Comparison of 100% Aloe Vera and 100% Bamboo Knitted Fabrics: Exploring their High-Performance Properties.

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Abstract. Natural textile fibers have become increasingly important because of their unique properties and eco-friendly attributes. This study explored the potential of aloe vera yarn in knitwear design. Furthermore, comparing aloe vera knitted fabric with bamboo knitted fabric provides a new perspective in the field of innovative textile research. Bamboo, derived from its stem pulp, is known for its mechanical properties and natural antibacterial qualities. Various studies have aimed to achieve antibacterial effects in fabrics, often focusing on coatings of nanoparticles, nanocomposites, or other textile processing techniques. Aloe vera used as a gel coating on textiles has shown good results. Despite numerous studies on aloe vera gel-coated textiles, research specifically on fabrics made from aloe vera yarn is lacking. The objective of this paper is to construct fabrics made of 100% aloe vera yarn and 100% bamboo yarn, respectively, and compare their high-performance properties by testing bursting strength and anti-bacterial activity. 100% aloe vera and 100% bamboo double jersey fabric of 2/40s yarn count, 4 ply, was knitted using a 7-gauge hand flat knitting machine. The bursting strength test was carried out on the Electro Burst 100 machine as per ISO 13938-2: 2019, whereas the antibacterial activity was evaluated using the disc diffusion method. Results indicated that bamboo fabric was more durable than aloe vera fabric, while aloe vera fabric exhibited antibacterial properties slightly better than bamboo fabric. Furthermore, both fabrics exhibit good bursting strength and antibacterial properties, underscoring their potential for sustainable, high-performance textiles.

Keywords: Aloe Vera Yarn, Bamboo Yarn, High-Performance.

1 Introduction

The textile industry is increasingly seeking sustainable and innovative materials that not only meet consumer demands but also contribute positively to health and well-being. Among these materials, aloe vera and bamboo have garnered attention due to their numerous beneficial properties. Aloe vera is a succulent plant that has applications that extend beyond traditional uses. Aloe vera yarn is made by first harvesting mature aloe vera leaves from plantations or gardens. The thick skin of the leaves is removed, exposing the inner fibers. Next, retting is performed; fibers are soaked in water or a chemical solution to soften the pectin and facilitate their separation from the gel. Fibers are thoroughly rinsed, washed, and cleaned to remove excess gel and impurities. Fibers are then carded by brushing to align them in the same direction, producing a sliver, which is a rope-like strand. The silver is spun into yarn using a spinning wheel or machine. The yarn can then be dyed using natural or synthetic dyes. It is treated with natural oils or waxes to enhance softness and texture.

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Bamboo fiber extraction involves several methods, including retting, mechanical, and chemical processes, each influencing the characteristics and applications of the resulting fibers. Retting, which can be biological or chemical, focuses on removing surrounding tissues while preserving fiber integrity. Types include dew retting, enzymatic retting using pectinase, and water retting with anaerobic bacteria. These methods are eco-friendly, yielding high-quality fibers, but are labor-intensive and time-consuming. Mechanical extraction employs forces, such as through a decorticator, to separate fibers after enzymatic treatments. Although it is environmentally sustainable, mechanical extraction often results in fibers with uneven lengths and higher stiffness, suitable mainly for handicrafts or reinforcement materials. Chemical processes are widely used for producing regenerated bamboo viscose fibers. Chemicals such as sodium hydroxide and carbon disulfide treat bamboo, guiding it through multiple steps such as sulfurization and xanthation, before wet spinning produces fibers that resemble rayon or modal. While efficient, these processes raise environmental concerns due to the toxicity of the chemicals involved. An alternative is the lyocell-like process, which uses non-toxic solvents and operates in a closed-loop system with high chemical recovery. Combining mechanical and chemical methods enhances fiber separation for composite materials, although the fibers are unsuitable for textile applications.

Most studies on aloe vera involve its gel being coated on fabric for its antibacterial nature, but not in the form of yarn. Therefore, this research aims to study the scope of aloe vera yarn in knitting processes, evaluating its performance in comparison to bamboo yarn. Bamboo yarn was chosen to be compared with, as it is also a natural fiber and proved to be anti-bacterial in nature. Furthermore, comparing aloe vera knitted fabric with bamboo knitted fabric provides a new perspective in the field of innovative textile research. The main objectives of this paper are to, 1. Knit a double jersey structure using a) 100% Aloe Vera yarn, b) 100% Bamboo yarn, 2. Compare the bursting strength of the above two constructed fabrics, and, 3. Evaluate the antibacterial property of Bamboo and Aloe Vera knitted fabric.

2 Literature Review

2.1 Aloe Vera

Aloe vera is a succulent plant, with leaves arranged in a rosette pattern on the stem. The leaves are fleshy and triangular, with serrated edges consisting of a thick epidermis covered by cuticle surrounding the mesophyll. Aloe vera is considered one of the most potent and commercially important plants in the research field [1]. These benefits include anticancer, antioxidant, antiallergic, anti-inflammatory, immunomodulatory, antimicrobial, antiulcer, hepatoprotective, and antidiabetic [2]. There are many functional applications of aloe vera on textiles, most popularly being used as aloe vera gel coating on fabric, containing active components that act as an effective bactericidal agent [3].

Application of aloe vera has long been in the form of gel extracts, used for health foods/beverages and moisturizing cosmetics, starting in the United States and parts of Europe, during the 1970s. Modern application of aloe in clinical treatment started in the 1930s [4]. *Aloe vera* in the form of hydrogels, nanoparticles, nanofibers, nanocomposites, and bio-inspired sponges has had a significant effect in the fields of wound healing, drug delivery, and tissue engineering. There is growing interest in consuming and synthesizing materials based on eco-friendly methods, which highly encourages the use of numerous plant-based natural products, like aloe vera [5]. Researchers have also studied Aloe vera fiber in hybrid polymer composites

reinforced with Aloe vera and ramie fibers [6]. Aloe vera fiber mats used in the form of reinforcement and epoxy as matrix materials showed superior mechanical capabilities when compared to other fiber orientation composites [7].

2.2 Bamboo

Unlike aloe vera yarn, bamboo yarn has been studied extensively. Bamboo yarn is made of cellulosic fiber that is regenerated from the bamboo plant. Regenerated fibers are manufactured fibers that use cellulose (mainly from wood or plant fibers) as a raw material unlike extracted fibers which are obtained through retting processes. Bamboo is an excellent fiber, biodegradable and comparable in strength to glass fiber. The fiber is bacteriostatic, antifungal, antibacterial, hygroscopic, hypoallergenic, a natural deodorizer, and UV-resistant [8]. Due to these properties, regenerated bamboo fibers are being used in apparels (undergarments, socks, sports textiles), hygienic products (masks, bandages, surgical gowns and sanitary napkins), home furnishing textiles and UV protective clothing [9]. Bamboo fiber is also used in many forms in engineering products. It is used in the paper industry, construction industry, automobile, and sports goods in the form of composite materials. The natural structure of bamboo and its excellent mechanical properties are the reasons why bamboo fibers have such a variety of uses [10].

The usage of bamboo fiber in the textile industry depends on whether it is of natural origin or a regenerated form. Naturally it can be made by producing natural(bast) fiber through physical and chemical treatment or by spinning regenerated (pulp) fiber through retting [9]. Manufacturing bamboo yarn involves first preparing the fiber. 1) Rough bamboo fiber preparation (mechanical process): cutting, separation, boiling, and fermentation with enzymes; 2) Fine bamboo fiber preparation (chemical process): boiling, fermentation with enzymes, washing and bleaching, acid treatment, oil soaking, and air-drying. A variety of technologies have been developed for its processing, including the mechanical comb fiber technology, the degumming defibrase system technology by explosion, the chemical mechanical processing technology, and the processing technology by cracking [11]. The fiber is then carded, spun, twisted, and finished to form bamboo yarn.

The durability of bamboo fiber depends on factors like tensile strength, tensile load, elasticity, and molding capability. Compared to flax and jute, fabrics made from mechanically extracted bamboo fibers exhibit better resistance to pilling and abrasion in both dry and wet conditions [12]. Natural bamboo fibers demonstrate reduced shrinkage, enhanced dye absorption, improved color clarity, greater wrinkle resistance, and increased luster without requiring mercerization, surpassing cotton fabrics in these aspects. Studies have compared bamboo viscose fibers with viscose rayon, cotton, and modal fibers, finding similar dry tenacity, elongation at break, and moisture absorption properties between bamboo viscose and viscose rayon. However, bamboo viscose showed slightly better wet tenacity than viscose rayon but lower tenacity than cotton and modal fibers in both dry and wet states [13]. Blends with textiles such as cotton, hemp, modal, and lyocell widely use bamboo fibers, resulting in diverse fabric properties. Among these, bamboo viscose fabrics excel in tensile extensibility compared to cotton and cotton/bamboo blends [14] Additionally, blending bamboo fibers improves tensile strength, confirming their potential to enhance fabric performance. Bamboo viscose and rayon fabrics also offer higher hand values and better texture compared to cotton fabrics [15].

The functional properties of bamboo yarn include characteristics such as UV protection, eco-

friendliness, etc. The antibacterial property of bamboo yarn is considered one of the most important functional properties of bamboo yarn. It is this property of bamboo yarn which makes it a distinctive natural yarn option in high-performance textile applications. This is attributed to the presence of a natural bio-agent known as 'bamboo-kun', specifically 2.6-dimethoxy-p-benzoquinone, which provides resistance to microbial growth. Additionally, the protein dendracin, found in bamboo, offers unique antifungal properties [16]. These beneficial agents are tightly bound to bamboo cellulose, ensuring their persistence even after mechanical processing. Consequently, bamboo fabrics resist bacteria more effectively than other cellulose-based fabrics. A study by the National Textile Inspection Association of China (NTIA), Shanghai Microorganism Research Institute, and Japan Textile Inspection Association demonstrated that bamboo fabric retains significant antibacterial efficacy even after 50 washes [17].

3 Methodology

100% aloe vera yarn and 100% bamboo yarn of 2/40s count were used to make two 100% aloe vera flat knit swatches and two 100% bamboo flat knit swatches, respectively. The fabrics were knit on a 7-gauge hand flat knitting machine. A double jersey knit structure with 4 plies of yarn was chosen to be used to make the fabric. Double jersey is a type of knit fabric that is made using a double bed knitting machine, with selection of 2 sets of needles from both beds. This knit structure was chosen as it is one of the most basic knit structures, with its technical front and back looking the same. It was chosen over a single jersey structure as it doesn't curl, lays flat, and is more durable. While woven fabrics primarily resist unidirectional forces, knitted fabrics are more flexible due to their interloped structure, making bursting strength an essential parameter for analyzing their durability.

3.1 Bursting Strength Test

Two swatches—100% aloe vera knit fabric and 100% bamboo knit fabric, each 6×6 inches—were used to check their strength, respectively. It was tested using a bursting strength test carried out on the Electro Burst 100 machine as per the ISO 13938-2: 2019 method. The fabrics were clamped, and pneumatic pressure was applied to them until they burst, providing data on their performance under stress.

3.2 Antibacterial Activity Test

Two swatches—100% aloe vera knit fabric and 100% bamboo knit fabric, each 2×2 inches—were used to check their antibacterial properties. 1 cm each of the fabrics was cut and used for the testing. Antibacterial activity was evaluated using the disc diffusion testing method. Disc diffusion is a method used to determine the antimicrobial susceptibility of bacteria or fungi to antibiotics. It involves placing antibiotic-impregnated discs on agar plates inoculated with the test organism and measuring the zones of inhibition around the disks. In this study, 1 cm of each fabric is compared with filter paper dipped in chloramphenicol (antibiotic drug) to compare antibacterial activity. The stock culture of bacteria- E. coli and Streptococcus, was received by inoculating in nutrient broth media which was grown at 37% for 18 hours. The agar plates of the

above two bacteria were prepared. Then 1 cm of fabric and filter paper were placed into the media. After that, the plates were incubated at 37°C for 24 hours. The zone of inhibition was measured in mm to determine aloe vera fabric and bamboo fabric's antibacterial activity. It is the area around the fabric where bacterial growth is inhibited. It is measured from the edge of the fabric till the edge of the inhibition zone.

4 Findings And Discussion

4.1 Bursting Strength Test

Bursting strength is an important parameter in textiles, especially for high-performance knit textile applications as it defines the strength of the fabric. In knits, the point at which the loops burst due to the applied multi-dimensional pressure by the testing apparatus is recorded to derive the bursting strength test results. For the study, the bursting strength of both, 100% aloe vera double jersey knit fabrics and 100% bamboo double jersey knit fabrics was assessed using the Electro Burst 100 machine according to the ISO 13938-2: 2019 method. The following findings were observed:

100% Aloe Vera Double Jersey Knit Fabric: The aloe vera fabric exhibited moderate bursting strength. Its performance under stress demonstrated its capability to withstand a reasonable amount of pneumatic pressure before failure.

100% Bamboo Double Jersey Knit Fabric: The bamboo fabric showed slightly higher bursting strength compared to the aloe vera fabric. This indicates that bamboo yarn is more resilient to stress in this double jersey knit structure.

Table 1. Comparison of bursting strength between 100% aloe vera double jersey knit fabric and 100% bamboo double jersey knit fabric

Sample	**Bursting Strength (psi = pounds per square inch)**
100 % Aloe Vera Double Jersey Knit Fabric	86 psi
100% Bamboo Double Jersey Knit Fabric	116 psi

Discussion. The higher bursting strength of the bamboo fabric can be attributed to the inherent tensile strength and flexibility of bamboo fibers. The aloe vera fabric, while moderately strong, may have slightly lower performance under stress due to the softer nature of the fibers. This suggests that bamboo fabric may be more suitable for applications requiring higher durability and resistance to mechanical stress.

4.2 Antibacterial Activity Test

The antibacterial activity test is a method used to evaluate the ability of a material or substance to inhibit the growth of bacteria. This test is commonly applied in textiles, medical devices, coatings, and other materials to determine their effectiveness in preventing bacterial colonization and ensuring hygiene. For the study, antibacterial properties were evaluated using the disc diffusion method with E. coli and Staphylococcus aureus as the test organisms. The zones of inhibition were measured in millimeters for both, 100% aloe vera double jersey knit fabrics and 100% bamboo double jersey knit fabrics, compared to a standard antibiotic (Chloramphenicol) and the following results were obtained:

100% Aloe Vera Double Jersey Knit Fabric: For aloe vera, the zone of inhibition for E. coli was recorded as 9 mm and the zone of inhibition for Staphylococcus aureus was recorded as 8 mm (See Fig 1). 100% Bamboo Double Jersey Knit Fabric: For bamboo, the zone of inhibition for E. coli was recorded as 8 mm and for the zone of inhibition for Staphylococcus aureus was recorded as 6 mm (See Fig 2).

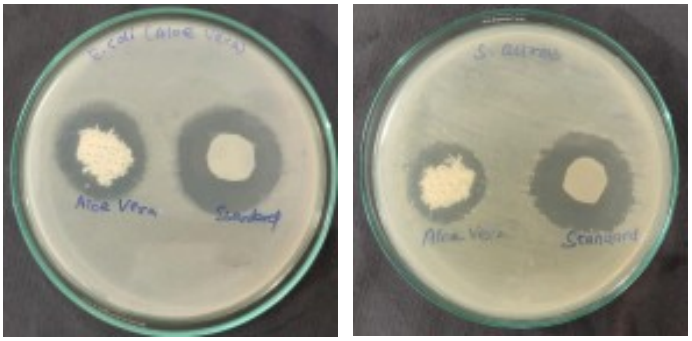

Fig. 1. Antibacterial Activity Test Samples of 100% Aloe Vera Double Jersey Knit Fabric

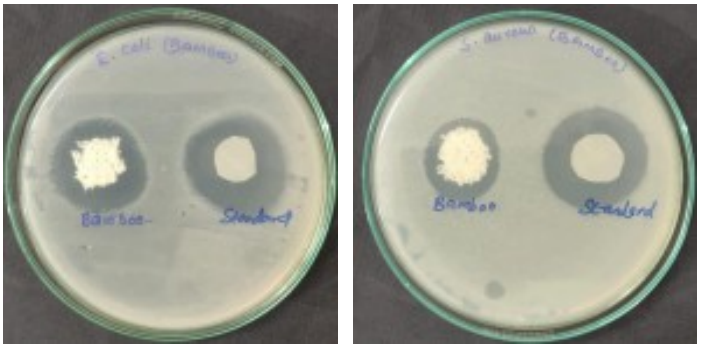

Fig. 2. Antibacterial Activity Test Samples of 100% Bamboo Double Jersey Knit Fabric

Table 2. Comparison of antibacterial activity between 100% aloe vera double jersey knit fabric and 100% bamboo double jersey knit fabric

Sample	E.Coli	Staphylococcus aureus	Standard (Chloramphenicol)
100 % Aloe Vera Double Jersey Knit Fabric	9 mm	8 mm	15 mm
100% Bamboo Double Jersey Knit Fabric	8 mm	6 mm	15 mm

Discussion. The 100% aloe vera double jersey knit fabric demonstrated superior antibacterial activity compared to the 100% bamboo double jersey knit fabric. This is likely due to the bioactive compounds naturally present in aloe vera, which are known for their antimicrobial properties. The larger zones of inhibition for both *E. coli* and *Staphylococcus aureus* indicate its effectiveness in reducing bacterial growth, making aloe vera yarn an excellent candidate for applications requiring antimicrobial functionality.

While bamboo yarn did exhibit antibacterial qualities, its zones of inhibition were narrower, indicating lesser antibacterial efficiency. This could be because bamboo fibers contain the "bamboo kun" bio-agent, which provides modest antibacterial protection but is less effective than the chemicals found in aloe vera.

4.3 Overall Findings

Considering durability, bamboo fabric exhibited higher bursting strength, indicating better mechanical performance. In terms of antimicrobial functionality, aloe vera fabric outperformed bamboo fabric in antibacterial activity, making it more suitable for hygienic and medical textile applications. These findings highlight the unique strengths of aloe vera and bamboo yarns. Both fabrics exhibit good properties, underscoring their potential for sustainable, high-performance

textiles.

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