 2021).

The textiles and clothing industry has faced high level competition due to globalization. Numerous factors are important in the textile industry, such as strength, length, trash, grade, short-fibre content, maturity, stickiness and fibre cohesion. The basic stages of textile processing are opening, cleaning, carding, drawing, spinning. Fabric production have remained largely unchanged for years. However, these processes have progressed notably with highly

mechanical systems and also increased production speeds (Delhom, Martin, Schreiner et al. 2017).

According to Singleton (1997), the Indian textile sector benefits from availability of raw materials and skilled manpower, and giving India a competitive advantage in production costs compared to other global textile producers. Maintaining a competition has become increasingly challenging in textile industry.

India's rich production of raw materials like cotton, wool, silk, and jute gives a strategy to its textile manufacturing industries. Today, textiles not only serve to meet the basic need for clothing , but also enable individuals to express themselves through fashion. As textile industry is one of the oldest industries, it holds a special position in India, contributing to 14% of its total industrial output. The textile industry has significant environmental challenges. Processes like pre-treatment, dyeing, printing, and finishing require substantial amounts of energy and water, leading to the generation of considerable waste. Various dyes, chemicals, and materials used in these operations produce waste that cannot be repurposed and can produce environmental risks if not properly treated before disposal. (Madhav, Ahamad et al. 2018).

The production of yarns and fabrics is considered as one of the most polluting processes in the industrial world. The environmental impact of textile manufacturing is focused through various treatments involved in raw material processing and filament fabrication, along with the use of insecticides, fertilizers, and numerous chemicals to enhance the quality of the product. Also, solid textile waste creates an additional challenge to environmental sustainability in fabric production. Many companies are implementing strategies to recover waste fibres and prevent them from disposing to the landfills. Recent studies have found out fibre recycling alternatives for creating compounds, utilizing recycled fibres from textile waste placed in various materials such as thermoplastic polymers, thermosetting resins, natural components, for specific applications (Patti, Cicala, Acierno et al. 2021).

Bizuneh (2020) stated that, fabric constituted the primary source of cut-and-sew waste, with an average of 28.55%. A majority of companies sell their waste to small-scale enterprises, while a minority of companies dispose it in landfills. More than half of the companies lack waste minimization strategies. Some companies implement re-designing and minimum waste pattern cutting techniques to enhance fabric utilization. For example, the jigsaw puzzle pattern layout technique increased the marker efficiency of a knit T-shirt manufacturing company from

79.0% to 84.9%, reducing fabric wastage and impacting both profitability and environmental sustainability.

According to Domina and Koch (1997), among increasing focus on environmental responsibility in waste management, the textile and apparel industry is increasing efforts to reduce the disposal of post-production textile waste in landfills. At the same time, there is a rising importance on finding alternative methods for managing post-consumer textile waste.

2.2 Sustainability

The production and consumption of clothing have continually Increased in recent years due to rapid population growth, higher global incomes, and improved living standards worldwide. As the population increases, more people have the means to purchase clothing, which leads to rising incomes and a desire for fashionable choice. Also, the popularity of fast fashion and global trade has led to a greater variety of clothing choices and continuous exchange of wardrobe items. With the economic benefits, this growth raises concerns about sustainability and environmental impact which highlights the need for more responsible practices throughout the textile industry's supply chain (Moghaddam 2020).

According to the classic Brundtland definition of sustainability, sustainable development meet the needs of the present without compromising the ability of future generations to meet their own needs, taken from World Commission on Environment and Development (1987).

Scarce resources create an important challenge to the sustainability of the clothing industry. Cotton which is known for its high water consumption, is estimated to require 8.5 tonnes of water per kilogram of textile production according to some analyses (Pfister 2009).

Instead of focusing on how design and production can incorporate with consumer preferences and sustainability, clothing is set up and manufactured to quickly adapt to trends, leading to old fashioned and early disposal. This approach make possible for a fast turnover of styles and leads increased sales, which maximizes revenue in a short time frame (Kozlowski 2018). The natural ecosystem faces major harm from the release of colored wastes and microplastics into the environment, which is mainly occurring during clothing production and disposal stages (Liu, Kiakhani et al. 2021)

Muthu (2017) brings up a crucial point about sustainability in the textile industry. While the environmental impact of textiles and clothing is widely discussed and rightly emphasized, it is essential to recognize the interconnectedness of all three pillars of sustainability. They are, environmental, social, and economic sustainability.

In the discussion around textile sustainability, the environmental aspects often dominate discussions due to the industry's significant and ecological footprint. But the social and economic extents are equally important. Social sustainability generates fair labour practices, worker rights, and community well-being throughout the supply chain. Economic sustainability involves ensuring fair wages, equal distribution of profits, and long-term existence of businesses in the textile sector. Matching these elements are essential for achieving true sustainability in textiles. Efforts towards sustainability should combine considerations of all aspects to create meaningful and lasting change in the industry (Muthu 2017).

Muthu (2017) states that, the textile Industry is important, which meets vital human needs and deeply combined in daily life. Discussing the environmental impacts of textiles and clothing is crucial in today's conditions. Numerous sources, especially literature and media, have usually observed that sustainability in textiles tends to emphasize the environmental effects while dismissing the social and economic aspects that are also important. Together, these three pillars, which define sustainability in the textile sector beyond basically the environmental features determine its long-term viability. The textile business, which involves apparel, fabrics, fibres, along with goods, is very important to the world economy. But it commonly ignores its effects on society and the environment. The textile industry frequently utilizes excessive amounts of water and produces waste.

Annapoorani (2017) stated the critical need for sustainability in the textile industry, cataloguing environmental and social impacts across the supply chain. It is clear that textile production and application have prominent application for environmental pollution and social security. From including sustainability principles into production processes to talking labour practices and welfare of the workers, investors are increasingly recognizing the importance of accepting eco-friendly practices and ethical standards. The aim of sustainability in this industry is necessary for reduce ecological harm and promoting responsible business practices.

According to Sawitri (2017), the fashion industry has experienced rapid growth. This is mainly in garment production for men, women, and children on a large scale. Fashion manufacturing can occur in various situations, from small-scale operations at home to large-

scale factories. This contains the production of apparels. These kind of fashion industries also generate fabric waste. This waste originates several problems, as it can contribute environmental pollution. Burning fabric waste, can lead to air pollution and environmental humiliation.

Enes and Kipoz (2020) explores that the inefficient use of fabric in traditional pattern cutting methods has resulted In a significant waste issue within clothing manufacturing processes. Approximately half of the total garment cost consist of fabric expenses, this inefficiency leads to unsustainable and economically unfavourable practices in the fashion industry. Fabric stands out as the most valuable material in the fashion production process. Apart from the unexpected economic consequences of this waste problem, pre-consumption waste also has severe environmental consequences.

MD Haque, Rizvi , Rahman, and Chowdhury et al. (2016) analysed that there are three types of fabric wastes were considered:

- EGI Waste: This refers to fabric that remains unused after completing an order but is still usable for making new apparels.
- Net Waste: This includes fabric waste that cannot be used at all, often categorized as hard waste.
- Waste of Completed Garments This category encompasses waste generated from completed garments that do not meet quality standards or remain unsold.

An ideal application for utilizing waste in a sustainable manner involves creating new and trendy garments that can satisfy customer demand. This not only in local but also international markets. Garment factories primarily generate two types of waste: knit fabric waste and woven fabric waste, consisting of both natural and synthetic fibers. Fabric waste containing synthetic fibers does not decompose in soil (Roy, Hannan, Uddin, Rana et al. 2015),

Pensupa and Leu (2018) states that natural fibers are mainly composed of cellulosic material, which serves as a valuable resource for producing bio based products. The primary challenge in utilizing textile waste lies in identifying methods capable of recovering sugars in the form of monosaccharides.

2.3 Recycling

According to Dissanayake, Weerasinghe (2021), fabric waste recycling plays a major role in proceeding towards a circular economy in textiles. The demand for fabric waste

recycling originates mainly from the need to improve resources and reduce the environmental hazardous situations associated with discarding and landfilling. Even though the strong desire for circularity in textiles, a complete point of view on fabric waste recycling has not been fully joined.

According to Youjiang Wang (2006), the extensive practice of landfilling textile waste is considered as unsustainable. Encouraging greater alteration of textile waste from landfills requires increased technologies for reuse and recycling. Reuse is generally chosen over recycling. There are several textile reuse and recycling technologies available that are continuously developing, especially to handle blended fabrics more effectively. The rate of textile recycling remains comparatively low. Each year, about ten million tonnes of textile waste is dumped in Europe and America. The diverse nature of textile waste and its various structures generates multiple technologies, which need to collaborate within a combined industry to enhance recycling rates.

Harmsen, Scheffer and, Bos (2021) states that, recycling, particularly for post-consumer waste, is still in its early stages and is assured to be a significant challenge in the years ahead. Numerous fundamental issues block a complete grasp of textile recycling developments. The categorization of textile fibres as natural or manufactured does not sufficiently support textile recycling efforts. There is a lack of uniform definitions for textile recycling technologies, and inadequate clear communication about technological progressions and the consumer benefits of textile recycling by industry and brands. These challenges may delay the crucial progression of textile recycling creativities. There are effective recycling solutions available for mono-material streams within cellulose, polyamide, and polyester groups. A point of view hopeful for fibre blends within a single polymer group, where recycling is possible. However, challenges arise with blends containing different polymers, which may confuse the recycling process.

2.4 Upcycling

LC Han, Chan, Tracy Cassidy, J Tyler et al. (2019) explained that the analysis of value streams for collected post-consumer textiles remains a key aspect of developing and implementing commercially viable, ethical, and sustainable strategies in the fashion industry globally. Upcycling is a proven strategy within fashion production, where discarded materials are repurposed to create higher value products, extending their productive lifespan. In the UK, several small, niche upcycling enterprises have emerged successfully. These brands have

achieved commercial success by designing stylistically relevant fashion using waste textile materials.

Han, D Tyler,,Apeagyei et al. (2015)states that upcycling aims to offer a transitional solution to the textile waste issue by extending the lifespans of discarded products within an inefficient system, while technological advancements progress towards more sustainable approaches. This design-focused waste solution involves using textile waste in fashion production to create products that have a higher retail value compared to traditionally recycled goods. The goal is to transform waste into desirable and valuable items, contributing to a more sustainable and circular economy in the fashion industry.

According to Diane Cassidy and Li-Chou et al. (2019) Han, upcycling is highlighted as a viable recycling method for repurposing textile waste that would otherwise be discarded. It contrasts with the conventional fashion production model by emphasizing creative reuse of materials. While upcycling can generate unique, high-value products, it presents challenges for mass production. Unlike traditional recycling, upcycling focuses on transforming discarded goods into new items through innovative design and craftsmanship. This approach offers an alternative by converting end-of-life garments and textile waste into fashionable products, promoting more sustainable production practices in the fashion industry. In terms of workforce demographics, the fashion and textile sector demonstrates equal opportunities, with approximately 57% male and 43% female representation. Within manufacturing, fabric cut-offs and end-of-roll materials are typically considered waste.

Environmental concern, consumer creativity, and fashion consciousness and examines the relationships between these variables and consumer interest in learning upcycling techniques and purchasing upcycled clothing. According to Aus, Moora, Vihma Unt, Kiisa, Kapur et al. (2021) the efficiency of upcycling design approach is described by analysing the generation and potential use of various types of fabric leftovers from garment manufacturing. Implementing upcycling on an industrial scale necessitates transparency to grasp the waste generated in garment production and to tailor designs that align with the production system. It’s crucial to recognize that the upcycling design process diverges from conventional design practices. Rather than starting with a concept and sourcing materials accordingly, upcycling involves designing garments around the parameters of available waste materials. This approach requires a shift in mindset and workflow to effectively utilize and transform textile waste into new, desirable products.

S Han, Apeagyei, D Tyler et al. (2015) analysed that the UK government agency WRAP (Wase & Resources Action Programme) has choose textile products as priority materials for reuse and recycling due to significant levels of carbon, water, and waste metrics. Upcycling presents a sustainable design approach that maximizes economic and environmental benefits through reuse techniques. This involves sourcing used clothing and textiles to create newly designed fashion products, reducing waste and contributing to a more circular economy in the textile industry.

2.5 Natural fibres

India contributes a large percentage to total world production of rice husk, jute, banana, and coconut fiber. All these natural fibers have excellent physical and mechanical properties, which can be used effectively in the development of composite materials for various structural applications (Kr Sharma and V Kumar 2013).

In recent years, substantial attention has focused on the development and application of natural fibres due to their eco-friendly, renewable, and cost-effective nature. Natural fibres can serve as substitutes to synthetic materials because they are lightweight and give to energy conservation. They are plentiful and cost effective to harvest. Natural fibres have possible applications, especially when strengthen with a proper medium, as alternatives for metal-based materials or composites used in aerospace and automotive industries. At the same time, synthetic fibres produce toxic byproducts and pose challenges for recycling.

Natural fibres are liable to degradation when reveal to the environment and can be interesting to mix with polymer mediums. Surface modification of fibres is employed to improve bonding between the polymer and fibres. Given escalating environmental concerns and the depletion of petroleum-based resources, there is a growing global interest in developing environmentally compatible composites. Industries are increasingly inclined to use eco-friendly materials to minimize their environmental impact (Boppana, P Kumar, A. P Kumar, Dayanand et al. 2022).

Natural fiber composites, along with natural fibers in general, are pivotal for achieving a sustainable and environmentally friendly future. The automotive industry is making significant strides towards a more eco-friendly product chain by incorporating natural fibers into various components like seat backs, door panels, spare tire covers, and boot linings. Global production of natural fibers is on the rise alongside the expanding product base. Each year, more synthetic fibers and high-energy-consuming products are being replaced by those based

on natural fibers. This trend is driven not only by increased environmental awareness but also by the excellent properties of natural fibers, including their lightweight nature and relatively low costs (R Dunne, D Desai, R Sadiku,J Jayaramudu et al. 2016).

2.6 Banana stem

Banana is an important consumed globally and cultivated in humid and subtropical climes. Almost all the parts of this plant, that are, fruit, leaves, flower bud, trunk, and pseudo-stem, can be utilized. After fruit production, the trunk of the banana plant, known as the pseudostem, is often discarded as agricultural waste on a large scale. To solve this, efforts have been made to mechanically extract fiber from the stem for various product applications. However, these pseudostems can be effectively utilized for producing banana fibers. Annually, about 1.5 million tons of dry banana fibers can be extracted from the outer sheath of the pseudostem. This biomass waste represents a rich source of natural fibers that can be profitably used for various applications and the production of different products.

The stem typically contains around 14 to 18 sheath layers. The outermost 4-6 sheaths produce coarser fibers, the next 6-8 sheaths yield soft and lustrous fibers, and the remaining middle sheaths (excluding the innermost 4-6 sheaths) yield very soft fibers (C. Vigneshwaran, 2015).

The structure comprises three distinct layers: The outer layer, which includes the epidermis containing fibers dispersed within a soft tissue matrix. The middle layer, composed of vascular tissue responsible for water transport. The inner layer, consisting of soft, cellular tissue.. The amount and quality of fiber within each sheath are determined by its width and position within the stem. These factors influence the characteristics of the fiber, such as its strength and suitability for different uses, reflecting the plant's internal structure and growth conditions (C. Vigneshwaran,2015).

Banana stem can be utilized for manufacturing pulp to produce fiber, film, and paper. The process involves pulping to separate the fibers from lignin and hemicelluloses, which can be achieved through chemical, mechanical, or a combination of both treatments. Chemical pulping involves using chemicals to separate the lignin from the cellulose in lignocellulose materials (M Kumar, D Kumar,).

The pseudo-stem represents a significant portion of banana waste biomass and produces high-quality fiber suitable for various industrial applications. This fiber has potential uses in

manufacturing sanitary pads, textiles, pulp and paper, food products, and reinforced composite materials used in automobiles, construction, aerospace, and other composite applications. Today, a significant portion of banana fibers produced are utilized for making ropes and cordage (Balda, A Sharma, N Capalash, P Sharma et al. 2021).

The banana pseudostem serves multiple purposes in various industries, including edible use, fiber production, and environmental improvement. When employed for treating heavy metals in wastewater, its fibers are robust enough to create cardboard and food packaging materials. Certain types of pseudostems can also be processed to extract pectin for use as food additives. Additionally, powdered pseudostem is utilized to enhance the nutritional value of numerous recipes (S Pillai, Morya, W Khalid, Z Khalid, Almalki, Siddeeg et al. 2024).

2.7 **Banana fibre**

Banana fibers are highly strong and easily blend with other fibers to create composites. They are lightweight, biodegradable, rapidly renewable, and exhibit water and flame resistance.Banana fiber is a lignocellulosic fiber extracted from the pseudostem of the banana plant. It is a bast fiber which has strong mechanical properties. Banana fiber has excellent specific strength properties similar to conventional materials such as glass fiber but with a lower density compared to glass fibers (Bhatnagar, G Gupta, S Yadav, et al. 2023).

Banana fiber is a natural bast fiber with diverse applications in handicraft product development, including mats, ropes, and twines. Only 10% of its pseudo stem is currently utilized for manufacturing products, with the rest considered waste or used as fertilizer. As hey have weatherproof nature, UV protection (due to lignin content), moisture absorption, antioxidant properties, and biodegradability, banana fiber holds potential for creating various economically beneficial products that could open up new markets for farmers. Recent studies highlight banana fiber's numerous advantageous physical and chemical properties, positioning it as an excellent raw material for the textile and packaging industries (C. Vigneshwaran, V. Pavithra, V. Gayathri and K. Mythili et al. 2015).

Banana fiber is increasingly replacing pulp in various industries. This fiber's numerous advantages have propelled its use in the fashion industry, where prestigious clothing brands and designers are adopting banana fabric. Moreover, banana fibre is eco-friendly and biodegradable, contrasting to many synthetic fibres.

This natural fibre extracted from banana pseudo stems is progressively being discovered for use in the fashion and technical textile industries, and supports the sustainable product development. Specific banana fibre extractors are employed to harvest these fibres from banana plants. The extracted fibres are typically bleached and then blended with jute fibres to create varied and value-added textile products (Debnath, 2017).

Banana fibres are usually extracted from the outer surface of the plant using various methods such as hand grinding, chemical retting, or boiling in sodium hydroxide solution. Hand-stripped fibres are generally of superior quality compared to those obtained using other methods like raspadors. During the monsoon season, banana stems are plentiful, facilitating fibre extraction. The process involves scraping the exposed leaf sheaths using blunt blades on a soft wooden plank, with the goal of removing the pith until clean fibres are exposed. Fresh pseudo stems harvest fibres equivalent to about 1.5% of the pseudo stem weight. Artisans in the cottage industry segment classically perform this extraction method. Efforts to use machines for fibre extraction have not harvested pleasing results in terms of fibre quality. Fibers extracted from stems after harvesting the banana fruits are generally stronger compared to those extracted before fruit harvest (Chand, Fahim, 2021).

During the extraction process of fibres, two or three of the outer sheaths are discarded because the outermost layered fibres are too hard. Similarly, the innermost two or three sheaths are also discarded due to containing of more pulpy materials, which are too soft and making it difficult to extract high-quality fibre from them. After extraction, the fibres are thoroughly washed and then hung in sunlight to dry directly after stripping. The time of drying varies depending on how much pulpy material remains on the strips. On typical dry days, it takes only about 5 hours for them to completely drying. These fibres generate a bright lustre and are white in colour. Insufficient cleaning, washing, or insufficient drying can lead to fibre degradation due to chemical and biological processes which results in in loss of strength and lustre over time. Meanwhile banana stems are abundant during the rainy season, it’s not always possible to extract fibres punctually from all of them. Any delay in extraction can lead to poorer fibre quality (Chand, Fahim, 2021).

Achmad Jusuf Zulfikar, Muhammad Yusuf Rahmansyah Siahaan have designed and manufactured skateboard from banana stem. The aim of this study was to develop and produce a skateboard using composite fiber reinforced from banana stem fibers, and then assess its flexural strength to determine the material’s properties.

2.8 Banana paper

The banana stem fiber is the best alternative to replace plastic and paper . Banana fibers have great potentialities for papermaking because of their high alpha-cellulose and lignin content. (Patil, 2019).

The demand for paper products remains high in everyday life. Globally, around 90% of paper is sourced from wood, driving deforestation to meet this demand. Recent studies indicate that Uganda's wood demand is expected to more than double by 2040, reaching 105 million tonnes, depleting all sustainable wood sources by 2035. This alarming trend underscores the urgency to find alternative raw materials for papermaking from non-wood sources, fueled by increasing environmental awareness. Agricultural residues present a promising alternative due to their economic, environmental, and technological advantages for paper production.

Banana stems can be utilized as a sustainable and suitable raw material for producing paper with the necessary mechanical properties, such as thickness, density, and tensile strength (Lubwama, Opio, Menya, , Nono, Lubwama, Yiga ,et al. 2023).

A traditional approach to experimental work for developing paper from banana stem fiber can be to vary one factor at a time, holding other factors fixed but this is extremely time consuming and unable to produce satisfactory results in a wide range of experimental settings (Tharazi 2017).

The manufacturing method of banana paper is in straight path and involves small quantity of chemical usage compared to traditional papermaking methods which depends on trees and other materials. Also, industrial papermaking is highly polluting, requires large amounts of water and chemicals to convert pulp into paper (Patil, 2019).

The banana paper industry has grown in popularity due to its eco-friendly features and positive impact on forest preservation and preservation of vegetation, with less amount of water and air pollution. The export of handmade banana paper has uncountably increased in both developed and developing countries, leading to the formation of export-oriented units completely dedicated to banana paper production. These units export handmade banana paper and related products to numerous countries, determined by growing demand in local and international markets.

India cultivates various varieties of bananas, and the banana trees, which are typically harvested for fibre extraction. This is done immediately after fruit harvesting. Banana fibre is

particularly hopeful for papermaking due to its high primary-cellulose content and low lignin content which is making it well suited for high quality paper production (Patil, 2019).

Most of the recycled paper is using fibres of trees or recycled fibres. Trees are still cutting to make recycled paper. Paper of banana plant or fibre is the only way to stop tree cutting and most suitably applying sustainable resources (Patil, 2019).

Uses of banana papers are:

- Disposable dishes, paper cups, disposable glasses, and carry bags.
- Wallets for both men and women.
- Handicrafts and home décor items.
- Artistic purposes and currency notes in certain countries.
- Printing business cards, greeting cards, visiting cards, and wedding cards.
- Gift boxes, notebook covers, and drawing paper.
- Sanitary towels due to its absorbent nature.
- Alternative to art paper for artisans.
- Filter paper, pen stands, photo frames, lampshades, and more.
- Writing paper for various purposes.
- Eco-friendly substitute for plastic wrapping material.
- Food storage and serving purposes.
- Origami and other handicrafts and arts.

  Banana paper made from banana bark is incredibly durable, with a shelf life of over 100 years and the ability to be folded up to 3,000 times without tearing. It is an environmentally friendly material that can replace plastic in many applications and offers unique properties for various creative and functional uses (Patil 2019).

METHODOLOGY

3. METHODOLOGY

The Methodology for the project titled "**Creating Innovative Ecofriendly Products by Blending Banana Fibre with Fabric Waste"** is discussed under the following heads:

3.1 Collection of banana stem

3.2 Extraction of fibres

3.3 Smashing of fibres

3.4 Boiling and cutting

3.5 Collecting and cutting of waste fabrics and threads

3.6 Grinding and adding dyes

3.7 Straining of mixture

3.8 Drying

3.9 Coating natural gum

3.10 Developing designs for making utility products

3.1 Collection of Banana Stem

Gathered banana stem from my surroundings, which would otherwise have been discarded as waste. The layers of the stem were separated and cut into small pieces as seen in Plate.1

Plate.1

Banana stem cut into pieces

3.2 Extraction of Fibers

Fibres were extracted from each layer of the stem by removing the pulp of the stem, excluding the outermost and innermost parts. The outer part was damaged and the inner part was too soft. Making fibres from these layers are difficult as seen in plate.2a and plate.2b.

Plate 2a
Removing pulp

Plate 2b
Extracted fibre

3.3 Smashing of Fibres

The extracted peels were then smashed using grinding stone. This is done to obtain more finer fibres as seen in plate.3

Plate. 3
Mashed fibres

3.4 Boiling and Cutting

The fibres were boiled in water to obtain a softness as in plate.4a. And then cut these fibres into small pieces as seen in plate.4b.

Plate.4a.
Boiling of fibres

Plate. 4b.
Cut fibres into small pieces

3.5 Collecting and Cutting of Waste Fabrics and Threads

Gathered fabrics and thread waste from nearby local industries, then proceeded to cut this waste into small pieces as seen in plate.5.

Plate. 5
Chopping fabric waste

3.6 Grinding Fabric Waste and Banana Fibre

The chopped fabric-thread waste and banana fibres were combined and grind together to create a paste like mixture as seen in plate.:6a and plate.:6b.

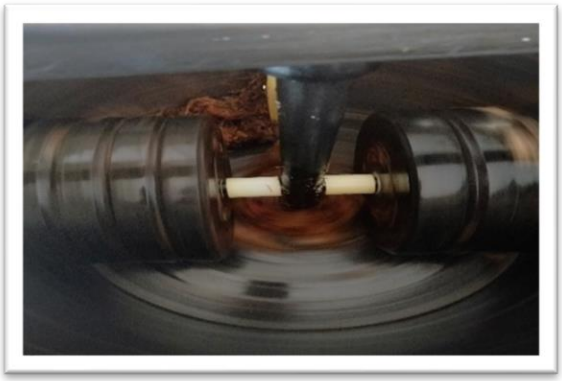


Plate.6a

Grinding of the mixture

Plate.6b

Grinded paste form

3.7 Straining of Mixture

The strainer was submerged in water, and the mixture was added onto it, arranged the mixture according to the quantity of the product. Then, the mixture was strained as seen in plate.7.

Plate.7

Straining of the paste

3.8 Drying

The strained mixture was kept for drying. It took almost 5 hours to get the paper dried completely (plate.8).

.

Plate.no:8

Drying

4.9 Coating Natural Gum

A natural gum mixture, made from corn flour, wheat flour, baking soda, sugar, salt, vinegar and water, was applied as a coating to prevent the paper breakage. This was done after the paper had fully dried as seen in plate.no:9a and plate.no:9b.

Plate.:9a

Natural gum

Plate: 9.b

Coating gum onto the paper

The dried eco- friendly papers developed by blending banana fibres with fabric waste is shown in Plate 10.

Plate.10

Developed papers

4.10 DEVELOPING DESIGNS FOR MAKING UTILITY PRODUCTS

Nine different utility product designs were developed. The designs were created in accordance with the strength of the developed fabric mixed banana paper.

The sketched designs are given from Fig No :1 to Fig no: 9

Designs for Lamp Shade

DESIGN 1A DESIGN 1B

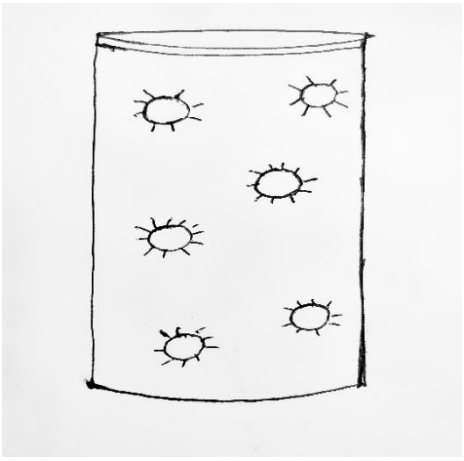


Fig No:1

Designs for Lamp shade

Desings for Book Cover

DESIGN 2A DESIGN 2B

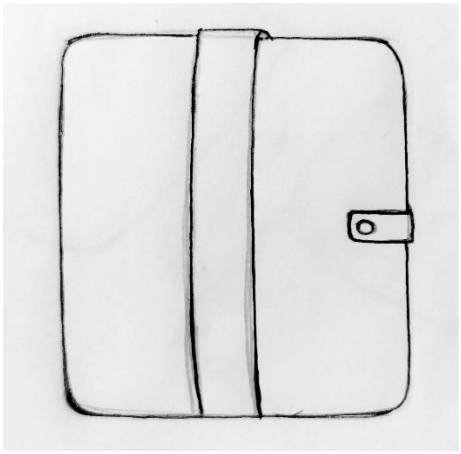


Fig No:2

Designs for Lamp shade

Desings for Wall Hanging

DESIGN 3A

DESIGN 3B

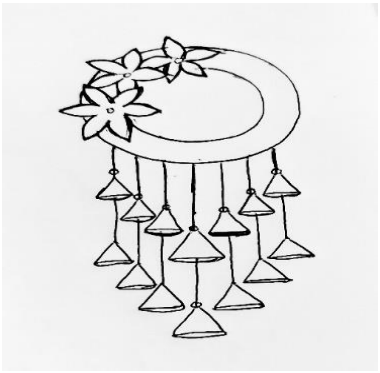
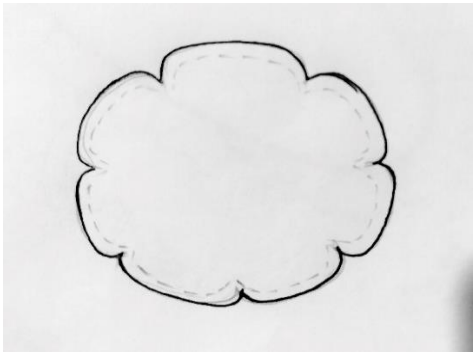


Fig No: 3

Designs for Wall Hanging

Designs for coaster

DESIGN 4A



DESIGN 4B

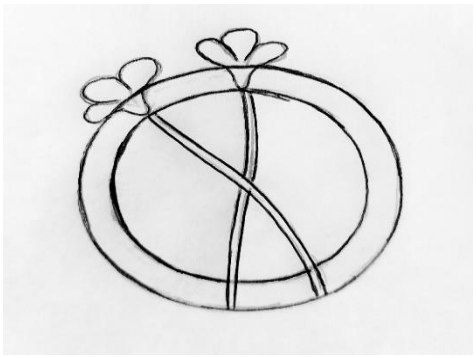
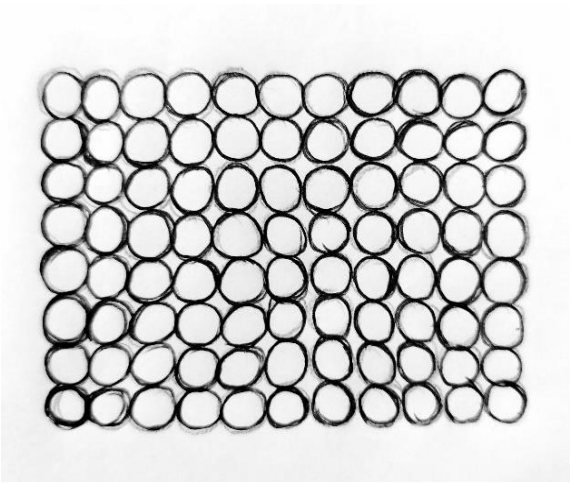


Fig No:4

Designs for Coaster

Designs for Table Mat

DESIGN 5A



DESIGN 5B

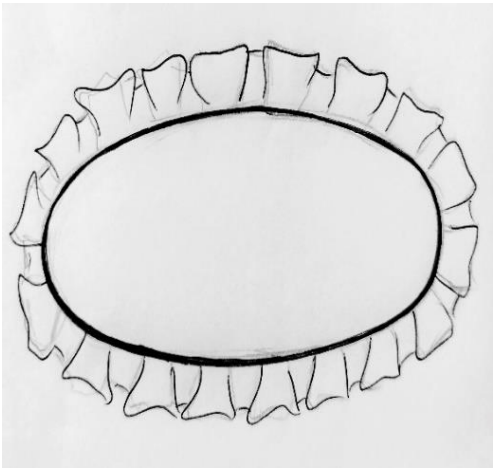
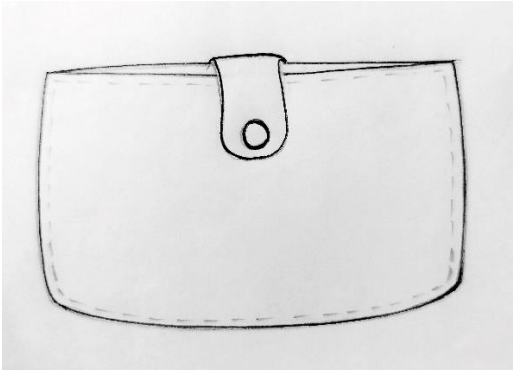


Fig No: 5

Designs for table mat

Designs for Lady's Wallet

DESIGN NO:6



DESIGN NO: 6

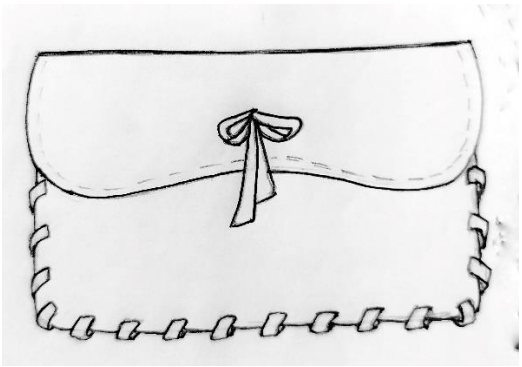
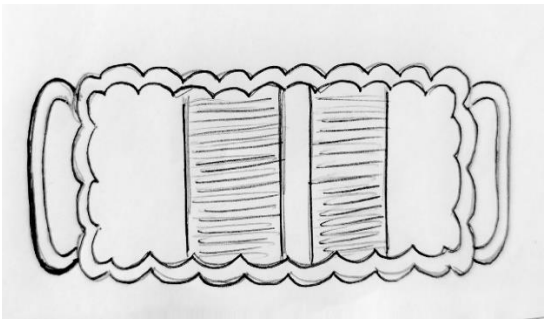


Fig No: 6

Designs for ladies' wallet

Designs for cup case

DESIGN 7A



DESIGN 7B

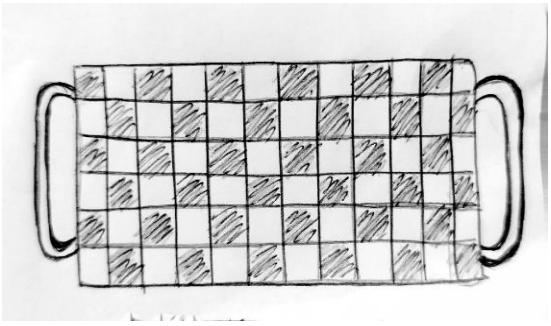
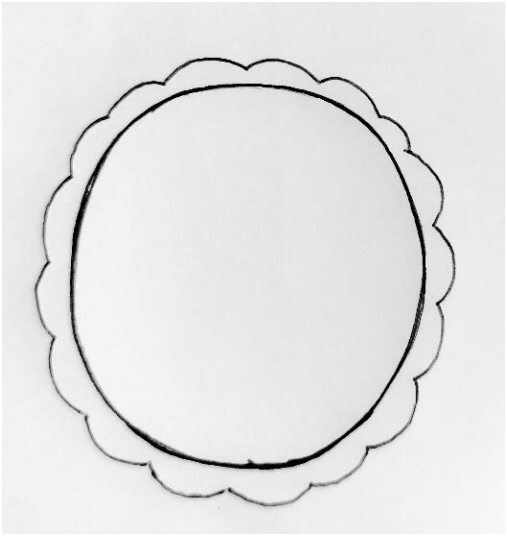


Fig No: 7

Designs for cup case

Designs for mouse pad

DESIGN 8A



DESIGN 8B

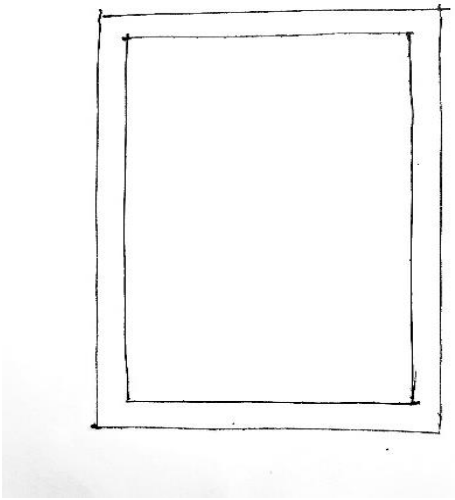


Fig No. 8

Designs for mouse pad

DESIGN 9A

DESIGN 9B

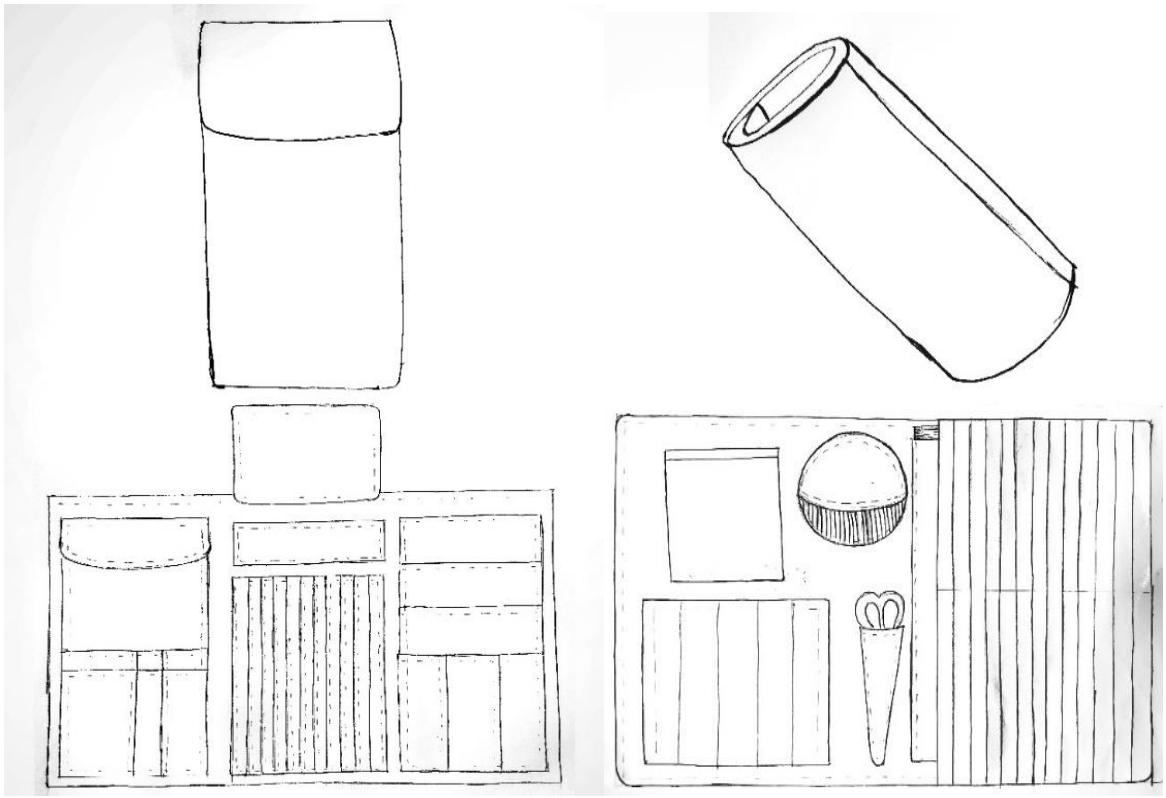


Fig No. 9

Designs for Designer Bag

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The Result and Discussion for the project titled "**Creating Innovative Ecofriendly Products By Blending Banana Fibre With Fabric Waste**" is discussed under the following heads.

4.1 Data collection

4.2 Product Development

4.3 Evaluation of developed products

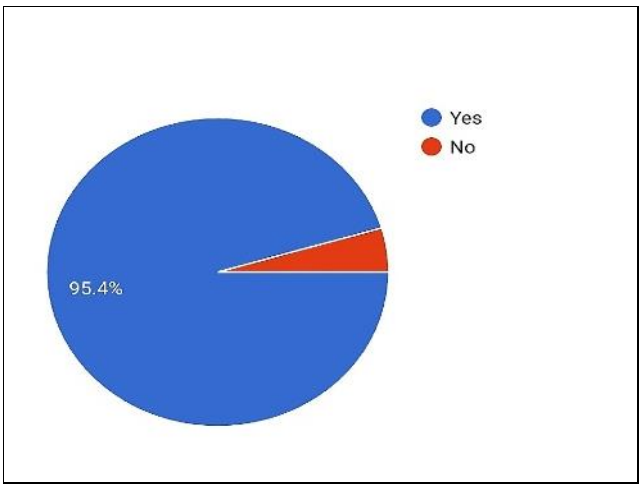
4.4 Coasting of the developed product

4.1 Data Collection

A questionnaire was prepared to collect data regarding the preferences to know the design selection of utility product developed from eco friendly paper made from banana fibres mixed with fabric waste. A survey involving 60 college students was conducted to choose one design out of nine sketched product designs.

The results of the data collection are given below:

4.1.1 Have you ever used any eco-friendly products?

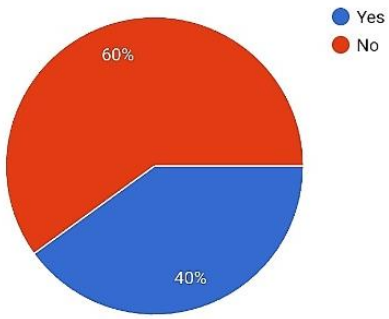


Graph 1

Responses for usage of eco friendly products

Among 60 responses, 95.4% were responded positively and the remaining responded as they don't knew about eco-friendly products.

4.1.2 Have you used recycled products for daily use?

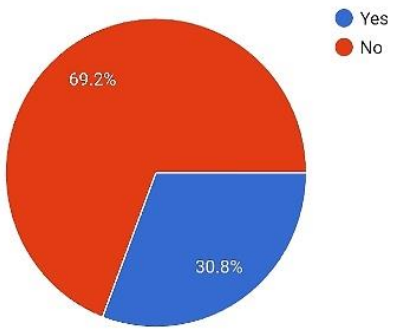


Graph 2

Responses for the usage of recycled products for daily use

Out of 60 responses, 60% of the individuals were used ecofriendly products for daily purpose and rest of the 40% responded as they don't use recycled products.

4.1.3 Have you heard about banana mashed recycled products?



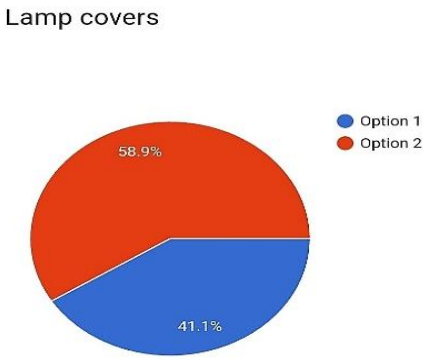
Graph 3

Responses for the familiarity of banana mashed recycled products

69.2% replied that they have heard about banana mashed recycled products whereas remaining 30.8% were responded negatively

4.1.4 Select one product design from each of the below banana mashed recycled products.

- **LAMP COVERS**

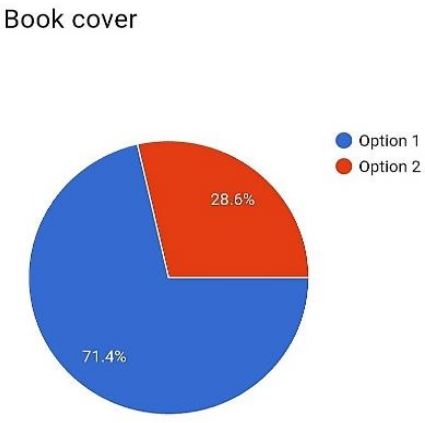


Graph 4

Lamp cover response

Out of 60 responses, 58.9% selected the design no: 1A of Fig no:1 for lamp shade

- **BOOK COVER**

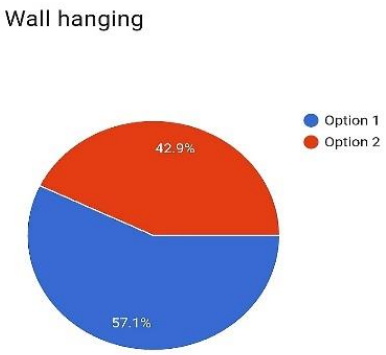


Graph 5

Responses for book cover

From the responses of 60 students, 71.4% selected design no: 2B of Fig no:2

- **WALL HANGING**

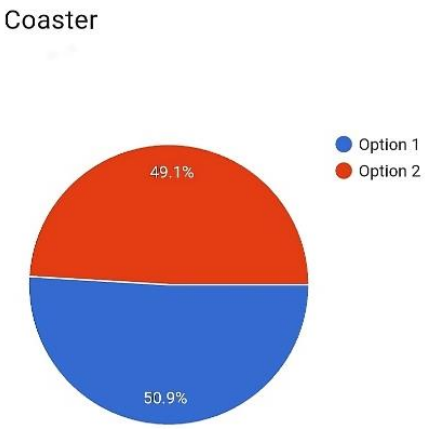


Graph 6

Responses for wall hanging

From the survey of 60 students, 57.1% selected design no: 3B of fig no:3.

- **COASTER**

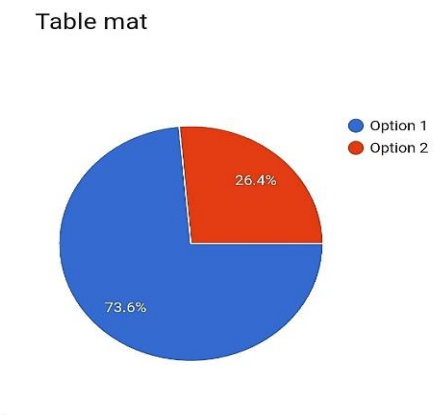


Graph 7

Coaster

Out of the response from 60 college students, 50.9% selected design no: 4A of fig no: 4

- **TABLE MAT**

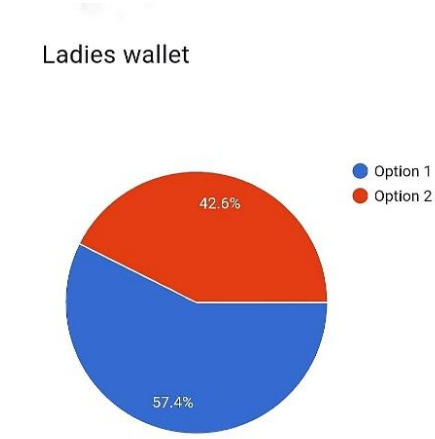


Graph 8

Table mat

From 60 responses, 73.6% of the students were selected design no: 5B of fig no:5

- **LADIES' WALLET**

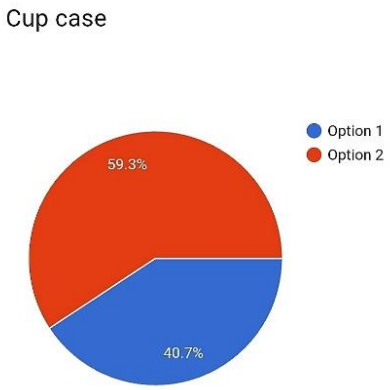


Graph 9

Ladies' wallet

Among the responses of 60 college students, 57.4% of them selected design no:6 of fig no: 5

- **CUP CASE**

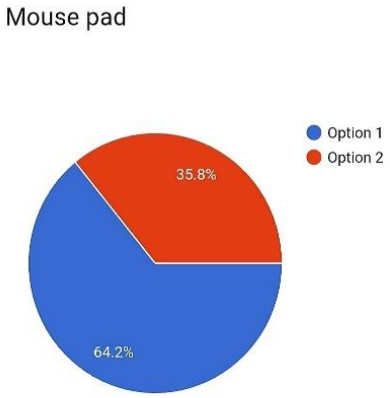


Graph 10

Cup case

From 60 responses of the college students, 59.3% choose design no: 7B of fig no: 7

- **MOUSE PAD**

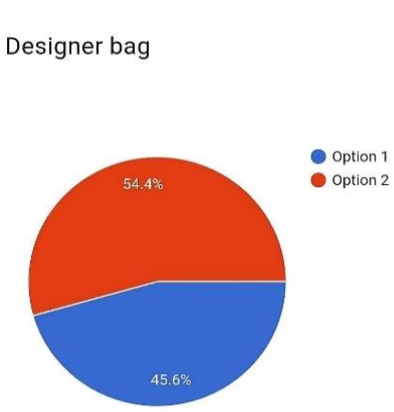


Graph 11

Responses for mouse pad

Out of 60 responses, 64.2% of the students were selected design no: 8B of fig no: 8.

- **DESIGNER BAG**



Graph 12

Responses for designer bag

From the response of 60 college students, 54.4% were selected design no: 9A of fig no: 9.

Out of the 9 products selected through the survey, 7 designs were chosen to be developed. They are lamp cover, book cover, table mat, mouse pad, coaster, ladies' wallet and designer bag.

4.2 Product development

The selected 7 products were made from the developed eco-friendly paper utilizing banana fibre mixed with fabric waste. Each of the products were embellished suitable using box pleat, embroidery etc.

The developed utility products are shown from Plate 11 to 17

Plate 11

Lamp cover

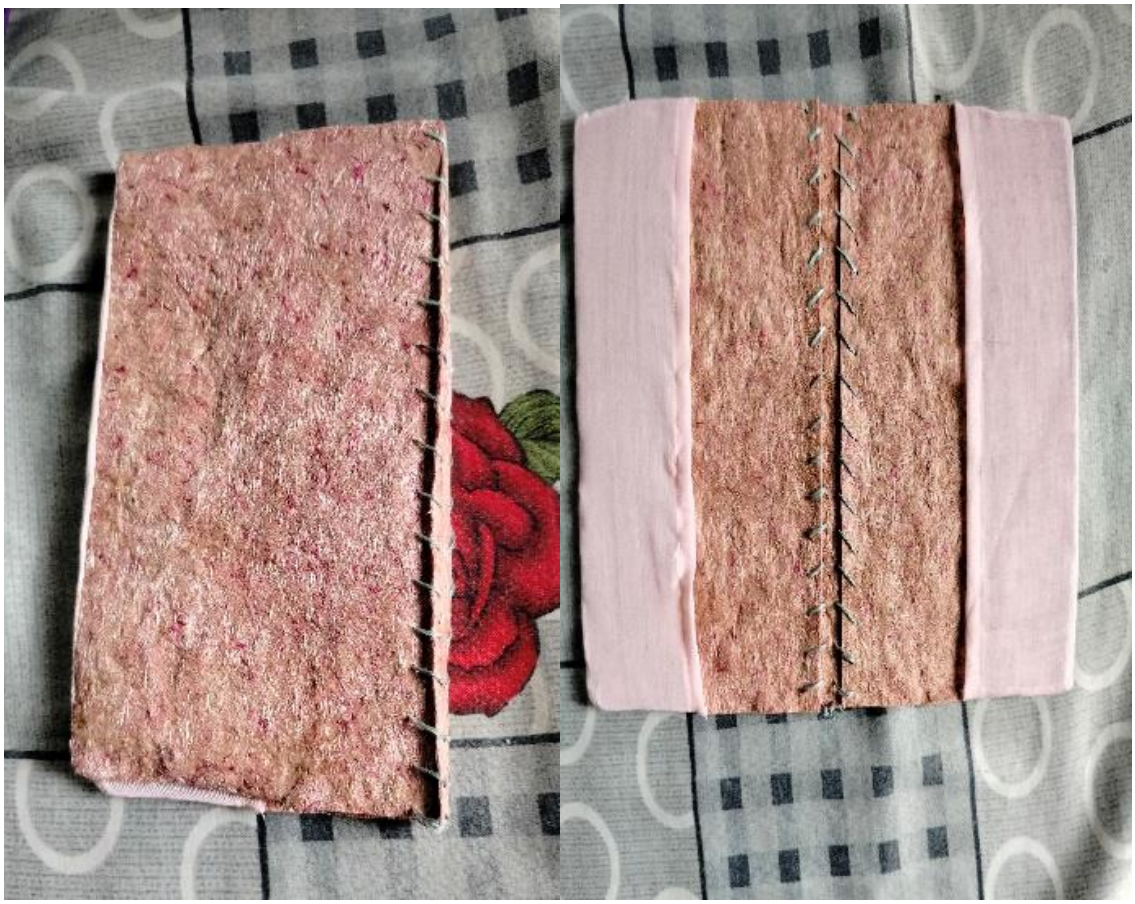


Plate : 12.a **Plate :12b**

Book cover

Plate :13

Table mat

Plate :14

Coaster

Plate: 15

Ladies' wallet

Plate: 16

Mouse pad

Plate : 17a

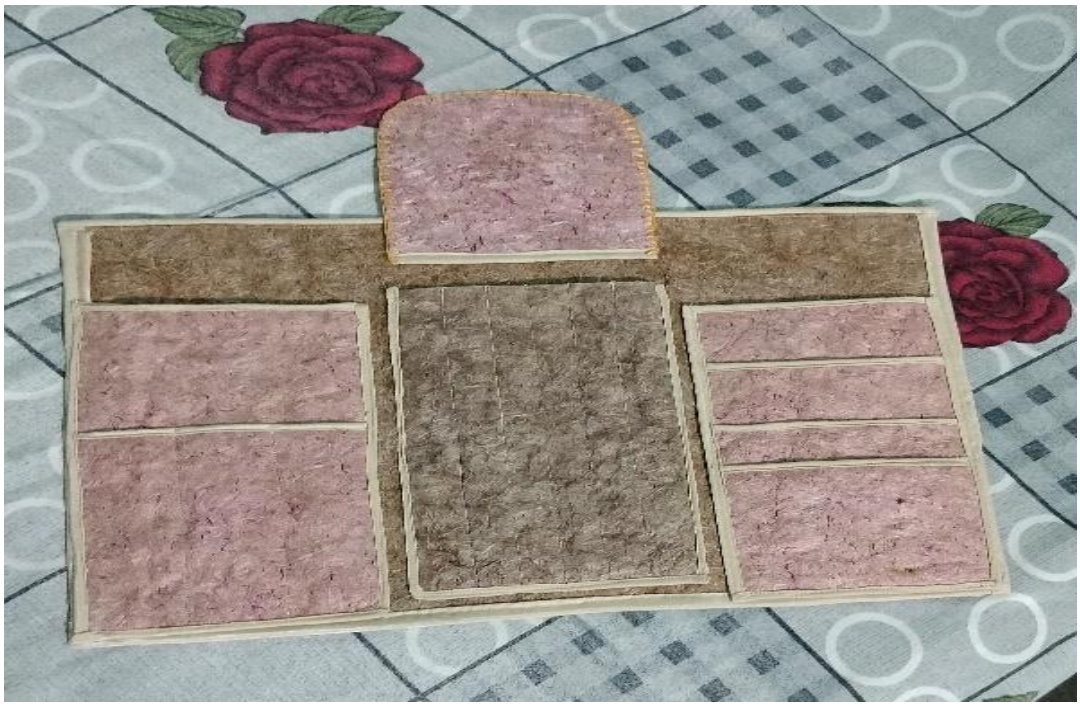


Plate: 17b

Designer bag

4.3 Evaluation of the Developed Products

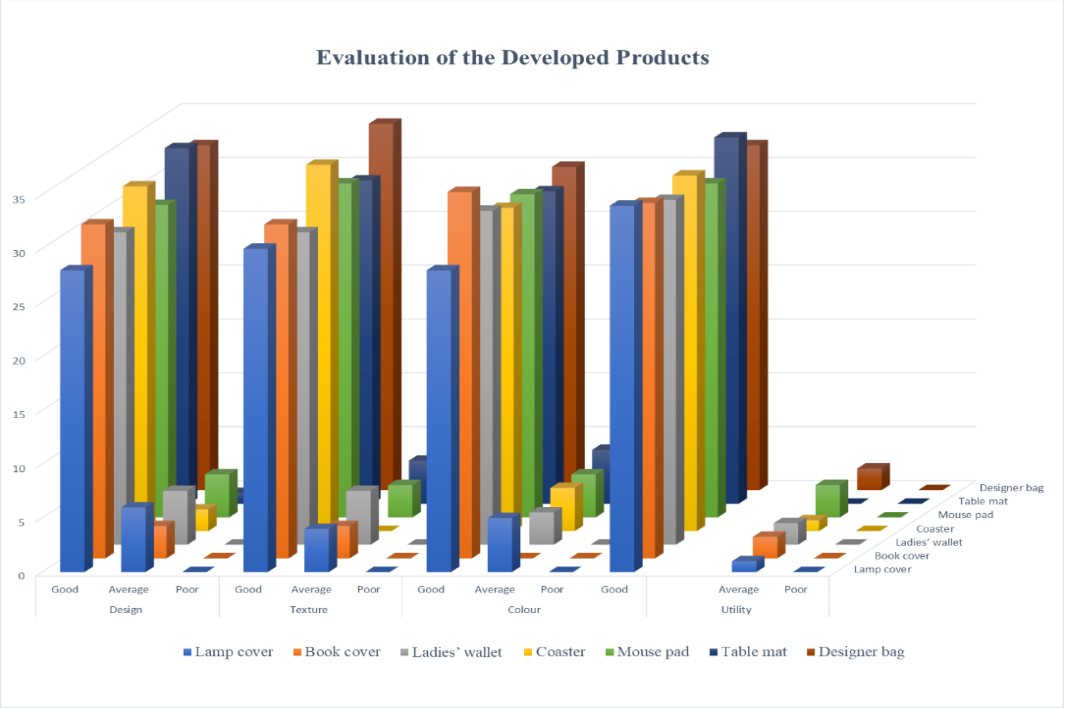
The developed utility products from eco- friendly paper made out of banana fibres mixed with fabric waste were given for physical evaluation. The products were evaluated for design, texture, colour and utility from 34 students. The results are given in Table I, Graph .1.

Table I

Evaluation of Developed Products

Product	Design			Texture			Colour			Utility		
	Good	Averag	Poor	Good	Average	Poor	Good	Average	Poor	Good	Average	Poor
Lamp cover	28	6	0	30	4	0	28	5	0	29	5	0
Book cover	31	3	0	31	3	0	34	0	0	31	3	0
Ladies' wallet	29	5	0	29	5	0	31	3	0	32	2	0
Coaster	32	2	0	34	0	0	30	4	0	31	3	0
Mouse pad	29	4	0	31	3	0	30	4	0	31	3	0
Table mat	33	1	0	30	4	0	29	5	0	34	0	0
Designer bag	32	2	0	34	0	0	30	4	0	31	3	0

Out of the total responses for the survey, all the developed eco friendly products made from banana fibre blended with fabric waste were good in design, texture, colour and utility.



Graph 1

Evaluation of the Developed Products

4.4. Costing of the Developed Products

The costing of the developed utility product made from eco friendly and sustainable paper is given in Table II

Table II

Costing of the Developed Products

Product	Cost
Lamp cover	150/-
Book cover	100/-
Ladies' wallet	120/-
Table mat	150/-
Coaster	80/-
Mouse pad	60/-
Designer bag	200/-

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

Textile and apparel sectors are considered as one of the most significant industrial sectors in the world. Also, they are one of the most polluting industries. Reduce, reuse, and recycle ate the key factors to consider for reducing waste management in the textile industry. The use of natural fibres is experiencing a global increase due to heightened environmental concerns. Blending banana fibres with fabric waste presents a promising avenue for creating innovative eco- friendly products. This not only contributes to sustainable practices by repurposing waste materials but also shows the unique properties of banana fibre to enhance the characteristics of the resulting products. Instead of using fabric waste, other discarded materials such as waste papers, plastics etc. can also be mixed with banana fibres to create unique products.

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APPENDIX

APPENDIX I

1. Questionnaire to know the preference for developing utility products

- Have you heard about banana mashed recycled products?
- Have you ever used any eco-friendly products?
- Have you used recycled products for daily use?
- Select one product design from each of the below banana mashed recycled products.

  - Lamp cover
  - Book cover
  - Wall hanging
  - Coaster
  - Table mat
  - Ladies' wallet
  - Cup case
  - Mouse pad
  - Designer bag

APPENDIX II

Chart for Evaluating the Developed Utility Product

PRODUCTS	DESIGN	TEXTURE	COLOUR	UTILITY
LADIES WALLET	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐
LAMP COVER	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐
TABLE MATE	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐
COASTER	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐
DESIGNER BAG	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐
MOUSE PAD	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐
BOOK COVER	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐	GOOD ☐ AVERAGE ☐ POOR ☐