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INFLUENCE OF FIBER BLENDS ON THE PERFORMANCE CHARACTERISTICS OF WEFT KNITTED FABRICS

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Abstract: This research investigates the physical properties and performance features of natural fibers used in the production of knit fabrics, with a focus on single jersey and rib structures. The fabrics were assessed using key parameters, such as loop length, courses per inch (CPI), wales per inch (WPI), grams per square meter (GSM), pilling resistance, and thickness. The study incorporates materials like 100% cotton, as well as blends of 40% modal/60% cotton and 40% tencel/60% cotton. It explores how these different fiber blends impact essential fabric qualities such as softness, breathability, moisture-wicking performance, and durability. By comparing these properties across multiple fabric types, the goal of the study is to identify the best material combination for producing weft knit fabrics that deliver an optimal balance of comfort, performance, and sustainability.

Key Words: *Weft knit fabric, Cotton, Modal, Tencel, Knit structure, Physical Properties*

Introduction

The production of high-performance weft knit fabrics requires a delicate balance between key attributes such as comfort, durability, breathability, and moisture management. These factors are significantly influenced by the physical properties of the knitted fabrics used. Weft knit fabrics are highly regarded for their inherent stretch ability, soft texture, and ability to adapt to dynamic movements, making them suitable for a wide range of applications. Among the various knitted structures, single jersey and rib are two of the most commonly used in weft knit fabric production.[1] Single jersey fabrics are known for their smooth, flat texture, which enhances softness and comfort. This makes them ideal for applications that prioritize a gentle feel against the skin, such as casual wear or athletic apparel. Their lightweight construction allows for breathability and ease of movement, ensuring a comfortable fit. The flexibility of single jersey fabric allows it to stretch and conform to the body, offering a high level of comfort during everyday activities and providing an excellent balance of softness and functionality.[4] In contrast, ribbed fabrics provide superior elasticity and a snug, secure fit, making them ideal for applications that require the fabric to retain its shape and stay in place during movement. The rib knit structure, which alternates between knit and purl stitches, creates a textured pattern that helps the fabric maintain its form and prevents it from sagging or losing shape over time. The added stretch provided by the ribbing makes these fabrics perfect for garments that need both durability and flexibility, as they can easily accommodate dynamic movements while maintaining a firm fit. Ultimately, the choice of knitted structure—single jersey or rib—depends on the specific performance requirements of the weft knit fabric. Single jersey excels in providing softness, comfort, and breathability, while ribbed fabrics are best for achieving a secure fit and enhanced elasticity. Both structures are essential in creating weft knit fabrics that deliver an optimal combination of comfort, performance, and versatility, catering to a wide range of textile needs.[3].

This study examines key physical properties of fabrics, including loop length, courses per inch (CPI), wales per inch (WPI), pilling resistance, fabric thickness, and grams per square meter (GSM).Loop length affects fabric softness and insulation, with longer loops providing more warmth and comfort. CPI and WPI measure fabric density in the vertical and horizontal directions, influencing structure, stability, and breathability. Pilling resistance indicates how well the fabric resists fiber balls, impacting its appearance and longevity. Fabric thickness influences weight, drape, and insulation, while GSM measures fabric weight per unit area, affecting durability and comfort. Together, these properties determine the fabric's performance, including softness, breathability, durability, and insulation, enabling manufacturers to create fabrics suited to specific applications.[5]

This research focuses on four different fiber compositions: 100% cotton, and 40:60 modal/cotton and 40:60 tencel/cotton blends. Cotton, a widely used natural fiber, is renowned for its softness, breathability, and moisture-wicking abilities. In recent years, however, cotton blends with other fibers have become increasingly popular due to their improved functional properties and greater sustainability.[7] Modal, a type of regenerated cellulose fiber, is praised for its silky feel, strength, and resistance to shrinking. Tencel, another cellulose-based fiber, offers excellent moisture absorption and is biodegradable, making it an attractive alternative for eco-conscious consumers. By exploring how these different fiber blends affect the fabric's physical properties, the study aims to better understand their impact on the overall performance of knitted fabrics[6,8]. This includes assessing how the fabric's ability to regulate temperature, wick moisture, and provide comfort can be optimized based on the specific blend used. In addition, the research seeks to identify which combination of fibers provides the best balance of comfort, durability, breathability, and sustainability, ultimately guiding the development of knitted fabrics that deliver high performance, enhanced comfort, and longevity[9]. The findings from this study are expected to contribute valuable insights for the textile industry in the quest to create high-quality, sustainable, and functional knitted fabrics for garments.

Material and Methods

In this study, weft knitted fabrics were manufactured using three different yarn compositions, including 100% cotton and various fiber blends. These yarns were selected for their differing properties, such as breathability, moisture-wicking capabilities, and environmental sustainability. The following yarn compositions were used in the study:

1. 100% Cotton (30s count): A natural fiber known for its softness, breathability, and moisture-absorbing properties, cotton yarn is commonly used in sock production for its comfort and versatility.
2. 40:60 Modal/Modal (30s count): This blend combines the softness and breathability of cotton with the smooth, silky texture and moisture management properties of modal, a type of regenerated cellulose fiber.
3. 40:60 Tencel/Cotton (30s count): Tencel, also known as lyocell, is a biodegradable fiber made from wood pulp. This blend provides excellent moisture absorption and enhanced durability, along with an environmentally friendly production process.

The yarns used in this study had a 30s count, indicating a moderate thickness, which is suitable for the manufacturing of knitted fabrics with a balance of strength, softness, and comfort.

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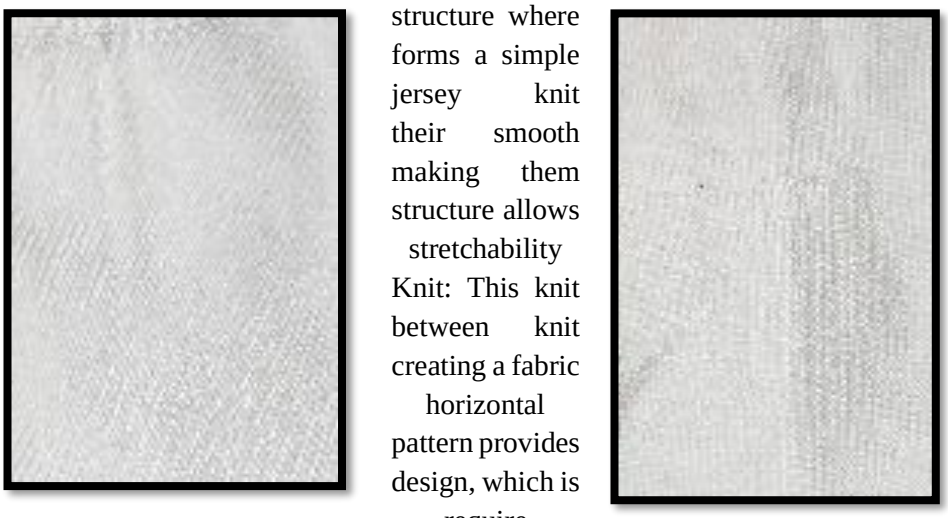
Fabric Structures

Two different knitted fabric structures were chosen for fabric production named Single Jersey Knit: A basic knit structure where one set of needles forms a simple loop pattern. Single jersey knit fabrics are known for their smooth surface and softness, making them ideal for casual socks. This structure allows for good stretchability and comfort and 1x1 Rib Knit: This knit structure alternates between knit and purl stitches, creating a fabric that has both vertical and horizontal stretch. The ribbed pattern provides a snug, form-fitting design, which is essential for socks that require elasticity and a secure fit around the foot and ankle. This structure improves the fabric's ability to stretch, making it ideal for performance and active wear.



Single Jersey 1 x 1 Rib

Figure 1: Image of Socks produced from different knit structures

Testing and Characterization

Once the fabrics were produced, the following physical properties were evaluated to assess the performance and comfort characteristics:

1. Loop Length: The loop length of the fabric was measured to assess the softness and thermal insulation properties. Longer loops are expected to offer greater insulation, while shorter loops contribute to a more compact, durable fabric.
2. Courses Per Inch (CPI) and Wales Per Inch (WPI): These measurements were taken to evaluate the density of the fabric, which directly impacts its stretchability, breathability, and durability.
3. Grams per Square Meter (GSM): The fabric weight was measured to determine its thickness and overall weight, which are critical factors influencing comfort, warmth, and moisture management.
4. Fabric Thickness: Fabric thickness plays a crucial role in determining the weight, insulation, and overall feel of the material. Thicker fabrics provide more warmth and durability, while thinner fabrics are lighter and more breathable. The thickness also affects the drape, comfort, and moisture-wicking capabilities of the fabric.
5. Pilling: The Pill Test evaluates fabric's resistance to pilling caused by friction, with factors like fiber type, fabric thickness, and weave structure affecting results. Thicker fabrics are generally more durable and less prone to pilling. The test helps assess a fabric's longevity, appearance, and performance in real-world use.

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Experimental Method

S.No	Sample	Fibre Type	Structure	Loop Length	GSM	CPI	WPI
1	CSJ	100 % Cotton	Single Jersey	0.33 mm	2.19 gm	28”	20”
2	SRB	100 % Cotton	1 x 1 Rib	1.16 mm	2.4 gm	24”	22”
5	MOCSJ	40 % Modal / 60 % Cotton	Single Jersey	0.40mm	0.96gm	28”	22”
6	MOCRB	40 % Modal / 60 % Cotton	1 x 1 Rib	1.20mm	2.90gm	25”	26”
7	TNCSJ	40 % Tencel / 60 % Cotton	Single Jersey	0.32mm	1.27gm	30”	20”
8	TNCRB	40 % Tencel / 60 % Cotton	1 x 1 Rib	1.17mm	2.91gm	27”	25”

Table 1: Technical specifications of Knitted Fabric

The produced knitted fabrics were tested according to the standard procedure for evaluating their physical and structural properties, such as loop length (ASTM D 3887), CPI and WPI and GSM. A summary of the physical and structural properties assessed for the fabrics is provided in Table 1.

Result and Discussion

The performance and comfort characteristics of knitted fabrics are largely influenced by the physical properties of the fabric structure. These properties are determined by several key factors, including loop length, grams per square meter (GSM), wales per inch (WPI), and courses per inch (CPI). Understanding the role of each of these parameters is essential for optimizing the design and functionality of fabrics, ensuring they meet specific performance requirements such as comfort, breathability, durability, and moisture-wicking capabilities.

Loop Length

Loop length is the height of the individual yarn loops in a knitted fabric. In the context of socks, loop length plays a crucial role in determining the fabric’s texture, softness, and insulation properties.

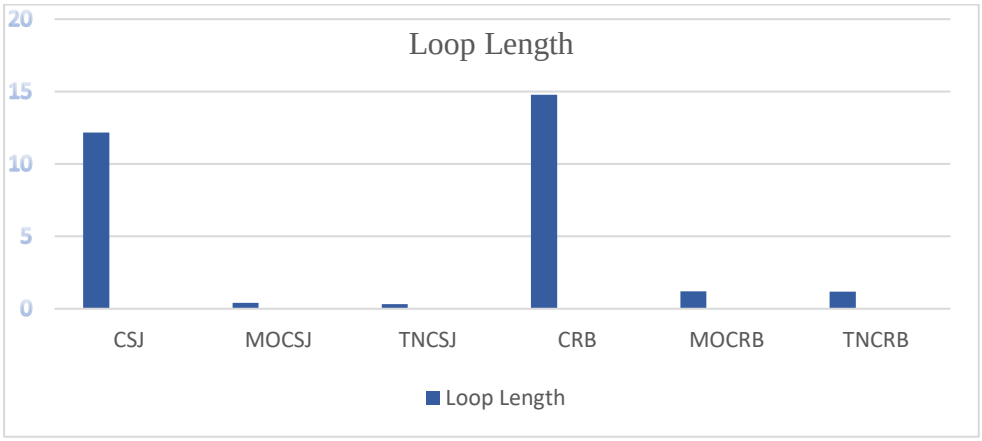

Figure 2: The graph of Loop Length of tested socks

Knitted fabrics used in sock production show varied properties based on yarn blends and knit structures. Single jersey (SJ) socks with 100% cotton were the thickest and densest (2.19), while the 40:60 modal/cotton blend was the lightest (0.96) and breathable. The 1x1 rib (CRB) cotton rib was the densest (2.94), offering elasticity, while

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modal/cotton and tencel/cotton ribs (2.9–2.92) balanced softness and moisture management. These results highlight the impact of yarn composition and knit structure on fabric performance.

Grams per Square Meter (GSM)

GSM is a standard measurement of fabric weight, which is directly linked to the fabric's thickness and density. The GSM value gives a clear indication of the weight and heaviness of the knitted fabric, which in turn impacts the sock's warmth, durability, and breathability. The GSM value must be carefully controlled, as it affects not only thermal insulation and comfort but also the durability and overall feel of the sock. For instance, too high a GSM can result in a sock that is too bulky and less comfortable, while too low a GSM may compromise the sock's durability.

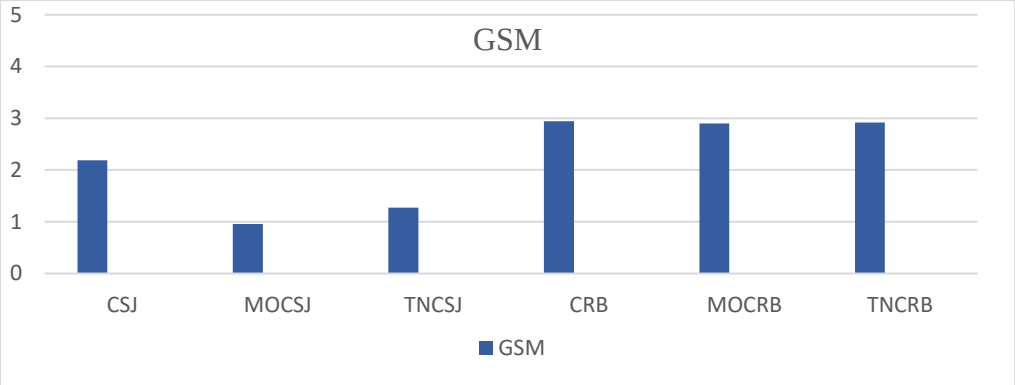

Figure 3: The graph of GSM of tested socks

GSM analysis of knitted sock fabrics reveals differences in weight, density, and comfort. In single jersey (SJ), 100% cotton socks (2.19 GSM) were the heaviest and most durable, while the modal/cotton blend (0.96 GSM) was light and moisture-managing. In 1x1 rib (CRB), GSM values were higher, with cotton rib (2.94 GSM) being durable, and modal/cotton (2.9 GSM) and tencel/cotton (2.92 GSM) offering a balance of softness, durability, and moisture management.

Wales per Inch (WPI)

Wales per inch (WPI) refers to the number of vertical columns of loops, or "wales," within an inch of the fabric. The WPI is a key indicator of the fabric's density and its overall structural integrity. WPI also influences the elasticity and stretchability of the fabric. A fabric with a higher WPI will generally have less stretch, while a fabric with a lower WPI will stretch more easily, contributing to a snug, comfortable fit.

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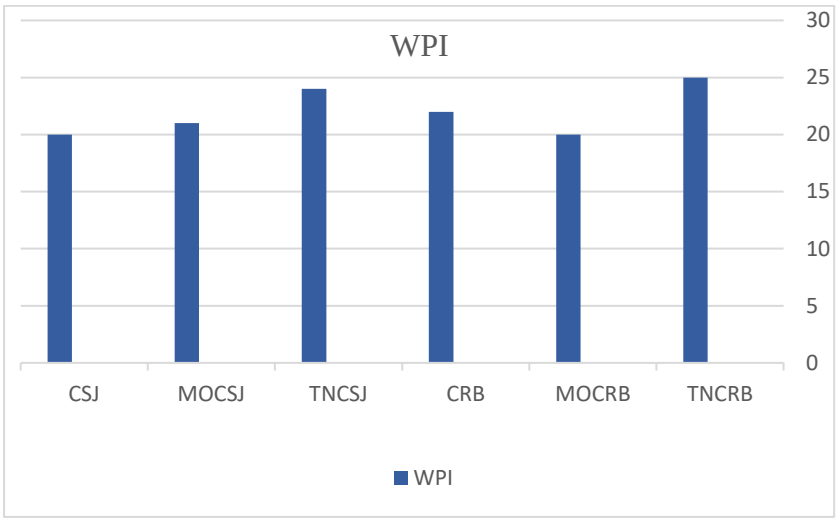

Figure 4: The graph of Wales Per Inch of tested socks

The Wales per Inch (WPI) for knitted socks varies based on the fiber type and knit structure. For Single Jersey (SJ)**,** the WPI for cotton is 20 and tencel/cotton (24). In 1x1 Rib (CRB) knit structures, the WPI for cotton is 22, and tencel/cotton (25), while modal/cotton remains at 20. These variations reflect the influence of both the fiber blend and the knit structure on the density of the fabric's vertical stitch columns.

Courses per Inch (CPI)

Courses per inch (CPI) measures the number of horizontal rows of loops, or "courses," within an inch of fabric. Similar to WPI, CPI is a measure of fabric density, but it specifically relates to the vertical and horizontal properties of the knitted structure. The relationship between CPI and WPI plays a significant role in the overall elasticity and stretch of the fabric. A fabric with a balanced CPI and WPI provides a well-rounded performance that balances durability with comfort.

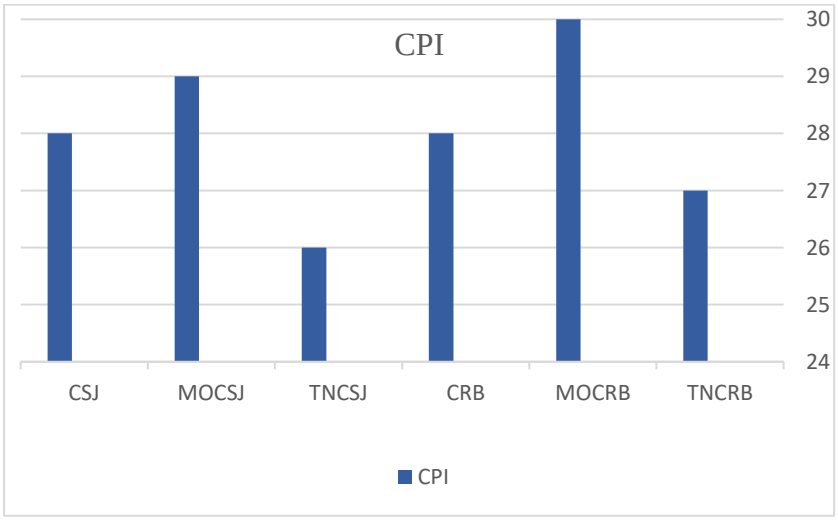

Figure 5: The graph of Course Per Inch of tested socks

The Course per Inch (CPI) for knitted socks varies based on fiber type and knit structure. For Single Jersey (SJ)**,** the CPI for cotton is 28, tencel/cotton (26), and increases slightly for modal/cotton (29). In 1x1 Rib (CRB)

knit structures, the CPI for cotton is 28, and tencel/cotton (27), while modal/cotton has a slightly higher value of 30. These variations demonstrate how the fiber blend and knit structure influence the density of the fabric's horizontal stitch rows.

Conclusion

The analysis of knitted fabrics production reveals significant differences in fabric properties, including weight, density, comfort, durability, and moisture management, based on yarn blends and knit structures. In single jersey (SJ), 100% cotton socks were the heaviest and most durable, while bamboo/cotton blends offered lighter, more breathable options with moisture-wicking properties. Modal/cotton blends were the lightest, ideal for warmth and comfort, and tencel/cotton blends provided a balanced fabric. In 1x1 rib (CRB) structures, fabrics were denser and more durable. Modal/cotton and tencel/cotton rib knits provided a balance of softness, density, and moisture management. The Wales per Inch (WPI) and Course per Inch (CPI) values further highlighted how fiber composition and knit structure impact fabric density, with higher WPI and CPI values indicating denser, more durable socks, while lower values correspond to lighter, more breathable fabrics. Overall, these findings emphasize the importance of selecting the right fiber blend and knit structure to optimize the performance, comfort, and durability of fabrics for various applications.

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