DESIGNING AND DEVELOPING UTILITY PRODUCTS USING NATURALLY DYED BAMBOO-COTTON BLEND FABRIC ENHANCED WITH ECO-PRINTING TECHNIQUES

PROJECT SUBMITTED

In practical fulfilment of the requirement for the

award of the degree

MASTER'S PROGRAMME IN FASHION DESIGNING

BY

BEEMA NASSIR
(REGISTER NO. SM23MFD001)

Under the guidance of

Dr. VINITHA PAULOSE

DEPARTMENT OF FASHION DESIGNING

WOMEN'S STUDY CENTER

ST. TERESA'S COLLEGE (AUTONOMOUS)

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Ms. CHINCHU. V. JOY 29/04/2025

Name and Signature of

External Examiner

ST. TERESA'S COLLEGE DEPT. OF FASHION DESIGNING ERNAKULAM

Dr. Vinitha Paulose 29/4/25

Name and Signature

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APRIL 2025

NAIR SUPRIYA DAMODARAN
Name and Signature of
Head of the Department

Dr. Vinitha Paulose
Name and Signature of Guide
28/4/25

ST. TERESA'S COLLEGE DEPT. OF FASHION DESIGNING ERNAKULAM

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF GRAPHS

DECLARATION

I hereby declare that the matter in this research entitled **"Designing and Developing Utility Products Using Natural Dyed Bamboo-Cotton Blend Fabric Enhanced With Eco-Printing Techniques"** submitted in partial fulfilment of the requirement for the award of Degree of **Master's Programme in Fashion Designing** is a record of original research work done by me under the supervision and guidance of **Dr. Vinitha Paulose,** Assistant Professor, Department of Fashion Designing, Women's Study centre, St. Teresa's College [Autonomous], Ernakulam and that the thesis has not previously formed on the basis for the award of any degree work has not been submitted in part or full or any other degree/diploma/associate ship/fellowship or the similar title to any candidate of any other university

Signature of the Candidate

Dr. Vinitha Paulose 28/4/25

Signature of the Guide

ST. TERESA'S COLLEGE DEPT. OF FASHION DESIGNING ERNAKULAM

Place: Ernakulam

Date: 29-04-2025

ST.TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM

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CHAPTER 1

INTRODUCTION

DESIGNING AND DEVELOPING UTILITY PRODUCTS USING NATURALLY DYED BAMBOO-COTTON BLEND FABRIC ENHANCED WITH ECO-PRINTING TECHNIQUES

I. INTRODCUTION

Textiles are materials produced through weaving, knitting, crocheting, or bonding fibers to create a fabric. These materials find application across various sectors, including fashion, interior design, industrial uses, and healthcare. Textiles can be composed of natural fibers like cotton, wool, and silk, or synthetic ones such as polyester, nylon, and spandex.

The word Textile signifies anything weaved or suitable for weaving. It applies to any product or fabric made from natural or synthetic fibers, filaments, or yarns. As a result, this term is extremely broad and covers everything from clothes to carpets, curtains, tapes, upholstery, etc. The word Textile means manufacture of raw materials, processing machinery, buildings, personnel used in the organization connected with the technology of their manufacture, which includes the following: Textile Mill, Textile Institute, Textile Engineer, Textile Research, Textile Printing, Textile Designer, Textile Technologist, as said by. Murthy H.V. Sreenivasa (2016).

The textile sector includes processes like spinning, dyeing, and finishing that convert raw materials into usable items. Textiles have been vital to human existence for millennia, serving important roles in clothing, protection, comfort, and even in sophisticated technological uses. With ongoing advancements, textiles are evolving, embracing sustainable methods, modern manufacturing techniques, and innovative technologies.

1.1 ECO-FIBRES

Eco fibres are eco-friendly, sustainable materials obtained from recycled or natural fibres that are intended to lessen the negative environmental effects of conventional textiles. These fibres are produced with little negative impact on the environment, frequently by using non-toxic dyes, water-efficient techniques, and renewable resources. Organic cotton, hemp, bamboo, recycled polyester, and even waste materials like plastic bottles or marine debris can be used to make Eco fibres.

Eco-friendly fibers are substitutes for fibers that pose a threat to the environment and are designed to reduce their adverse impacts, describes School (2018).

Eco-textiles, another name for green textiles, are sustainable and environmentally friendly substitutes for traditional textiles, which are regarded as the sector with the worst environmental impact, as expressed by Choudhury (2013).

Eco fibres are a viable substitute for traditional materials as the fashion and textile sectors come under growing pressure to embrace sustainable practices. Brands and customers may help reduce waste, carbon footprints, and promote more ethical manufacturing processes in the fashion and textile industries by making the use of these fibres a priority.

1.2 CELLULOSE FIBRE

The textile industry makes extensive use of cellulosic fibers due of their intriguing natural qualities, which include comfort, hydrophilicity, and biodegradability. These fibers can be derived from natural cellulose resources like viscose, lyocell, and modal, or they can be regenerated from natural renewable resources like cotton, linen, jute, and bamboo. Cellulosic fibers can be used in the textile industry either by themselves or in combination with other natural or synthetic fibers to lower manufacturing costs or enhance the qualities of textile goods says Eid and Ibrahim (2021).

Cotton, hemp, jute, kapok, ramie, sisal, flax (linen), and regenerated cellulosic fibers are among them. Due to their ease of ignition and quick consumption once ignited, these fibers are regarded as flammable. Cellulosic fibers, on the other hand, are frequently utilized to make clothing because of their superior drape, comfort, and durability. After burning, the cellulosic fiber remnant is called ash, and it usually separates from the remaining unburned fabric or clothing. The most combustible of all the cellulosic fibers is usually rayon. To make textiles and clothing less flammable, flame-resistant compounds can be sprayed; some of these chemicals can survive numerous washings, however handling is frequently negatively impacted, as said by Haule and Nambela (2022).

Natural fibres made from plant resources, cellulose is mostly obtained from bamboo, cotton, wood, and other plant sources. Known for their sustainability and biodegradability, these fibres are derived from cellulose, a complex carbohydrate present in plant cell walls. Cotton, linen, and, more recently, regenerated fibres like rayon, lyocell, and modal are common examples of cellulose fibres. Because of their softness, breathability, and adaptability, cellulose fibres are widely used in textiles. Since cellulose fibres are renewable, biodegradable, and can be manufactured with less of an impact on the environment when managed properly, they provide an environmentally favourable substitute for synthetic materials as the demand for sustainable materials rises. Chemical techniques may create regenerated cellulose fibres from recycled resources or wood pulp, which makes them an essential.

1.3 ECODYES

Eco dyes represent sustainable alternatives to conventional synthetic dyes, aimed at reducing the adverse effects of dyeing processes on the environment and human health. In contrast to traditional dyes, which frequently contain toxic chemicals and heavy metals, eco dyes are obtained from natural materials such as plants, fruits, vegetables, and minerals, or are produced through sustainable, non-toxic synthetic methods. These dyes are biodegradable, contribute to the reduction of water pollution, and require only less energy and water during the dyeing process.

The majority of materials and fibers can be dyed with natural dyes, although the degree of success varies greatly in terms of color fastness and clarity. However, people who use natural dyes also frequently employ natural fibers, so this group will receive a lot of attention, according to Schumacher Centre for Technology & Development (2009). Natural fibers mostly originate from either vegetable or animal sources. Animal-derived fibers include alpaca, wool, silk, mohairs, and a few other, less well-known types. The basis of all animal fibers is protein. Natural dyes work well with animal-based fibers, particularly wool, silk, and mohair, and the results are typically favorable. Cellulose is a fundamental component of numerous plant fibers, such as cotton, flax or linen, ramie, jute hemp, and many more. Certain plant-based textiles may not dye as well when dyed naturally as their animal counterparts. Every category requires a different mordanting method. When dyeing a blend of fibers from both plant and animal sources, a recipe that highlights the fiber that must be dominant should be used, according to Schumacher Centre for Technology & Development (2009).

A dye is a natural or artificial coloring agent used to color textiles, paper, leather, and other materials so that the color of the materials is not fading when they are washed, heated, exposed to light, or otherwise exposed to common environmental factors. Aqueous solutions are typically used to apply the colors. By creating solutions, covalent bonds, or in situ complexes with metals or salts, as well as by mechanical retention or physical adsorption, the dyes can stick to suitable surfaces. Othmer (2004) and Zollinger (1987).

The use of eco dyes is increasingly embraced in the fashion, textile, and home goods sectors as both consumers and brands become more aware of the environmental and social consequences of their decisions. By adopting eco dyes, manufacturers can lower their carbon footprint, encourage cleaner production methods, and offer safer options for both workers and consumers. This transition towards eco-friendly dyeing practices is part of a larger movement advocating for sustainability and ethical production within the textile industry.

1.4 ECO PRINTING

Eco-Printing, botanical printing, eco-dyeing, or leaf printing. Known in several terms is a technique where plants, leaves, flowers, and other floral leaves their shapes, colours and marks on fabric. Eco- dyed or print cloth is made by the bundling plant material with cloth then binding it and applying heat by steaming which transfers the colour from plants to the fabric. The process of dyeing the fabric is fun and gives a magical effect on the fabric. These causes one to wonder what secrets are held inside the plants that surround us which we so often hardly take notice.

Ancient methods of natural dyeing and printing are the roots of eco printing, sometimes referred to as botanical printing. Many civilizations throughout the world use traditional methods to make designs on fabric using plant materials. Artists like India Flint have been instrumental in the resurgence of environmental printing in recent years. Eco printing gained popularity as a sustainable practice thanks to Flint's work with plant-based dyes and contact printing methods. Eco printing is now a widely accepted art form that honors the historical foundations of textile design while embracing a more ecologically conscious future by fusing creativity, sustainability, and natural resources, as opined by Dixit (2023).

Plants will give some colour, but only certain plants or flowers combined with various adjuncts will render long lasting colours. Eco printing is an opportunity to work with these plants in their last whoopee, to walk the woods or your garden and see things differently. Pick up a few leaves from the ground, arrange them on fabric, roll into a bundle, then steam. The heat transfers the pigments and images onto the fabric, creating an ethereal design, an explosion of colour and pattern. The advantage of vegetable-based ink is that it does not require additional equipment or training to be used instead of the regular ink. It is supported by regular offset presses and has become increasingly available. Vegetable based inks replace a certain amount of the petroleum base with bio-derived oil that can greatly diminish the Volatile Organic Compounds emissions. This bio- derived oil can be canola, sunflower, linseed, tall or soy oil. However, vegetable-based inks take more time to dry and may require longer heat setting, therefore increasing the energy consumption of a printer. Sahu (2022).

1.5 SUSTAINABILITY IN THE FASHION INDUSTRY

Fashion is one of the largest Industry in the world. For all the glamor that its luxury segment is often associated with, textile and apparel production is also plagued by pollution, water waste, greenhouse gas emissions, labour violations, and short product life spans. The fast fashion industry, in particular, has been criticized in recent years for the environmental damage it causes and the poor working conditions in textile manufacturing firms across the globe. Increasingly, initiatives and business models for more sustainable fashion sourcing and manufacturing have been developed.

'Slow fashion' represents an alternative that may be able to counter many of the disadvantages of fast fashion. However, business models that are innovative and based on responsible and sustainable practices are also more capital-intensive. While the environmental impact of initiatives can often be tracked and measured, the question of whether sustainable fashion is 'good business' from a financial point of view is still under debate. Fashion brands are starting to realize that investment in long-term, innovative initiatives that champion social responsibility and sustainability makes financial sense and is perhaps the only strategy that will support the future of the industry, as said by Kirpalani (2022).

Most people would recognize supply chain difficulties when recognizing sustainability issues in the fashion business. Sustainability challenges are influenced by the different supply chain phases. It should be obvious to a fashion company that integrating sustainability into the supply chain has advantages. Long-term advantages include boosting natural resources through waste reduction, incorporating moral accountability, and ensuring adherence to social and environmental norms, according to Ashby (2013).

The first issue that falls under the umbrella of sustainability in the garment industry is fibers. Cotton, for instance, is regarded as a superior fabric for apparel. It is a natural fabric that is soft and feels pleasant against the skin. However, it has a very detrimental effect on the ecosystem. Cotton requires excessive amounts of water to grow and herbicides and insecticides to keep the plant healthy, which contaminates the soil.The fashion business is the second most polluting sector in the world, after the oil industry. Kent (2021).

OBJECTIVES OF THE STUDY

1. To study about ecofriendly fibres, cotton and bamboo
2. To study about the extraction of dye from coconut husk
3. To test the phytochemistry of extracted dye
4. To test the UV absorption of the extracted dye.
5. To dye the bamboo cotton blend fabric with the extracted dye.
6. To test the colour fastness properties of the dyed fabric
7. To finish the dyed fabric with eco printing technique
8. To develop utility products from natural dyed fabric finished with eco-printing technique.
9. To evaluate the aesthetic appearance of the developed fabric and ecofriendly products.

CHAPTER 2

REVIEW OF LITERATURE

I. REVIEW OF LITERATURE

The review of literature pertaining to the study titled **“Designing and Developing Utility Products Using Naturally Dyed Bamboo-Cotton Blend Fabric Enhanced with Eco-Printing Techniques”** is discussed under the following heads:

2.1 Textiles

2.2 Eco-Friendly Fibers

2.1.2 Bamboo

2.1.3 Cotton

2.1.4 Bamboo Cotton Blend

2.3. Natural Dyes

2.3.1 Coconut Husk Dye

2.4. Natural Dyeing

2.4.1 Conventional and non - conventional dyeing

2.5. Mordant

2.5.1 Types of Mordanting

2.5.1.1 Oil-mordant

2.5.1.2 Tannin

2.5.1.3 Metallic mordant

2.5.1.4 Aluminium mordant

2.6. Eco-Printing

2.6.1 History of Eco-Printing

2.6.2 Inventor of Eco-Printing

2.6.3 Importance of Eco-Printing

2.6.4 Eco printing materials

2.6.4.1 Madagascar periwinkle

2.6.4.2 Cosmos

2.6.4.3 Indigofera tinctoria

2.6.4.4 Common wormwood

2.7. Eco printing technique

2.7.1 Steaming technique

2.7.2 Hammering technique

2.8. Sustainable Utility Products

2.1 TEXTILES

The word textile is derived from the Latin adjective textilis. Textiles includes various Fiber-based materials, such as fibers, yarns, filaments, threads, and other types of fabric, are all included under the general word "textile." Originally, the term "textiles" was limited to woven textiles. Weaving is not the sole manufacturing technique, though; numerous additional techniques were later created to create textile structures according to their intended purpose. Two more common methods of producing cloth are knitting and non-weaving. Textiles meet the material requirements for a wide range of uses in the modern world, from basic everyday Eco-friendly fabrics or fibers are produced to lessen the negative environmental effects of textiles. They play a significant role in eco-friendly fashion. It may also apply to clothing or accessories made of natural, organic, or reused materials that reduce waste and require less energy during production apparel to spacesuits, bulletproof jackets, and doctor's gowns.

Technical textiles and consumer textiles for home use are the two categories of textiles. While functional qualities are the top concern in technical textiles, aesthetics and comfort are the most crucial aspects in consumer textiles.

2.2 ECO – FRIENDLY FIBERS

. For maximum softness, natural fibers—like cotton fibers—are meticulously cleansed. when no toxic pesticides or insecticides are applied during harvest, even though chemicals can taint certain crops. Eco-friendly fibers might also be man-made. Synthetic and regenerated fibers are the two types of fiber. Chemicals are used to provide the softness of synthetic fabrics like polyester and nylon. Regenerated fibers, on the other hand, are made by chemically altering natural materials.

Eco Friendly Fibres includes

Bamboo - Bamboo pulp is used to make Bamboo, a regenerated cellulosic fiber. Soundri, (2014) It is a resilient, highly regenerative grass that often requires minimal chemical inputs to grow. Its renewable nature is the primary characteristic that qualifies it as an environmentally beneficial fiber. The cloth breathes and has inherent antibacterial qualities. Bamboo's comfort, softness, luster, and absorbency give it a wider range of uses. Bamboo clothing has won the title of "Air Conditioning Dress." Christy and Kavitha (2014).

Organic Cotton-It is more environmentally friendly than conventional cotton since it doesn't use pesticides or insecticides during the growth cycle, whereas conventional cotton utilizes more than 25% of the world's pesticides. However, it requires more work, and before a crop can be certified organic, fields must be chemical-free for three years. Geetha Margret (2014)

Hemp: Hemp is the most promising environmentally friendly fiber. When compared to other fibers, hemp fibers are thought to have a minimal ecological footprint. It grows without fertilizer, needs little care, is quickly renewable, uses little or no pesticides, and doesn't deplete soil nutrients. Harvesting it is therefore simple. It is a long-lasting, long-fiber material.

Soy Cashmere/Silk: This fabric is manufactured from the leftover soy protein fiber from the food processing of soybeans. Proteins that have been liquefied are extruded into fibers, which are subsequently spun and used similarly to other fibers. It is responsive to natural dyes because of its high protein content. in order for them to produce their own hues. Geetha Margret (2014)

Banana Fibre: Banana stems are increasingly being used as a source of fiber, including cotton and silk. It is utilized globally for a variety of products, including the production of automobile tires, Japanese yen notes, tea bags, and sanitary napkins. One of the strongest natural fibers, it is sometimes referred to as musa fiber. Previously regarded as a total waste, banana stems are now used to make banana-fibre cloth, which varies in thickness and weight depending on which section of the stem was used to extract the fiber. The thicker and more resilient fibers originate from the outer sheaths, whereas the softest fibers are found in the interior sheaths. Benitta Christy and Kavitha (2014).

Corn Fibre: There are two types of corn: spun and filament. It is made from sugars found in plants naturally. Comfort, softness, and drape in fabrics are balanced with durability and strength. Additionally, corn is inherently flame retardant and doesn't require any surface treatments or chemical additives. Manufacturers of corn fiber assert that their fibers can be utilized for clothing, outerwear, sportswear, and jackets, among other items. Benitta Christy and Kavitha (2014).

2.2.1 BAMBOO

A plant rich in lignocellulose, bamboo has significant ecological, commercial, and cultural significance. While the culms can be processed and utilized in the paper and lumber industries, the bamboo shoots can be consumed as food. It belongs to the grass family. Although bamboo has been used for more than 7000 years as a valuable resource, it wasn't until the late 18th century that it was acknowledged as a unique member of the Gramineae family. Wang et al., (2014) and Worobiec and Worobiec (2005). Due to the fibers' longitudinal orientation, bamboo fiber is often referred to as natural glass fiber. Zakikhani et al., (2014); Wang and Chen, (2016). It is one among the many trees found in deep woods, particularly in China, where 400 species and 40 families are present. Fan and Weclawski (2016); Van Dam et al., (2018). Bamboo fiber's light weight, affordability, strength, and stiffness make it a popular choice for reinforcement in polymeric composites. Bamboo has long been utilized in the construction of traditional boats, bridges, and homes. In many different sectors, the fibers taken from bamboo are utilized as reinforcement when creating sophisticated composites. Deshpande et al., (2000); Osorio et al., 2011; Zakikhani et al., (2014). It is made from the pulp of bamboo trees and it has cellulose fiber that has been regenerated. Only when it is extracted mechanically is it environmentally benign. The remaining organic bamboo not bleached by the producers Its chemical processing is not good for the environment. Following mechanical processing, biological enzymes are added to the crushed bamboo to break it down into a mushy mass, from which the individual fibers are then combed out. The producers do not bleach the organic bamboo cloth. Bamboo fibers produce silky, plush, antimicrobial, and opulent textiles with excellent absorption capabilities. Sirohi (2016). Both asexual and sexual reproduction are used by bamboo to spread. From a seed, it can produce new individuals, but these seedlings grow very slowly. Furthermore, moso bamboo seldom flowers or bear fruit. After flowering, bamboo grows less and eventually dies all at once, which has a major negative impact on bamboo forest management and costs bamboo farmers a lot of money. From seed germination to flowering and fruiting, it may take decades or even more than a century. Throughout its life cycle, bamboo experiences growth-related developmental events, and compared to other plants, it displays a wider variety of developmental patterns. Mcclure, (1966).

Bamboo cloth is highly valued due to its inherent bacterial resistance, breathability, and softness. However, depending on the processing technique, the environmental impact of producing bamboo might vary significantly. The environmentally favourable advantages of traditional technologies are negated by their use of harsh chemicals.

Sustainable Bamboo Practices:

- Mechanical Pulping: Uses a chemical free procedure to break down bamboo fibers.
- Closed-Loop Production: Recycles water and uses less chemicals in the processing step.

Advantages:

- Exceptionally soft and breathable: excellent for delicate skin in particular.

- Naturally antibacterial: Provides resistance against odors.
- Renewable Resource: Bamboo grows rapidly, making it a sustainable source. making it perfect for textiles and apparel that are meant to last. V. S., and Singh. (2024).

BAMBOO PLANT/BAMBOO FIBER

FIG.1

2.2.2 COTTON

In India, cotton is the main crop farmed for fiber and is used extensively in both the agricultural and industrial sectors. Cotton accounts for 38% of the nation's exports, which bring in about 42,000crore, and 70% of the total fiber consumed in the textile industry. Cotton production and area in 2018–19 were 362 lakh bales (170 kg each bale) and 12 million hectares, respectively. Cotton is one of the organic harvesting crops in an ecosystem of farming that is diverse and sustainable thanks to the methodical, knowledge-intensive process of organic cotton cultivation. Restoring soil fertility, lowering production costs, and improving prices for certified organic cotton growers are the primary goals of organic cotton farming. Mageshwaran, v., et al, (2019)

In addition to its home or commercial purposes, cotton is a versatile crop whose whole or individual portions can be used for their by-products. It supplies cottonseed oil for cooking, edible oil, and protein-rich oil cake leftovers for cattle, as well as lint as a raw material for the ever-growing textile sector. Sticks, fibers, seeds, and oil are the main products of cotton that humans can use to their advantage; these components are also used to make a number of secondary items. Cotton fiber is special because it can be used to create a wide range of goods that improve and sustain people's quality of life while also adding aesthetic appeal. More pesticides are used on cotton than on any other crop. Ten percent of pesticides and twenty-five percent of insecticides used globally are used in cotton farming. Ahmad & Mirza Hasanuzzaman (2020)

Cotton can be woven or knitted into textiles. The plain and twill weaves are the two most popular styles for cotton. Cotton is a popular fabric because it is comfy all year round and requires little maintenance. Cotton is currently a popular textile fabric for garments and household textiles. The primary source of intriguing and practical qualities needed in completed textile items is the chemistry of cotton fiber. Lewin (2007)

Cotton is simple to clean; it may be dry washed or laundered. Although it is susceptible to shrinking, it can tolerate high water temperatures. Prewashing is essential before sewing because most cotton fabrics shrink during the first wash, even if they have already been washed. Cotton one of the most important crops in the world, cotton is produced cheaply and in large quantities, which makes cotton items reasonably priced. Cotton textiles have a high degree of durability and abrasion resistance. Cotton can be pressed at relatively high temperatures, is often washable, and accepts a wide variety of dyes. Its rapid absorption and release of moisture makes it comfortable to wear. The cloth can be napped to give it a downy surface when warmth is desired. Weigmann, and H., H. (2025).

Organic cotton, which is grown without the use of dangerous fertilizers and pesticides, protects farmers, fosters biodiversity, and preserves soil health. Additionally, it needs a lot less water than traditional cotton, which makes it perfect for areas that are prone to drought.

Advantages:

- Hypoallergenic: Ideal for people with eczema or allergies, it is mild on delicate skin.
- Biodegradable: Reduces the amount of textile waste that ends up in landfills by breaking down easily.
- Comfortable & Durable: Provides a breathable feel and extended usage for daily attire.
- Certifications: To guarantee organic cotton production methods, look for GOTS (Global Organic Textile Standard) certification. Venkatesan and Periyasamy (2019)]

COTTON FIBRER

FIG.2

2.2.3 BAMBOO COTTON BLEND

Bamboo is a cellulosic fiber that is entirely natural. It is one of the fastest-growing plants that needs little water to develop and doesn't require pesticides, fertilizers, or herbicides. The fiber solves numerous environmental problems and is fully biodegradable. "Bamboo Kun," a special antibacterial and bioagent found in bamboo fiber, Jothilinkam et, al. (2018). When bamboo fiber is manufactured, it is mixed with bamboo cellulose, which gives it bacteriostatic and deodorant qualities and makes it naturally antibacterial. Bamboo is a great eco-friendly fabric because of its numerous positive qualities, including permeability, hygroscopicity, and soft feel. Bamboo fiber's qualities are enhanced when combined with cotton or any other fiber, and this combination can be used for a number of things. One of the oldest methods of producing textiles in India is handloom weaving. India's cultural legacy is preserved by the handloom weaving tradition, which also gives many people jobs. However, because of globalization and technical advancements, this industry is currently dealing with a number of difficulties. Maulik and Agarwal (2013).

In the spinning industry, blending several fibers is a relatively popular technique. One common technique for improving a fabric's functionality and appearance is to blend several kinds of fibers. Blends of bamboo and cotton are typically 50/50.The mechanical characteristics of bamboo fibers are found to be just as strong as glass fibers. Compared to bamboo materials, cotton fabrics were more durable, thicker under heavy loads, absorbed water more quickly, and dried better. Chidambaram and Govindan (2012)

2.3. NATURAL DYES

Natural and synthetic dyes are the two main types used in the clothing industry. Natural dyes can be obtained from mollusks, lichens, mushrooms, and other natural sources such plants, flowers, vegetables, insects, and minerals. Natural dye has been around for over 4,000 years, and a lot of knowledge has been passed down through the generations. Ancient societies created patterns on textiles in sustainable ways and experimented with natural dyeing techniques. In many regions of the world, natural dyeing is regarded a ceremonial tradition that is still practiced in handicraft businesses. Natural colors have several benefits to the wearer as well as the environment. They are recyclable, biodegradable, and decomposable because they come from nature. Natural colors are also safe for people of all ages because they don't include any dangerous ingredients and aren't allergic or toxic. Natural dyes were used to color fabrics until the development of synthetic dyes in 1856. The textile business has been dominated by the use of synthetic colors ever since. "Natural dyes currently make up only around 1% of the total amount of dyes used worldwide after synthetic dyes became so popular." Due to a lack of documentation and accurate understanding of the extraction and dyeing processes, the usage of natural dyes has decreased throughout the years. Natural dyes, on the other hand, can create unique aesthetic features that benefit the earth and its inhabitants. Ratnayaka (2022).

Dyeing has existed for as long as human culture. Remains of dyed textiles discovered during archaeological digs at various locations across the globe offer proof that dyeing was a common practice in prehistoric societies. Until the nineteenth century, natural dyes were only employed to color fabrics. Natural dyes are made from natural resources, as the name implies. Different textile fabrics were colored using coloring ingredients derived from natural resources of plant, animal, mineral, and microbiological origins. Using the local natural resources, many parts of the world have their own customs for natural dyeing. Before the first synthetic dye was discovered in 1856, the only dyes that humans could use to color fabrics were those made from natural materials including plant leaves, roots, bark, insect secretions, and minerals.

Only in a few remote areas did the custom of utilizing natural colors endure. Interest in natural dyes has increased recently, mostly among those who care about the environment. Due to their renewable nature, biodegradability, skin-friendliness, and potential health advantages for the wearer, natural dyes are regarded as environmentally benign.Nearly every kind of natural fabric may be dyed using natural dyes. They can also be used to dye certain synthetic textiles, according to recent studies. In addition to being utilized in textiles, natural dyes are also employed in the coloring of food, medications, toys, handicrafts, and leather. Many plants that produce dye are also used to be medicines in a variety of traditional medical systems. Saxena and Raja (2014)

2.3.1 COCONUT HUSK

Coconut husk refers to the fiber that is extracted from the outer layer of the fruit of the coconut tree (Cocos nucifera) Yogaratnam,(2011). The fibrous husk can be utilized as a source of natural textile dyes, according to earlier studies on colorfastness, color extraction processes, and color optimization strategies. After boiling, the first extraction yields a brown hue. Ratnayaka (2022).

Coconut husk, sometimes referred to as coir or coconut fiber, has emerged as a substitute for non-renewable or synthetic materials. This is because these natural fibers are more readily available and therefore less expensive than synthetic fibers. Because they are a non-polluting, repurposed waste, they are regarded as an environmentally benign renewable resource. This kind of fiber becomes stronger and less flexible as it ages because it accumulates a lot of lignite. Additionally, because these fibers are comparatively impermeable, salt water is less likely to harm them. Slebi-Acevedo., et al, (2019)

The complete fibrous covering of the fruit, which includes the outer mesocarp (fibrous portion) and interior endocarp (liquid and solid food portion), is represented by the coconut husk. Cementing the fibrous elements scattered throughout the mass is the mesocarp, a collection of fibers and elastic cellular cork-like parenchymatous cells. The leathery exocarp (thin outer slippery layer) and the spongy fibrous mesocarp separate when this material is retted in water. The fibrous strands are rough and stiff because they are made of a highly lignified form of cellulose. Known as coconut pith, these non-fibrous parenchymatous husk cells make up between 50% and 70% of the husk's total weight. The quantity and quality of the fiber in coconuts vary, and there are roughly 300 eco-types. The length and thickness of the fibers vary, even within the same type. Because the husk is not gathered according to quality (eco-type), a mixture of coconut fiber from various eco-types produces lower-quality fiber with significant length and diameter variance.The husk's age has a significant role in choosing high-quality fiber. The best fibers are said to be found in the husks of near-ripe to ripe nuts. Meenatchisundarm (1979).

COCONUT HUSK

FIG.3

The fibrous husk of the coconut is used to make coconut fiber, sometimes referred to as coir. This is the coconut's thick, fibrous central layer. The coconut shells are sliced in half and then retted in order to separate the fibers. To enable microbial breakdown of the softer tissues, the coconut shells are buried in moist soil during the retting process. The coir fibers are then easily separated by beating and washing the shells. By the way, coconut shell activated carbon, which is highly valued in adsorbent filter media, comes from the hard inner layer known as the stone.Because of its high lignin content, coir fiber is robust, tough, and extremely long-lasting. Hutten (2015)

COCONUT HUSK

FIG.4

2.4 NATURAL DYEING

The goal of dyeing is to give a substrate a consistent color, usually in accordance with a color that has already been chosen. There shouldn't be any unevenness or shade changes across the substrate; the color should be consistent and solid throughout. The final shade's appearance will be influenced by a number of factors, such as the substrate's texture, construction (both chemical and physical), pre-treatments done before dyeing, and post-treatments applied after the dyeing process. There are other ways to apply color, but the three most popular ones are printing, continuous (padding), and exhaust dyeing (batch) clark (2011).

The ancient art of dying precedes written history. Europe's Bronze Age is when its practice first appeared. Sticking plants to fabric or pressing crushed pigments onto fabric were examples of early dyeing methods. With time and the development of some light and water fastness (resistance) tests, the process got increasingly complex, employing natural colors made from crushed fruits, berries, and other plant materials that were cooked into the fabric. Jothi (2008).

Some of the ancient dyes include Madder, a red dye derived from the roots of the Rubia tinctorum, blue indigo from the leaves of Indigofera tinctoria, yellow from the stigmas of the saffron plant, and dogwood, a pulp extract from the dogwood tree, are a few of the well-known ancient dyes.

In the modern world, dyeing is a sophisticated, specialized science, and almost all dyes are now made from synthetic compounds, which has greatly decreased costs and improved certain application and wear characteristics. However, many people who practice the art of natural dying, or using dyes derived from naturally occurring sources, maintain that natural dyes are far superior in terms of aesthetic quality and are more aesthetically pleasing. In the West, natural dyeing is now only done as a handcraft, with synthetic dyes being used in all commercial applications. Some craft spinners, weavers, and knitters use natural dyes as a distinctive aspect of their work. Foulds and John (1989).

2.4.1 Conventional and non - conventional dyeing

The term "conventional dyeing" describes the conventional techniques of dying textiles with chemicals and synthetic dyes. Pre-treating textiles with chemicals, applying synthetic dyes using heat, water, and chemicals, fixing the dye with chemicals, and then washing the materials to get rid of extra dye and chemicals are all steps in the process. Conventional dyes are economical and may produce vivid, long-lasting hues, but they also pose serious health and environmental risks. In addition to contaminating soil and releasing harmful chemicals into waterways, the dyeing process can cause cancer and skin discomfort. In order to lessen the negative effects of conventional dyeing on the environment and human health, many are turning to alternatives like natural dyeing, eco-friendly dyeing, and sustainable fabrics.

The art of extile coloring is ancient. It involves physically and chemically altering textile substrates such that color is perceived through reflected light. Salem (2010) At its most basic, dyeing involves applying the colorant uniformly, fixing it, and using the right auxiliary chemicals. Khatri and White (2015). The type of materials, the dye class, the equipment, and the shape of the textile substrate all affect the dyeing methods. Fibers, yarns, textiles, nonwoven materials, or finished clothing can all be dyed using the textile dyeing process. Although fabric dyeing is the most common method, fiber dyeing is typically used to achieve cambric and mélange effects. Contrarily, garment dyeing is used when product replacement needs to happen quickly, whereas yarn dyeing is done to create stripes and checks. Sinclair, R. (Ed.) (2014).

Non-conventional dyeing reffers to alternative techniques to traditional synthetic coloring methods for textiles. These techniques include eco-friendly dyeing, which makes use of environmentally friendly chemicals and procedures, and natural dyeing, which makes use of plants, minerals, and other natural materials to generate dyes. Additionally growing in popularity are microbial dyeing, which makes use of microorganisms such as bacteria or fungi to manufacture dyes, and enzyme-assisted dyeing, which breaks down natural materials and produces pigments using enzymes. Shahid et al., (2019).

Additionally, textiles can be dyed via solar dyeing, which uses sunshine. Kumar et al., (2018). Among the many advantages of these unconventional techniques are enhanced fabric quality, distinctive colors and textures, and environmental sustainability. Standardization, color consistency, and scalability are some of the difficulties they also bring. Chen et al., (2019)

2.5 MORDANT

The Latin word "mordere," which means "to bite," is where the word "mordant" originates. Mordants are metallic salts that have a preference for fiber and dyes and enhance color fastness. With the aid of mordants, some fugitive dyes have even been utilized with success. Vankar (2007).

A chemical that can both bind itself to the fiber and create a chemical link with natural colorants is called a mordant. It enhances the fastness qualities of the colored materials by preventing color fading and bleeding and aiding in the absorption and fixation of natural dyes. This complex can be created by applying the mordant first, followed by dyeing (pre-mordanting method), applying the dye and mordant simultaneously (meta-mordanting process), or applying the mordant after the dyed material has been treated (post-mordanting process). There are three different kinds of mordants: oil mordants, tannic acid (tannins), and metal salts, sometimes known as metallic mordants.

Due to their substantial limitations for the fiber, natural dyes necessitate the use of a mordant, which develops a complex with the dye to improve the natural colorant's fixation on the fiber. Alum, potassium dichromate, ferrous sulfate, copper sulphate, zinc sulphate, tannin, and tannic acid are a few of the crucial mordants that are employed. The majority of these metals are toxic by nature, and their presence is only determined to be safe for the user in small amounts, even though they help generate a wide range of colors after complexing with the natural coloring compounds. Prabhu and Bhute (2012).

The dye itself is less significant than a mordant. Furthermore, the optimal mordant for large-scale application should offer a respectable color yield under realistic dyeing conditions at a reasonable cost without significantly altering the fiber's physical characteristics or the dyes' fastness. Additionally, the dyed textile material shouldn't have any carcinogenic effects when used, nor should it have any harmful effects during processing. Three broad categories can be used to classify mordants:

Metallic mordants: They are generally metal salts of aluminum, chromium, iron, copper and tin. The metallic mordants are of two types.

Brightening mordants: a) Potash alum, b) Chrome (potassium dichromate), c) Tin (stannous chloride)

Dulling mordants: a) Copper (cupric sulphate), b) Iron (ferrous sulphate)

2.5.1 TYPES OF MORDANTING

2.5.1.1 OIL – MORDANT

The primary usage of oil mordants is in the madder dyeing of Turkey Red. The primary purpose of oil mordants is to combine with the primary mordant, alum, to form a complex. Alum is easily removed from the treated fabric because it dissolves in water and has no affinity for cotton. Fatty acids, including palmetic, stearic, oleic, and others, as well as their glycerides, are present in naturally occurring oil. K. H. and Bhute (2012)

2.5.1.2 TANNIN

Tannins serve as a mordant in the production of ink, dyeing, sizing paper and silk, and printing textiles. In textile dyeing, tannins are important for a number of reasons. First of all, they create essential mordants for the coloring of vegetable fibers such as linen and cotton. Second, their own pigment reinforces the color of the dye bath, which is why they are frequently linked to plants that have yellow, orange, red, and violet colorants. Tannin-dyed materials are good at holding up to light and washing. K. H. and Bhute (2012)

2.5.1.3 METALIC MORDANT

Metal salt of Aluminum, chromium, iron, copper, and tin metal salts are employed. Among the often-utilized mordants are potassium dichromate, alum, copper sulfate, ferrous sulfate, and stannous chloride. The two types of metallic mordants—Brightening Mordants and Dulling Mordants—are further separated based on the final color that is created using the natural dyes. Tin (stannous chloride), potassium dichromate, and alum are examples of brightening mordants, whereas copper sulfate and ferrous sulfates are examples of dulling mordants. K. H. and Bhute (2012)

2.5.1.4 ALUMINIUM MORDANT

The majority of rocks and soils that contain silicon, including bauxite, feldspar, and clay, contain aluminum, the most prevalent metal on Earth. Throughout history, a variety of aluminum compounds, including APS, AA, aluminum sulfate, and aluminum hydroxide, have been employed as mordants in textile dyeing. Both cellulose and protein fibers are strongly attracted to aluminum ions, which can easily act as a bridge between several dye molecules or the fiber and dye.

Haar, S et al (2013)

2.6 ECO PRINTING

Fashion industry uses a lot of chemicals and synthetic dyes that have an impact on society and the environment. The textile industry uses synthetic dyes a lot because they are inexpensive, produce bright colors, but are harmful to human health. To lessen the environmental impact, outdated eco-practices are now being reevaluated.We all know that natural elements like flowers are non-toxic, biodegradable, and environmentally beneficial, which is why they are so well-liked by those who value their health and the environment. The secret to building a sustainable fashion sector over the long run is cutting waste and needless environmental harm, such as eco-printing and eco-dying.Therefore, the environment should be protected by using natural elements.

Eco-printing is an art form that uses natural colorants found in plants, flowers, insects, fruits, vegetable byproducts, etc. to create visual effects. These materials' natural coloring was applied to paper or fabric by pounding, heating, and boiling. It enables designers and artists to freely express their ideas; unexpected patterns, colors, and visual effects are all imaginable. Flowers could be considered natural dyes and appropriate for eco printing since they are derived from nature and contain naturally occurring, biodegradable coloring ingredients. Batham and Mandhary (2023)

2.6.1 HISTORY OF ECO-PRINTING

The process of printing onto paper or fabric by employing natural items, such as plants or insects, is known as botanical printing. Over the years, the origin of this approach has been forgotten. Its history as a more formal practice dates back to the Middle Ages, but it is quite likely that it has been employed as an artisan skill for thousands of years. Plant classification, herbalism, and reproduction catalogues emerged in the past as a result of improved organization and a growing interest in science. Domestika (2001). Before the mid-1800s, natural dyes were the only source of colour on fabric. Most typically, a "tea" was brewed with the plant materials and then strained into a huge pot made with copper or iron. The material reacted with the tea, and left colour in the fibres. Dyers would stir constantly to keep the dye even. Not all plants make good dyes, but over the centuries the process of natural dyeing has been refined and shared so that dyers know which the good plants are. Eco-Print effects may be familiar to reads from several sources.

2.6.2 INVENTOR OF ECO-PRINTING

Flint, India (1958), Textile artist, dye developer. India Flint was born in Melbourne, Australia, Her fascination for textiles was greatly encouraged by her mother, who always seemed to have a piece of embroidery or knitting in progress and took her through seemingly endless museums during the family's wanderings around the world! Deepshikha sahu (2022)

2.6.3 IMPORTANCE OF ECO-PRINTING

1. Make sustainable and ethical apparel.
2. Use the shade and color intensity of flowers, plants, insects, etc. to create one-of-a-kind artworks.
3. Encourage safe and healthy working conditions for both the environment and employees.
4. Old clothing can be given new life
5. Garbage can be recovered
6. Possibility of chemical contamination (in soil, water, etc.) is eliminated. Batham and Mandhary (2023)

2.6.4 ECO PRINTING MATERIALS

2.6.4.1 MADAGASCAR PERIWINKLE

The Madagascar periwinkle, Catharanthus roseus, is one of the few pharmaceutical plants with a lengthy history of therapeutic use. It plays a significant part in herbal and traditional medicine for a variety of illnesses. Reviews of Madagascar periwinkle that have already been published often focus on the herb's chemical and medicinal components.This systematic review shed light on the Madagascar periwinkle's agrotechnological, biological, ecological, and pharmacological properties—particularly its anticancer compounds—as well as potential mechanisms of action. The many therapeutic and medical uses of Catharanthus roseus have demonstrated that this enchanted herb may be fully utilized and that it may be the focus of future research. Das and Sharangi (2017).

MADAGASCAR PERIWINKLE
FIG.5

2.6.4.2 COSMOS

Cosmos is a genus within the family Asteraceae. They are late-flowering annuals or tuberous perennials. Amamiya, K., & Iwashina, T. (2016). A traditional herbal cure for a number of illnesses, including splenomegaly, jaundice, and intermittent fever, uses Cosmos bipinnatus. It has different color categories (white, pink, orange, and violet). Jang, I. C et , al (2008). The Asteraceae family's Cosmos sulphureus is also referred to as sulfur cosmos and yellow cosmos. Butein, a substance found in this plant, has been shown to have anti-inflammatory and antioxidant properties. Additionally, it has dimethoxychalcone, flavonoids, and quercetin, which have antiviral and fibromyalgia-relieving qualities. It also helps with skin problems and weary muscles. Phuse and Khan (2018).

COSMOS

FIG.6

2.6.4.3 INDIGOFERA TINCTORIA

There has been a lot of recent research on the use of plants as natural dyes in the textile industry. Indonesia's wealth of natural resources provide a significant chance to innovate natural dyes. Among them is the indigo plant (Indigofera sp.), which has been used as a natural dye since ancient times and is among the oldest in the world. For ages, the plant has been grown and prized as a primary source of indigo dye. One of the main sources of natural dye among indigo plants is tinctoria. Indigo is the term for this plant's natural dye. The indican compounds found in Indigofera leaves are what give them their indigo blue hue. Purnama, H., et al (2017)

INDIGOFERA TINCTORIA
FIG.7

2.6.4.4 COMMON WORMWOOD

Wormwood is important to the food and medical industries.Essential oils and extracts from A rtemisia absinthium were evaluated for a range of biological activity and potential medical us es.The main differences in composition across oils from various regions were shown.The oils show potential antifungal and antibacterial activity on a broad spectrum of agricultural and foodborne pathogen development, as well as antifeedant and toxi c effects on numerous pests.

Wormwood oils also work wonders against worms and parasites, which can cause major illnesses and disorders in domestic animals. Additionally covered are the oils of A. absinthium's antioxidant and radical-scavenging properties. Wormwood's distinct smell, bitter flavor, preservation qualities, and digestive qualities make it a useful herb in cooking. Judžentienė, A. (2016).

COMMON WORMWOOD

FIG.8

2.7 ECO PRINTING TECHNIQUES

2.7.1 STEAMING TECHNIQUE

After placing the flowers in the desired pattern on the fabric, fold it and cover it with plastic.

Tie a thread or rope tightly around the outside of the cloth roll to secure it in place and prevent it from coming free.

To transfer the natural pattern of the flowers to the fabric and ensure that the pigment in the flowers is perfectly removed and fixed on the fabric, place a roll of cloth inside the steamer and steam it for two hours at a maximum temperature of 180°F/80°C.

Following two hours of steaming, take the cloth roll out of the steamer and allow the sample to cool for a little while.

Untie the fabric at last. Batham and Mandhary (2023).

2.7.2 HAMMERING TECHNIQUE

Using a second piece of fabric, fold the fabric over after placing the flowers on it**.**

Start taping the cloth with the hammer, making sure to hit all of the flowers.

By removing the flowers from the fabric and exposing the print, you can assess the progress. Batham and Mandhary (2023).

2.8 SUSTAINABLE UTILITY PRODUCT

Sustainable products are those that are produced, obtained, or processed in a way that benefits the environment, society, and economy while preserving the environment and public health at every stage of their life cycle, from the extraction of raw materials to the ultimate disposal. Wikipedia Contributors. (2019).

A sustainable utility product is one that minimizes its environmental impact over the course of its whole lifecycle while still offering a functional advantage. Bhamra and Lofthouse (2005).

sustainable textiles. Materials used, procedures carried out, the standard of living of workers, and the product's lifespan are all analyzed and quantified. Sustainable textiles are produced using renewable or recycled resources and materials. When it comes to items like sustainable utility products, every input and output counts. The longevity of the product, the materials used, the processes performed, and the workers' level of living are all examined and measured. Recycled or renewable resources and materials are used to create sustainable products. Aishwariya and Greeshma. (2019).

These items are long-lasting and durable, energy-efficient, reduce environmental impact, provide a functional requirement, and are made to be recyclable, reusable, or biodegradable. Reusable water bottles, solar-powered gadgets, eco-friendly cleaning supplies, and energy-efficient appliances are a few examples of sustainable utility products. By using these items, people can save money, improve public health, and lessen their environmental impact—all of which will lead to a more sustainable and ecologically conscientious way of living. Clark (2008).

CHAPTER 3

METHODOLOGY

III METHODOLOGY

The methodology for the study titled **"Designing and Developing Utility Products Using Naturally Dyed Bamboo-Cotton Blend Fabric Enhanced with Eco-Printing Techniques"** is discussed under the following heads:

3.1 SELECTION OF FABRIC

Natural fibers are a sustainable and eco-friendly choice, offering breathability, softness, and a unique texture.

Cotton: A naturally occurring polymer made entirely of cellulose. Because of the way this cellulose is structured, cotton has special qualities like strength, durability, and absorbency.

Bamboo: In the grass family, bamboo is a type of perennial evergreen flowering plant.

Blending: The process of combining two or more fiber types to create a single yarn. Handloom bamboo cotton blend fabric was selected for the study. (Plate1) The material was sourced from the local vendors.

BAMBOO COTTON BLENDED FABRIC

PLATE 1

3.2 SELECTION OF DYE

Coconut husk was selected as the natural dye for this project to create a sustainable and eco-friendly color on bamboo cotton blend fabric. The coconut husk was sourced from the from the neighbourhood. (Plate 2). The husks were then sun dried to remove excess moisture

.

COCONUT HUSK

PLATE 2

3.3 EXTRACTION OF THE DYE

The coconut husk was boiled in water at 90 to 100°C for one to two hours in order to extract the dye. (Plate 3 a) This allowed the natural colors to flow out and produce a rich, dark brown liquid. A clear and potent dye extract was obtained by straining and filtering the resultant liquid through cheesecloth to get rid of any last bits of husk. (plate3 b) A deep, dark brown dye was obtained by further condensing this extract through evaporation. (Plate 3 c).

Plate 3a

Plate 3b

Plate 3c

EXTRACTION OF DYE FROM COCONUT HUSK

PLATE 3

3.4 UV SPECTROSCOPY TEST

Optical density refers to the absorbance of a substance. Spectrometer is used for measuring wavelengths of light over a wide range of the electromagnetic spectrum. A simple cost effective and widely used test to find out the presence of phyto-constituents is UV VIS-Spectroscopy. Light in visible ranges or adjacent ranges are used in UV VIS-Spectroscopy.

The UV test procedure involves using water as a control and baseline reference. Initially, a blank scan of water is performed using a spectrometer, scanning the full range of wavelengths from 200 to 800 nanometers. Subsequently, a sample solution is added to the water, and the mixture is scanned again using the spectrometer. The resulting spectrum is analyzed to identify the wavelength at which the sample absorbs light, indicated by the formation of a peak line. This peak line represents the absorption maximum, providing valuable information about the sample's chemical composition and properties. The results of the UV Spectroscopic test are given in Results and Discussion

PLATE 4

FILTERED DYE EXTRACT

3.5 PHYTOCHEMICAL SCREENING TEST

Phytochemical screening is a process used to identify and quantify the various phytochemicals present in plant extracts, fractions, or isolated compounds. Phytochemicals are bioactive compounds produced by plants, including alkaloids, glycosides, phenolics, terpenes, and others.

3.5.1 Test for phenols

Ferric chloride Test (Mace, 1963): indicated the presence of the extract was dissolved in distilled water and few drops of neutral 5% ferric chloride solution was added. Phenolic compounds were indicated with the presence of dark green color.(Plate 5 a)

3.5.2 Test for flavonoids

Shinoda Test (Sofowora, 1993) 4 ml of extract was taken in separate test tubes, a piece of magnesium ribbon and concentrated hydrochloric acid were added drop wise. A color ranging from crimson to magenta indicates the presence of flavonoids(Plate 5b)

3.5.3 Test for terpenoids

Terpenoids (Harborne, 1973) 5 ml of the extract was mixed with 2 ml of chloroform and concentrated sulphuric acid to form a layer. A reddish-brown coloration of the inference showed the presence of terpenoids. (Plate 5c)

Triterpenoids (Harborne, 1984) The extracts were treated with chloroform with few drops of concentrated sulphuric acid and shaken well and allowed to stand by for some time. Formation of yellow coloured lower layer indicated the presence of triterpenoids

3.5.4 Test for tannins

Braymer's test: A portion of extract was mixed with 2 mL of water followed by the addition of a few drops of 10% ferric chloride solution. Formation of bluish black or greenish black colouration was taken as positive for the presence of tannins.(Plate 5d)

Potassium hydroxide test (Odebiyi and Sofowora, 1978; Williamson et al., 1996) The extracts were added to 10 ml of freshly prepared potassium hydroxide in a beaker and shaken to dissolve. A dirty white precipitate indicated the presence of tannins.

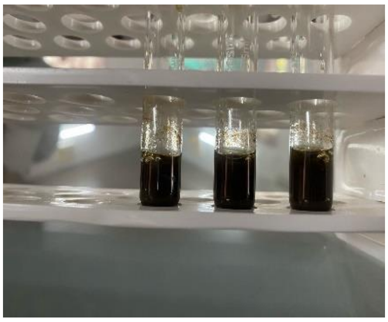
3.5.5 Test for saponins

Frothing/Foam Test (Brain and Turner, 1975) 1 ml of the extract was taken in a test tube and 5 ml of distilled water was added and vigorously shaken. A persistent froth that lasted for at least 5 min indicates the presence of saponins. (Plate 5e)

3.5.6 Test for alkaloids

Dragendorff's Test (Ciulci, 1994): 1 ml of extract was taken in a test tube, 2 to 3 drops of Dragendroff's reagent were added. An orange red precipitate or turbidity with Dragendorff's o indicated the presence of alkaloids. (Plate 5 f)

Mayer's Test (Ciulci, 1994) 1 ml of extract was taken in a test tube, 2 to 3 drops of Meyer's reagent was added. A white precipitate with Mayer's reagent indicated the presence of alkaloids. (Plate 5g)The results of the phytochemical screening of the extracted dye is given in Results and Discussion Table III

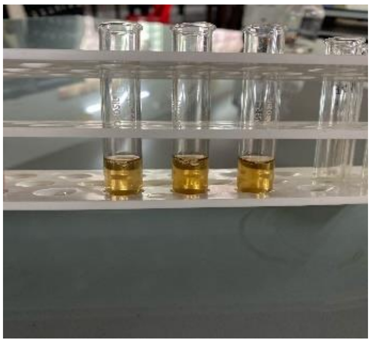


Test for Phenol
Plate 5a

Test for Flavonoid
Plate 5b

Test for Terpenoids
Plate 5c

Test for Tannin
Plate 5d



Test for Saponin
Plate 5e

Test for Alakloids
Plate 5f

Test for Alkaloids
Plate 5 g

PLATE 5

PHYTOCHEMICAL SCREENING TESTS

3.6 SELECTION OF MORDANT

In natural dyeing, the mordant is essential since it helps fix colors and produce the desired tones. Alum (aluminum sulfate) was chosen as the mordant for natural dyeing. (Plate 6). One popular natural mordant that served to strengthen the dye's lightfastness and fix its color was alum. It was selected because it can increase the color yield of the coconut husk dye and guarantee a more uniform and even dispersion of color on the fabric.

ALUMINIUM SULFATE/ALUM

PLATE 6

3.7 APPLICATION OF THE ETRACTED DYE TO THE SELECTED FABRIC

Through a sequence of soaking and dyeing procedures, the extracted coconut husk dye was applied to the chosen bamboo cotton blend fabric.50 gm alum was added to the dye solution. In order to improve color fixation, a small amount of salt was also added to the dye solution before the cloth was submerged in it. For the natural pigments to seep into the fibers, the cloth was left to soak for two hours. (Plate 7) To maintain the color, the cloth was then dried in the shade.

SOAKING THE SELECTED FABRIC

PLATE 7

3.8 SELECTION OF FLOWER FOR ECO PRINTING

3.8.1 Gathering of Materials

Common Wormwood leaves, Indigofera tincolia leaves, Cosmos flowers, and Madagascar periwinkle flowers were gathered from a variety of sources. (Plate 8). The natural dye qualities and texture of the plant components were taken into consideration when choosing them.

3.8.2 Preparing Plant Materials for Treatment

To get rid of any dirt or waste, the gathered plant components were cleaned and washed. After that, the leaves and petals were dried to eliminate any remaining moisture.

ECO-PRINTING MATERIALS

PLATE 8

3.9 APPLICATION OF FLORAL PRINT TO THE DYED FABRIC BY HAMMERING TECHNIQUE

3.9.1 Fabric Preparation

The dyed bamboo cotton blend fabric was cleaned and washed and made ready for eco-printing.

3.9.2 Arranging Plant Materials

On the prepared fabric, the dried flowers and leaves arranged in a manner to get an intended pattern.

3.9.3 Eco-Printing by hammering Method

To keep the plant elements in place, a covering of cellophane tape was placed over them. The natural colors from the plant components were then released by gently hammering the tape, which allowed them to adhere to the fabric. (Plate 9)

3.9.4 Drying

To set the colors and produce a smooth texture, the printed fabric was allowed to naturally dry. The resultant eco-printed cloth demonstrated distinctive, detailed patterns and organic hues, emphasizing the elegance of eco-friendly textile production methods.

ECO-PRINTING BY HAMMERING METHOD
PLATE 9

3.10 DEVELOPING UTILITY PRODUCTS FROM NATURAL DYED FABRIC EMBELLISHED WITH ECO- PRINTING TECHNIQUE

Four utility products were developed from the natural dyed bamboo cotton blend fabrics embellished with eco printing techniques. (Plate10) They are:

ECOPRINTED FABRIC

PLATE 10

1. **Laptop Bag**: A laptop bag with straps and a zipper closing was created by cutting and sewing the eco-printed cloth. (Plate 11)
2. **A Clock**: To create a distinctive and useful timepiece, a circular piece of eco-printed fabric was stretched over a clock mechanism. (Plate 12)
3. **Book Cover**: To make a book cover, eco-printed fabric was wrapped around a book and fastened with coir thread. (Plate 13)
4. **Artist's Folder**: An eco-printed cloth folder with pockets and sections to hold documents and art tools was made. (Plate 14)

The developed products were evaluated for their aesthetic appearance. The results are given in the Chapter Results and Discussion

LAPTOP BAG

PLATE 11

ARTIST'S FOLDER

PLATE 12

CLOCK
PLATE 13

BOOK COVER
PLATE 14

CHAPTER 4

RESULTS AND DISCUSSION

IV RESULTS AND DISCUSSION

The findings and analysis of the research project **"Designing and Developing Utility Products Using Naturally Dyed Bamboo-Cotton Blend Fabric Enhanced with Eco-Printing Techniques"** falls under the following headings:

4.1 Visual Evaluation of the Dyed Fabrics

4.2 Colour Fastness Test of the Dyed Fabrics

4.3 UV Spectroscopy of the Extracted Dye

4.4 Phytochemical Analysis of Extracted Dye

4.5 Visual Evaluation of the Developed Product

4.1 VISUAL EVALUATION OF DYED FABRIC

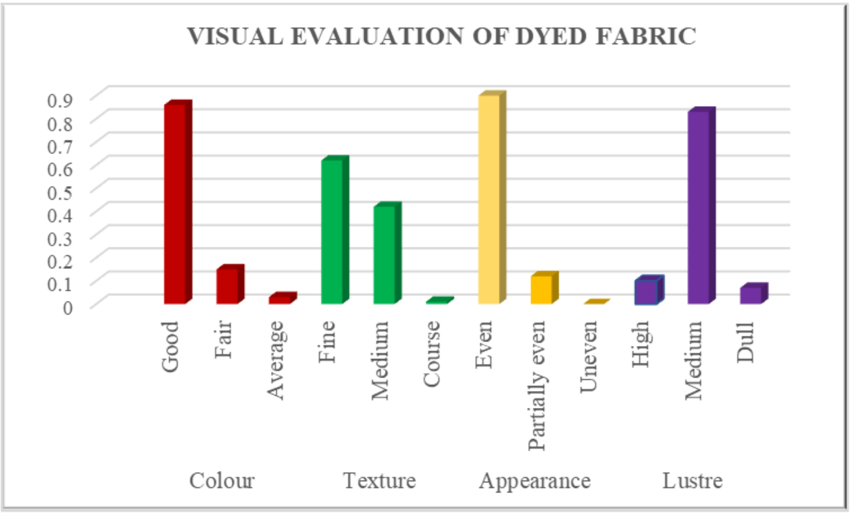
The dyed fabric sample was evaluated visually by 50 people and the results are given in Table I and Graph 1.

TABLE I

VISUAL EVALUATION OF DYED FABRIC

FABRIC	ATTRIBUTE	CATEGORY	PERCENTAGE (%)
Dyed Fabric	Colour	Good	86%
		Fair	15%
		Average	3%
Dyed Fabric	Texture	Fine	62%
		Medium	42%
		Course	1%
Dyed Fabric	Appearance	Even	90%
		Partially even	12%
		Uneven	0%
Dyed Fabric	Lustre	High	10%
		Medium	83%
		Dull	7%

From the table it was observed that 86% valued color as good and only 3% gave an average value. In the case of texture 42% texture as medium and 62% as fine. While in appearance 90% says that it was even and 12% people says that it was partially even in color and in the lusture 83% says the dyed fabric has a medium lusture.



VISUAL EVALUATION OF DYED FABRIC

GRAPH 1

4.2 COLOR FASTNESS TEST OF THE DYED FABRICS

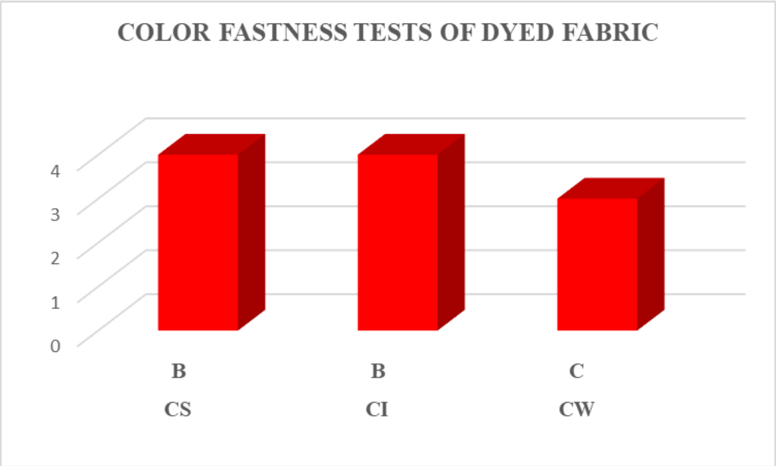
Color fastness test such as color fastness to sunlight (CS), color fastness to hot iron (CHI), color fastness to washing (CW) were done for dyed bamboo-cotton blended fabric. The result of all the color fastness test in dyed fabrics are given in Table II and Graph 2.

TABLE II

COLOR FASTNESS TESTS OF DYED FABRIC

DYED FABRIC	TESTS	GRADE	RATING
	CS	B	4
	CI	B	4
	CW	C	3

According to the table, the coconut husk dye exhibits acceptable color retention when exposed to sunshine and ironing, however the washing test result was only passably good.

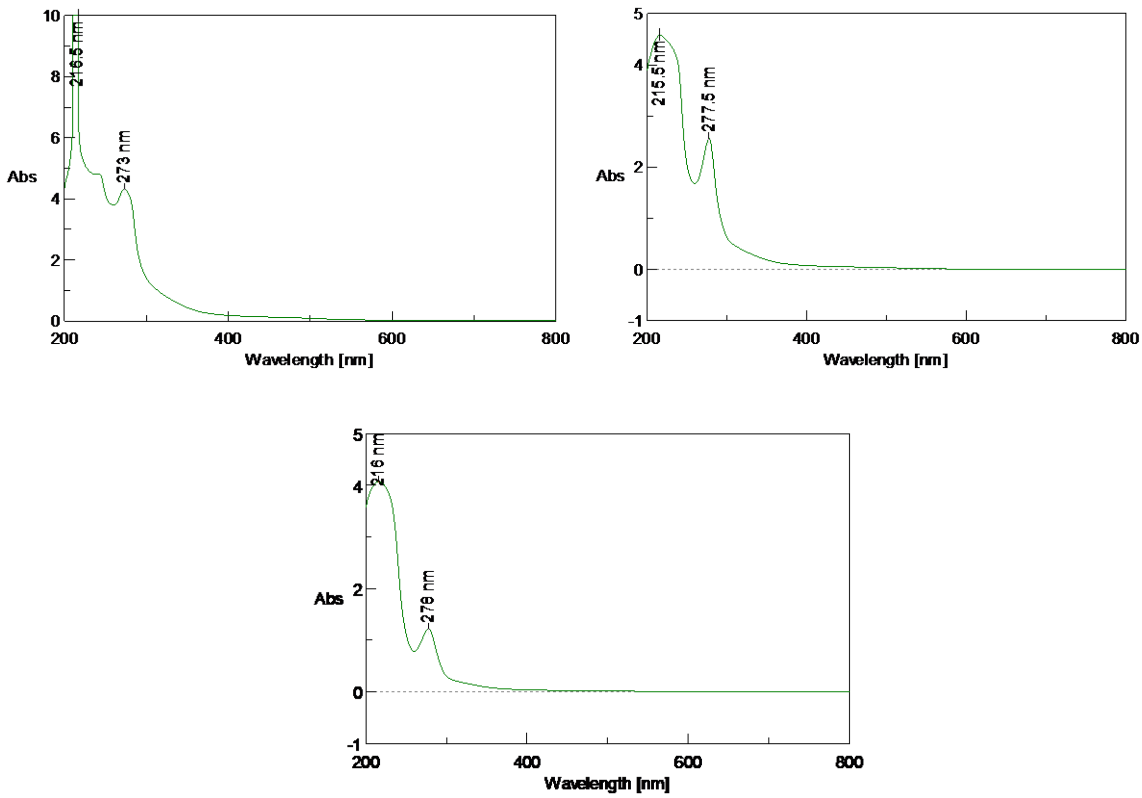


COLORFASTNESS TESTS OF DYED FABRIC

GRAPH 2

4.3 UV SPECTROSCOPY OF THE EXTRACTED DYE

From the UV spectroscopy test of the extracted dye (Graph 3), it was noted that the maximum light absorption is noted in the peak line from 273nm to 278 nm which says that the extracted dye has a good chemical composition and valuable properties for dyeing and printing.



UV SPECTROSCOPY OF THE EXTRACTED DYE

GRAPH 3

4.4 PHYTOCHEMICAL ANALYSIS OF EXTRACTED DYE

The results of the phytochemical analysis of the extracted dye are given in Table III.

TABLE III

PHYTOCHEMICAL ANALYSIS OF EXTRACTED DYE

Phytochemical category	Test Name	Result
Phenols	Ferric chloride	+
Flavonoids	Shinoda	–
Alkaloids	Dragendorff’s	–
	Mayer’s Test	-
Terpenoids	Terpenoids Test	+
Tannins	Braymer’s Test	+
Saponins	Frothing/foam	–

From the table it is noted the extracted dye shows the presence of secondary metabolites like Phenols, Terpenoids and Tannis which is also shows the visible peak wavelength in the UV Spectrometry tests.

4.5 EVALUTION OF THE DEVELOPED PRODUCTS

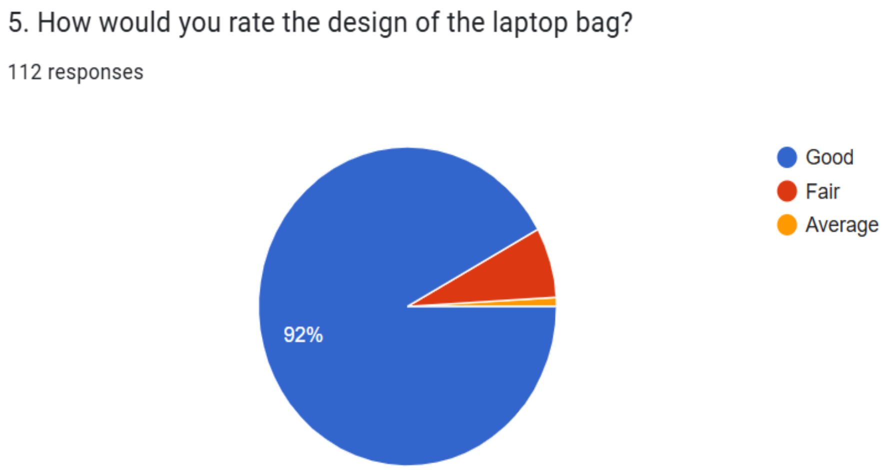
The four products namely Laptop bag, Artist folder, Wall clock and Book cover were evaluated by 100 people. The results are discussed below.

4.5.1 LAPTOP BAG

LAPTOP BAG

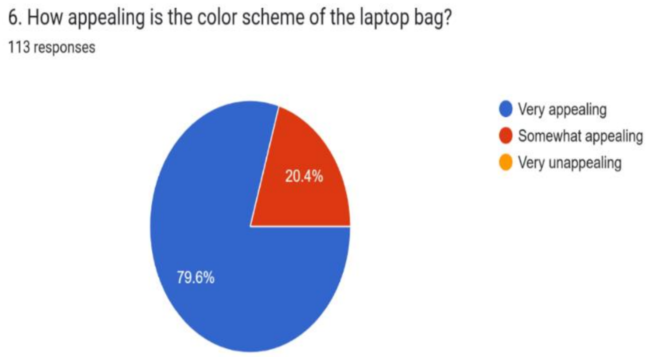
FIG.9

DESIGN



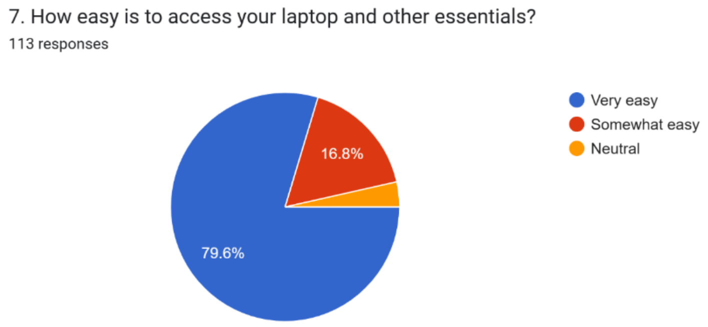
The laptop bag's design was rated by survey participants. 92% percent gave the design a Good rating, meaning that they were very happy with the way the bag looked.

COLOUR



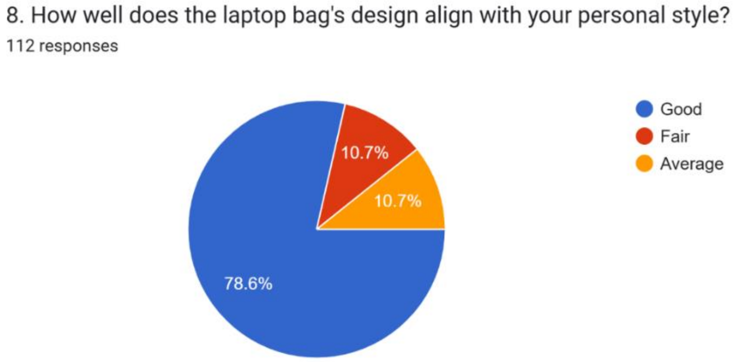
79.6% of respondents thought the color scheme was extremely appealing.

FUNCTIONALITY



79.6% described the laptop was very easily accessible.

STYLE COMPATIBILITY



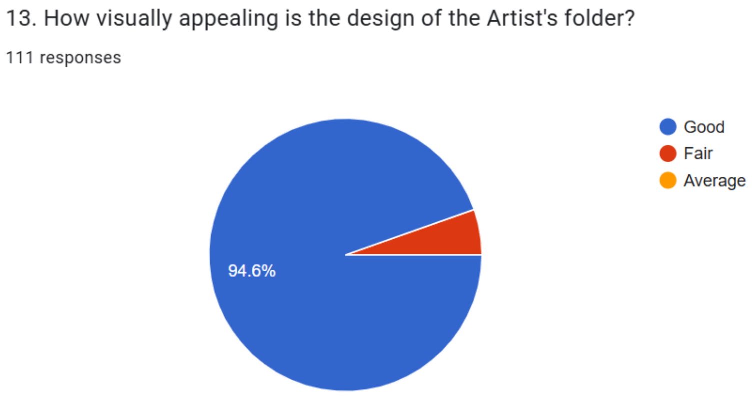
78.6% rated good for the style compatibility for their personal use. The laptop bag's design fits in nicely with the personal style preferences of the majority of customers.

4.5.2 ARTIST FOLDER

ARTIST FOLDER

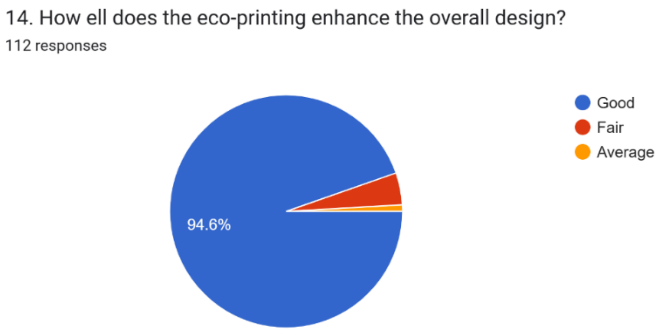
FIG 10

DESIGN ATTRACTIVENESS



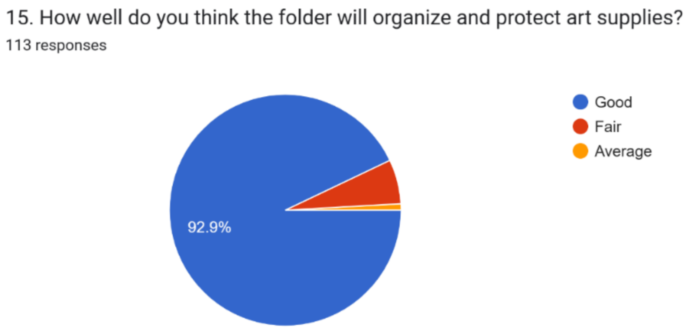
Participants in the poll were asked to rate the Artist's folder's design's aesthetic attractiveness. A resounding 94.6% of the 111 respondents described the design as Good, suggesting very favourable opinions.

ENHANCING ELEMENTS OF THE OVERALL DESIGN



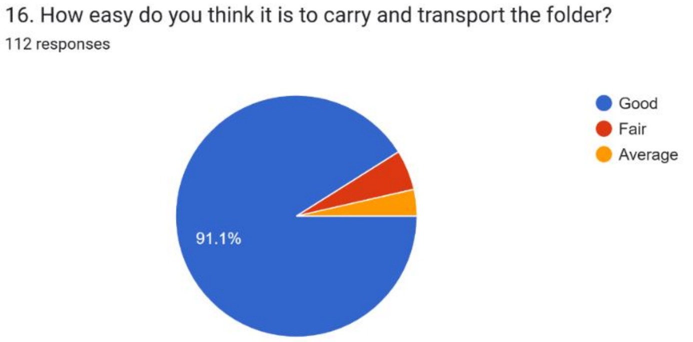
94.6% of the 112 replies ranked the enhancement as Good,a huge majority expressed strong support for it.

ORGANIZATION AND PROTECTION



A significant majority of the 113 respondents, 92.9% assessed the folder's efficacy as Good

CARRYING CONVENIENCE



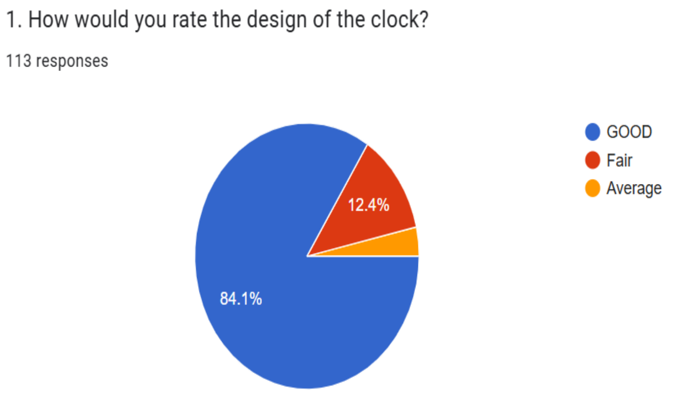
Regarding portability, 91.1% of respondents gave the folder a Good rating.

4.5.3 WALL CLOCK

WALL CLOCK

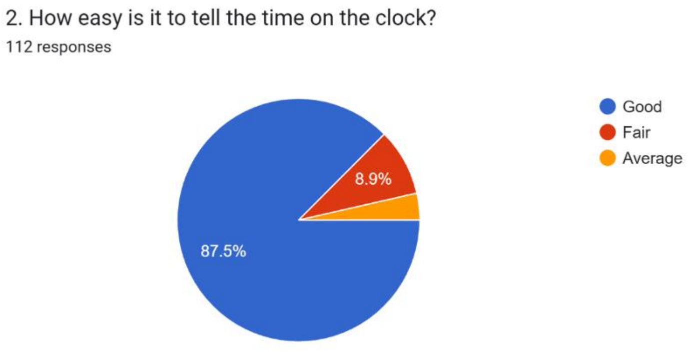
FIG 11

DESIGN



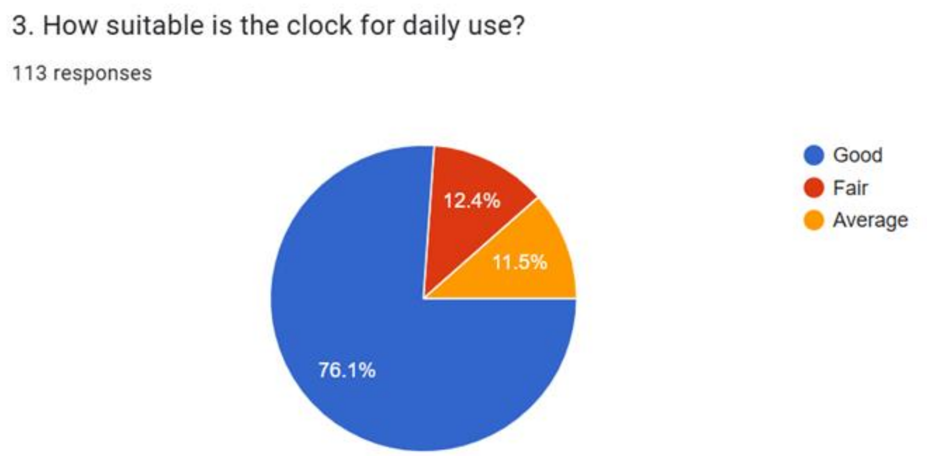
84.1% have opted that the design of the Wall clock is good.

ASSESSING READING SKILL



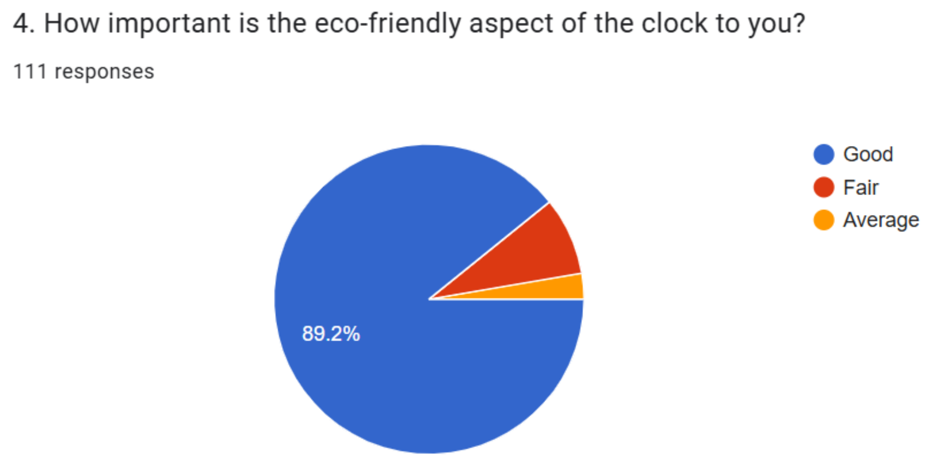
87.5%, rated Good for the reading access of the wall clock .The majority of individuals, according to the feedback, have no trouble telling the time on the clock.

SUITABILITY



76.1% of participants gave the clock a Good rating, demonstrating considerable support for its everyday usability.

ECO FRIENDLINESS IN CLOCK



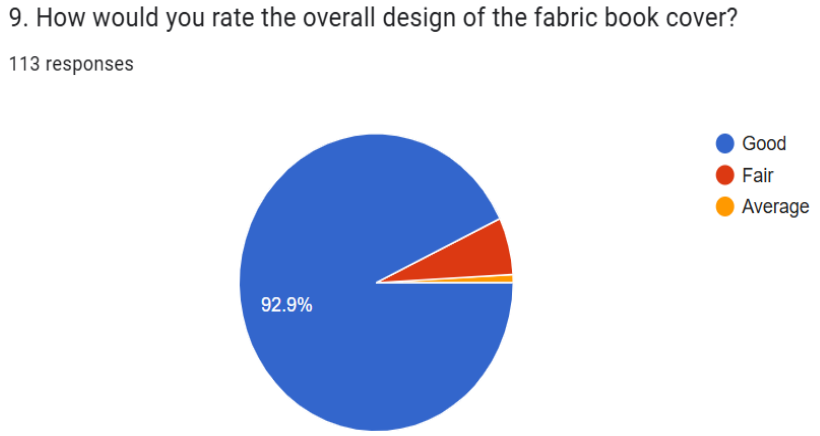
Respondents were asked in the survey how essential they thought the clock's eco-friendliness was. With 89.2% of the 111 respondents rating the eco-friendly characteristic as "Good," a sizable majority of respondents showed a high preference for products that are ecologically sensitive.

4.5.4 BOOK COVER

BOOK COVER

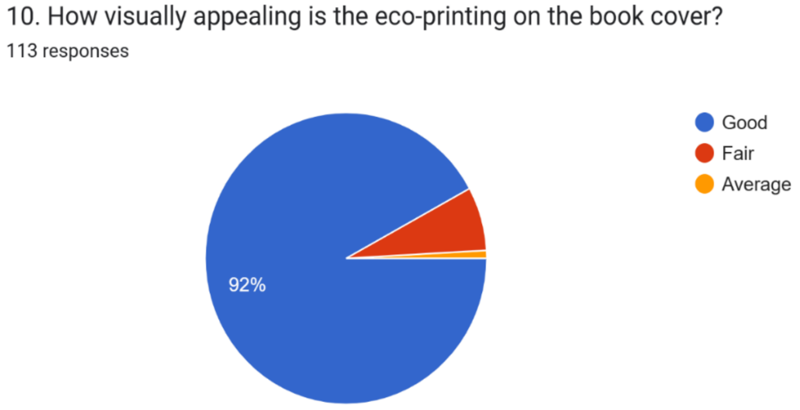
FIG 12

DESIGN



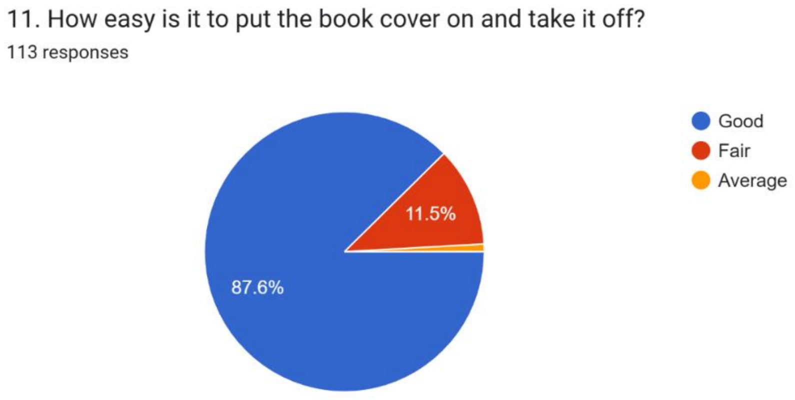
The majority of responders (113 in total) gave the fabric book cover's overall design a good rating.

VISUAL IMPACT OF THE ECO PRINTING



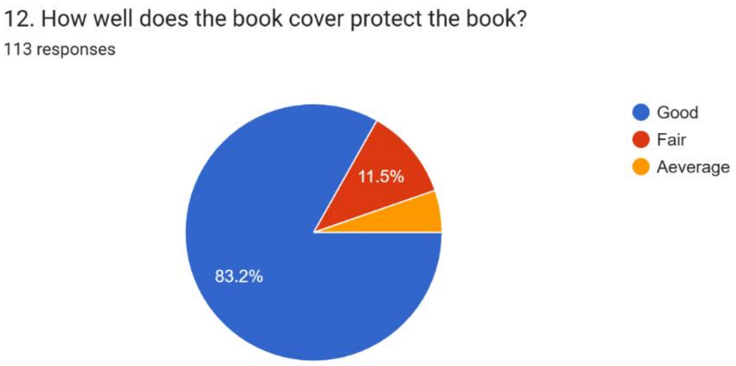
Respondents were questioned in the study how visually appealing they thought the book cover's eco-printing was. 92% gave the visual appeal a good rating.

COVER FLEXIBILITY



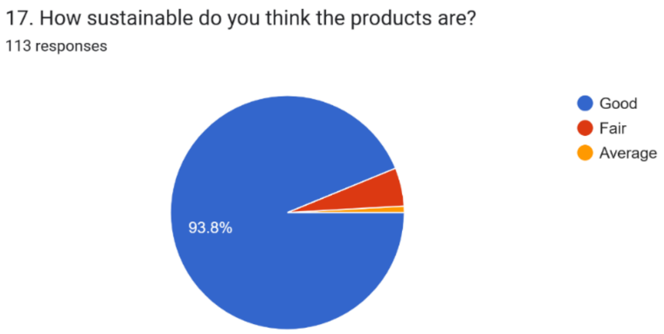
It was easy to put on and take off the book cover, according to the majority of respondents (87.6% out of 113), who rated the experience as Good.

PROTECTION LEVEL OF THE COVER



. The majority of responders (83.2%) gave the book cover's protection a good rating.

ENVIRONMENTAL IMPACT OF THE PRODUCTS

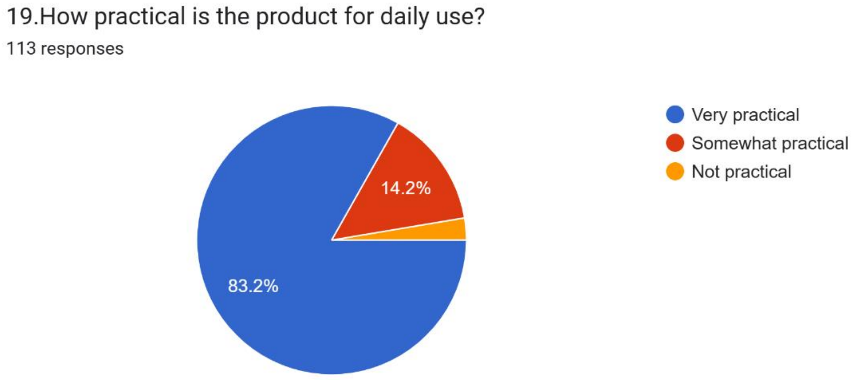


There were 113 responses to the survey, which asked about the items' sustainability. In terms of sustainability, a noteworthy 93.8% of participants gave the products a good rating.

LIKELIHOOD TO BUY THE PRODUCTS

Eighty-three percent of those surveyed said they were "Very likely" to buy the products

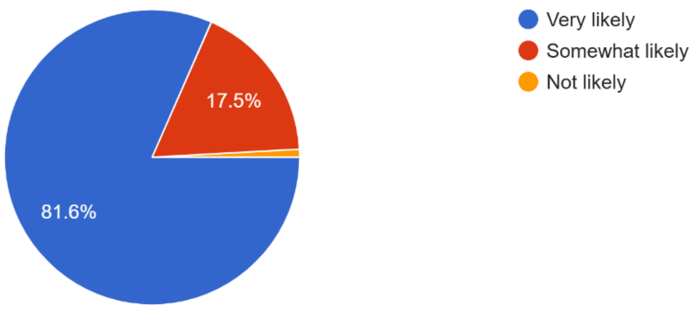
DAILY USABILITY OF THE PRODUCTS



A vast majority of respondents (83.2%) gave the products the rating Very practical,

PRODUCT PREFERENCE

20. How likely are you choose this product over similar products?
114 responses



81.6% of respondents said they were very likely to select these products.

V. SUMMARY AND CONCLUSION

V SUMMARY AND CONCLUSION

Combining natural dyes and eco-printing techniques with fabric derived from bamboo cotton blends is a potential approach to sustainable product creation. By showcasing the versatility and environmental friendliness of certain materials and procedures, this study aids in the development of environmentally responsible utility items.

By informing designers, manufacturers, and consumers on the benefits and potential applications of environmentally friendly materials and methods, the study's conclusions can assist the textile industry in its transition to a more sustainable future.

VI . BIBLIOGRAPHY

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VII APPENDIX