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Physical and Comfort Properties of Athleisure Wear Using Sustainable Bamboo/Cotton Blends

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Article

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ABSTRACT

Consumer demands for comfort performance are highly escalated, making global manufacturers turn their attention towards the development of technical textiles with enhanced comfort properties. The comfort characteristics of bamboo/cotton blend along with elastane knitted fabrics made by using ring-spun yarns were studied. Four different blend proportions, namely 53:42:5 cotton/bamboo/elastane, 51:41:8 cotton/bamboo/elastane, 45:40:15 cotton/bamboo/elastane and 59:31:10 cotton/bamboo/elastane were used to produce knitted fabrics by using ring-spun yarn of 14.7 tex. Single jersey knitted fabric was made with the first three proportions and interlock fabric was made with the fourth proportion. Fabric samples have been evaluated for physical properties like CPI, WPI, stitch density and thickness aside from measuring comfort properties like absorbency, air permeability and water vapour permeability. Based on the test results, it was concluded that a Lycra jersey developed with 51:41:8 cotton/bamboo/elastane blend showed good surface and moisture absorbency characteristics.

KEYWORDS

bamboo, cotton, sustainable, comfort, athleisure wear, air permeability, water vapour permeability, absorbency

INTRODUCTION

The novel coronavirus has forced the entire mankind to confine within their residences. As a result, consumer behaviour has been affected on a wide scale, making purchases more sensible and deliberate [1]. Contrarily, comfort became the key to everyday wear. The fashion trend of fall 2020-2021 as spotted by WGSN is “considered comfort” which puts emphasis on the type of fashion that is plain and stylish and can be worn both in and out of the house [2]. Workplace clothing has moved away from traditional work wear and toward exercise clothing. Athleisure wear quickly became the go-to look for midday Zoom calls, as well as evening pastimes [3]. As a consequence of the global pandemic, there is increased fitness awareness among consumers. Consumers are increasingly

integrating health and fitness habits into their daily routines whilst wearing comfortable and stylish clothes. Not only that the consumers have become more health-conscious, they have also started adopting sustainable choices of purchasing fashion goods, thus finding it an opportunity to save our planet [4]. Sports textiles are a significant field for developing new products with pragmatic characteristics, whereas athleisure wear, on the other hand, has become an influential trend that incorporates the concept of imparting comfort to the technical wear. As for active wear clothes, their role in an active life along with casual social life is significant. Athleisure wear involves the combination of active and traditional sportswear. It was recognised as recreational wear especially for daytime or leisure times but it later transformed as formal and occasional wear [5]. According to Allied Market Research, the US athleisure market was worth \$155.2 billion in 2018 and is anticipated to hit \$257.1 billion by 2026. As per the 2020 Cotton Incorporated Lifestyle Monitor TM Survey, approximately 48% of consumers claimed active or athleisure bottoms replaced their denim jeans [6]. Therefore, comfort and athleisure wear are two sides of the same coin.

Consumers would like to wear outfits that are both comfortable and perform well. Clothing can improve the body's interactions with the surroundings, resulting in physical, physiological, and psychological comfort. As a result, the fashion industry's primary aim is to achieve maximum comfort in garments. Comfort is one of the most significant factors that influences the performance of apparel [7]. The right garment will improve your comfort while protecting you from the harsh UV rays and also maintaining your skin cool and dry. Bamboo is one such fabric that is renowned for providing this level of comfort. Bamboo can be spun individually or in combination with other fibres like hemp, cotton, wool, Tencel, silk, and Modal [8]. Bamboo is renewable, environmentally friendly and an excellent alternative to plastic. It has odour-free properties and is antibacterial and antifungal. This plant's advantageous property is retained in fabric form, killing all bacteria and making the wearer feel fresher and odour-free for longer, making the garment safer and more hygienic. Bamboo T-shirts are suitable to be worn all day long and are ideal for exercise, hiking, yoga, and healthier lifestyles [9]. Cotton, on the other hand, has long been considered one of the most human-friendly plants due to its gentle, luxurious, and hygienic feel. As a result, a fabric made from blending bamboo and cotton can result in the creation of textiles that are of immense comfort. These blended textiles combine the properties of each component fibre to enhance the fabric's sensation, quality, and longevity [10]. Knitted fabric is more suitable to be worn in direct contact with the skin. The reason is that it has high extensibility with the parameters being low, which allows it to glide smoothly and comfortably on any form on which it is pulled [11]. A study using plain woven fabrics showed decreased thermal conductivity and thermal resistance with the increase of bamboo fibre ratio in a blend [12].

Knitted fabrics are most commonly suggested for athleisure wear because of their enhanced stretchability and elasticity when compared to woven fabrics. Knitted fabrics are generally used in clothing and trendy garments such as elastic denim or elastic velvet garments, as well as residential, medical, and technical wear. Fabric stretch is a basic property required in all sportswear, yoga and fitness activities. Using elastane can make a fabric repeatedly stretch and recoil back to its original shape. Also, it prevents a garment from becoming saggy and baggy. So, elastane is used to develop the knitted fabrics for our study. The abovementioned compositions were chosen for this study because stretch sportswear knitted fabrics with 5%, 8%, 10% and 15% elastane using polyester, nylon and cotton were highly successful in the market and many kinds of researches and studies have been carried out employing these elastane percentages in fabrics. Study on comfort properties of these blends put together is still an open area for study and there are many scopes to get an improvised fabric using sustainable fibres into the market. This study is aimed to investigate the comfort of knitted elastic sustainable fabrics based on 4 different bamboo/cotton compositions for use in athleisure wear.

EXPERIMENTAL

Origin and Physical Properties of Bamboo and Cotton

The bamboo fibre utilised in this study came from China and has a lot of strength, stability, and tenacity. It absorbs a lot of moisture, breathes well, deodorises well, and is velvety with antibacterial characteristics. It also has dry tensile strength of 2.10 N m^{-2} , wet tensile strength of 1.10 N m^{-2} , dry elongation at break of 17%, and cut length of 38 mm.

Cotton fibre was supplied from Gujarat, India, and had tenacity of $29.70 \text{ cN tex}^{-1}$, elongation of 10.93%, length of 29.4 mm, and a fineness of 4 dtex.

Materials and Methods

Four various mix proportions of cotton/bamboo/elastane, such as 53:42:5, 51:41:8, 45:40:15 cotton/bamboo/elastane and 59:31:10 cotton/bamboo/elastane, were fabrics knitted for this study using 14.7 tex yarn (Table 1). The first three compositions were used to create single jersey fabrics, while the last composition was used to create interlock fabrics. Terrot single jersey circular knitting machine, model s296 – 1, with the gauge of 28 gg and the diameter of 36", 60 rpm speed, was used to create the single jersey fabrics. The interlock fabric was developed using Terrot double jersey knitting machine, model i3p 572, with the gauge of 24 gg and the diameter of 38" at 40 rpm speed. The knitting process was carried out in an air-conditioned room with the temperature of $28 \pm 2^\circ\text{C}$ along with maintaining the humidity level of 65%.

Due to the fact that this study requires different mass per unit area of stretch textiles made of bamboo/cotton blends, heavier knitted fabric can be achieved in double jersey (interlock) fabrics and low to medium mass per unit area may be produced in single jersey fabrics due to their knit structure. Geometric properties such as CPI, WPI, thickness, and areal density were examined on the fabrics. The fabric's performance qualities, such as pilling, abrasion resistance, and bursting strength, were assessed. Along with this, the moisture absorbency, water vapour permeability, and air permeability were assessed. The pilling test was performed using an ICI Pilling Box Tester that was certified to ISO 12945. The abrasion resistance was measured using a Martindale abrasion resistance tester in accordance with ASTM 12947, and the bursting strength was measured using a PnuBurst bursting strength tester in accordance with ISO 13938:99. Other comfort attributes were tested, such as crease recovery, stiffness, and moisture absorbency. All of the tests were carried out under controlled conditions and in accordance with regular operating procedures.

Table 1. Composition of fabrics

Structure	Areal density, g m ⁻²	Cotton, %	Bamboo, %	Elastane, %
Composition 1: Lycra – Jersey	160	53	42	5
Composition 2: Lycra – Jersey	200	51	41	8
Composition 3: Lycra – Jersey	280	45	40	15
Composition 4: Interlock	350	59	31	10

RESULTS AND DISCUSSION

Table 2 shows the stitch density in course (Dh) and wales (Dv) direction (number of course and wales per cm), stitch density, loop length and thickness values of bamboo/cotton fabric of four distinct compositions that were used to investigate the physical and comfort attributes. The yarn count for all of the compositions is kept constant at 14.7 tex; nevertheless, it has been noted that as loop length increases, the fabric's mass per unit area drops. As a result, loop length and mass per unit area are inversely related. The loop length value has a greater impact on the fabric's porosity than the fabric's thickness or stitch density.

Table 2. Geometrical properties of fabrics

Fabric specimen	Dv, cm ⁻¹	Dv, cm ⁻¹	Stitch density, loops cm ⁻²	Loop length, mm	Thickness, mm
Composition 1: Lycra – Jersey	86	132	4491	3.1	0.36
Composition 2: Lycra – Jersey	107	147	7041	2.9	0.42
Composition 3: Lycra – Jersey	137	173	9327	2.7	0.68
Composition 4: Interlock	96	107	4054	1.8	0.76

Table 3 shows that fabric stiffness, crease recovery, and bursting strength were significantly different for single Jersey knit fabric with three different thicknesses and weights, but not for the abrasion and pilling tests. The interlock fabric, on the other hand, performed well in all of the tests. It is well known that if the fabric's bending length is smaller, there is less stiffness, and if the bending length is greater, the stiffness of the succeeding fabric is greater. The bending lengths of the offered fabrics were average in both warp and weft directions, according to the testing results. As a result, the stiffness of the materials tested is average. It is noted that composition 4 had comparatively more stiffness than other fabrics.

Table 3. Physical properties of fabrics

Fabric specimen	Fabric stiffness, cm	Crease recovery, °	Bursting strength, kPa	Abrasion resistance, rubs	Pilling rating
Composition 1: Lycra – Jersey	2.59	84.45	392.44	No holes observed up to 10,000	4
Composition 2: Lycra – Jersey	2.78	95.85	441.26	No holes observed up to 10,000	4
Composition 3: Lycra – Jersey	3.24	105.51	353.35	No holes observed up to 10,000	4
Composition 4: Interlock	3.65	119.52	764.69	No holes observed up to 10,000	3

Cellulosic fabrics, in general, have poor crease recovery, and the use of finer yarns further reduces crease recovery angles. The fabric's mass per unit area, fabric tightness, and stitch construction all have an impact on this attribute. Composition 4's crease recovery angle was significantly higher than that of other materials. Interlock fabric outperformed single jersey fabrics in the bursting strength test. All of the fabrics passed the abrasion and pilling tests, indicating that they have high performance qualities.

Table 4. Comfort properties of fabrics

Fabric specimen	Air permeability, Water vapour permeability, Absorbency of textiles,			Wicking test analysis		
	$\text{cm}^3 \text{cm}^{-2} \text{s}^{-1}$	%	s	Time, min	Length, cm	Width, cm
Composition 1: Lycra – Jersey	318	45.87	2	2 10	6.8 12.0	6.5 11.5
Composition 2: Lycra – Jersey	342	46.25	1	2 10	6.2 11.3	6.0 11.2
Composition 3: Lycra – Jersey	274	40.02	9	2 10	4.6 10.2	4.5 10.0
Composition 3: Lycra – Jersey	213	38.89	10	2 10	5.4 10.5	5.3 10.4

Table 4 shows that fabric thickness had a substantial impact on the air permeability of bamboo/cotton blended fabrics, with a drop in thickness resulting in an increase in air permeability. As a result, lighter, thinner fabrics are more permeable to air than heavier, thicker materials. On the other hand, the bamboo fibre has a higher air permeability due to the tiny gaps in the fibre system. The findings reveal that as the loop length grows, the air permeability of a fabric of a particular composition rises. Furthermore, when the bamboo fibre content in the cloth increases, air permeability increases regardless of loop length. For instance, composition 1 and 2 containing 42% and 41% of bamboo content respectively, shows increased air permeability than composition 4 containing only 31% of bamboo.

Figure 1. Influence of knitted fabric blend composition on the air permeability

The loop length of the fabric is another important component in air permeability. Increased loop length creates a looser structure, which improves the fabric's air permeability. As a result, compositions 1 and 2 have high air permeability.

The enhanced water vapour permeability of bamboo mixed fabrics can be attributed to the fabric's lower mass per unit area and thickness, which allows water vapour to easily pass through the fabric. According to prior studies, an increase in the thread count of the fabric leads to an increase in water permeability.

This is due to the fact that fabrics comprised of finer threads have a more porous structure, which affects the fabric's water permeability.

Figure 2. Influence of knitted fabric blend composition on the water vapour permeability

However, because all four fabrics were created with the identical yarn count of 14.7 tex, the water vapour permeability of these four fabrics was determined by the structure, mass per unit area and thickness of the fabric. Single jersey fabrics are also known to be thinner, lighter, and less stiff than interlock fabrics. Furthermore, increasing the hydrophilic groups in the material improves the material's water vapour permeability and absorbency, but this has a detrimental impact on the fabric's liquid moisture transfer speculation. Because bamboo fibre has a higher moisture recovery rate, the water vapour transfer owing to diffusion may be higher for bamboo/cotton blends (11.42%). Compositions 1 and 2 have a higher proportion of water vapour permeability than the rest. According to the absorbency test, compositions 1 and 2 took significantly less time than the other two compositions.

The wicking ability of a fabric is determined by the qualities of the component fibres as well as the fabric's structure. Wicking is one of the most important features of sports textiles, as it is responsible for wicking perspiration away from the body of the wearer. Compositions 1 and 2, with more bamboo content, have better wicking properties than the others do. The hydrophilic property of bamboo fibres explains this.

Figure 3. Influence knitted fabric blend composition on absorbency

CONCLUSION

Bamboo fibre is both hydrophilic and hydrophobic, which means it is drawn to and repels water. As a result of the unified action, i.e. cohesive force of water along these fibres, water molecules are drawn to each other along the fabric strands, pulling moisture up into the air from the skin. Air permeability is an important metric of how well a textile material can perform in terms of heat loss as a thermophysiological property. The greater the air permeability rate, the faster the heat loss is retrieved from a material. Single jersey structure could be used for summer wear or sportswear because it has increased air permeability, giving the wearer a comfortable feeling by allowing cooler air to pass through, drawing heat off the body and improving sweat evaporation from the body and fabric surfaces. The increased fineness of the yarn and the open structure of the knitted fabric result in enhanced air permeability. Moisture in clothing has long been recognized as being one of the key factors influencing wearer discomfort. For sports apparel to be comfortable, liquid absorption and transportation properties are essential. Moisture and heat should be transferred from the surface of the body to the atmosphere by perspiration to control thermal insulation caused by moisture accumulation.

- Composition 2 has higher air permeability than the other 3 compositions
- Composition 2 has higher water vapour permeability than the other 3 compositions
- Absorbency in composition 2 is much faster than in the other 3 compositions
- Wicking property is better than in compositions 3 and 4 and slightly lesser than in composition 1
- Fabric thickness and stiffness is lesser than in compositions 3 and 4 and little higher than in composition 1

So, based on the above geometry and the performance and comfort attributes of the four fabric compositions, it is determined that composition 2, which is made of 51% cotton, 41% bamboo, and 8% elastane, is the best for athleisure wear.

Author Contributions

Conceptualization – Saravanan K; methodology – Saravanan K; formal analysis – Satheeshkumar D and Poojashri K; writing- review and editing – Saravanan K and Prakash C; visualization – Saravanan K and Prakash C; supervision – Prakash C. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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