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Effect of Ecocell™ Fiber Blends on Comfort Performance in Sustainable Clothing Production

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Abstract

In this study, single jersey, interlock, and 1x1 rib knitted fabric structures were produced using yarns composed of Ecocel™ fibers blended in varying proportions with cotton and polyester (PET) fibers. The primary comfort and performance parameters of knitted fabrics made from varying ratios of Ecocel™, cotton, and PET—including bursting strength, thermal conductivity, thermal resistance, air permeability, abrasion resistance, dimensional stability, and moisture vapor transmission rate (MVTR)—were examined. The results indicated that Ecocel™-containing knitted fabrics demonstrated superior performance, particularly in terms of air permeability, thermal resistance, and moisture vapor transmission rate (MVTR). In terms of abrasion resistance and bursting strength, the PET-containing blends (70% Ecocel™/30% PET and 67% Ecocel™/33% PET) exhibited enhanced mechanical performance. However, these blends showed lower air permeability and moisture transfer values. In dimensional stability tests, 100% PET structures exhibited minimal deformation after washing, whereas increasing the cellulosic content led to greater shrinkage. For comfort-related properties that require durability, PET/Ecocel™ fiber blends may be considered preferable.

Keywords

Ecocell Fibers, Knitted Fabrics, Comfort Properties, MVTR, Air Permeability, Thermal Resistance, Bursting Strength

1. Introduction

The textile industry is increasingly facing pressure to reduce its environmental impacts, including global warming, water resource depletion, and microplastic pollution. These concerns have made sustainability efforts essential. In the production of environmentally friendly textiles, regenerated cellulosic fibers—derived from renewable sources and characterized by low energy and water consumption—have gained prominence due to their biodegradability.

Among these, Ecocel™, a next-generation regenerated cellulosic fiber, has been developed using an eco-conscious manufacturing method that utilizes minimal water and energy, resulting in a significantly reduced carbon footprint [1] [2]. Unlike conventional viscose or modal, Ecocel™ is engineered to enhance both sustainability and functional performance. However, despite its growing availability in the textile market, scientific studies investigating its performance in textile structures remain limited.

Several recent studies have begun to examine Ecocel™ and other new-generation regenerated fibers. For instance, Sen, K *et al.*, compared Ecocel™, Ecocel™, and Naia™ fibers to cotton in terms of color fastness and dimensional stability in knitted fabrics [3]. The findings suggest that these new fibers may serve as viable alternatives to cotton. Another study examined the yarn-level performance of Ecocel™ blended with bast fibers (linen, recycled linen, hemp), revealing that 100% Ecocel™ yarns exhibited excellent tensile properties and uniformity; however, fibrillation led to increased hairiness [4]. Additionally, the reactive dyeability of Ecocel™/acrylic blended woven fabrics was evaluated, demonstrating that Ecocel™ is compatible with single-bath dyeing processes and contributes to water and chemical savings [5]. Also, Ecocel™'s behavior in various weaving and dyeing configurations was analyzed, focusing on aesthetic and technical feasibility but not comfort performance [6].

Knitted fabric surfaces produced from different fiber blends play a significant role in determining comfort properties. Fabrics made from cellulosic-based fibers offer high comfort performance owing to their softness, elasticity, and air permeability. These fibers are increasingly preferred not only for their functional performance but also for the comfort they provide to users. In knitted fabric structures—such as single jersey, interlock, and 1 × 1 rib—the type and proportion of fibers used have a direct impact on the comfort and performance parameters of the fabric [7].

Existing research on sustainable fibers in knitted fabrics has primarily focused on more established alternatives such as viscose, modal, bamboo, Ecocel™, and Cupro. In his study, Oner systematically compared single-jersey knitted fabrics made from nine fiber types, including regenerated fibers [8]. It was found that Tencel™ fabrics showed high air permeability, good bursting strength, and high thermal resistance, outperforming several natural and synthetic alternatives in terms of comfort. In a study examining greige and dyed knitted samples obtained from 100% regenerated yarns such as Tencel™, Modal, Cupro, and Umorfil®, it was emphasized that both the fiber type and the processing stage significantly affect thermal behavior, moisture management, and bursting strength [9]. Although these studies highlight the functional potential of regenerated fibers in knitted fabrics, they tend to focus on single fiber types, single knit constructions, or limited property sets. Furthermore, Ecocel^{TM} has not yet been evaluated comprehensively in terms of its interaction with other common fibers (e.g., cotton, polyester) across various knitted structures and comfort-related parameters.

To bridge this gap, the present study systematically investigates the performance of knitted fabrics produced from yarns blended with Ecocel^{TM}, cotton, and PET fibers, across three common knit structures: single jersey, interlock, and 1 × 1 rib. Key comfort and durability parameters—including thermal conductivity, thermal resistance, air permeability, moisture vapor transmission rate (MVTR), abrasion resistance, bursting strength, and dimensional stability—were measured and analyzed comparatively. By evaluating the combined effects of fiber blend ratios and knit geometry, this study provides novel insights into the design of sustainable, high-comfort knitted fabrics and expands the current understanding of Ecocel^{TM}'s suitability in functional garment applications.

2. Experimental

2.1. Materials

In this study, Ecocel^{TM} fibers were combined with cotton and polyester (PET) fibers in various proportions, subsequently processed into yarns utilizing the ring spinning system. The cotton fibers were sourced from Kıvanç Tekstil (Türkiye), the PET fibers from Weihigh (China), and the Ecocell fibers were supplied by Karafiber (Türkiye). The blend ratios of Ecocel^{TM}, cotton, and PET (70/30, 67/33, and 40/60) were selected based on their practical relevance in textile production and their balanced performance in terms of comfort, mechanical stability, and spinnability. These ratios also reflect commonly used industry standards for sustainable fiber integration. From the produced yarns, single jersey, interlock, and 1 × 1 rib knitted fabric structures with a weight of 200 g/m^2 were manufactured (Knitting gauge 28 GG and 30 rpm) To determine the properties of the yarns incorporated in the knitted fabric structures, ASTM D1577 and ASTM D2256 testing standards were applied. The results of these tests are presented in Table 1.

Table 1. Yarn properties.

Fabric Composition	Fiber Fineness (µm)	Yarn Count (Ne)	Twist (T/m)	Twist Multiplier	Tenacity (cN/tex)	Yarn Tension (cN)	Elongation (%)
100% Ecocell	13.6 µm	30	800	4.1	29.6	11.5	7.4
70% Ecocell /30% Cotton	13.6/16.8	30	750	3.9	26.7	12	7.2
40% Ecocell /60% Cotton	13.6/16.3	30	700	3.8	26.1	11.8	6.9
100% Cotton	16.5	30	700	3.8	23.7	11	6.2

Continued

70% Ecocell/ 30% PET	13.6/16.1	30	820	4.3	31.3	10.8	6.2
67% Ecocell/ 33% PET	13.6/11.3	30	820	4.4	32.4	12.1	6.9
100% PET	11.3	30	840	4.3	34.3	12.5	6.3

2.2. Methods

The knitted fabrics produced from yarns containing varying percentages of Ecocell™, cotton, and PET fibers were subjected to a series of tests in order to evaluate their comfort and performance characteristics. The specific test methods and related international standards applied during the characterization of these fabrics are detailed in Table 2.

In this study, a one-way analysis of variance (ANOVA) was employed to assess the impact of varying Ecocell/cotton blend ratios on the bursting strength and elongation properties of knitted fabrics. Statistical analyses were conducted based on different fiber blend groups. The bursting strength data were analyzed to reveal the differences in the bursting strength characteristics of knitted fabrics produced with various fiber blends and to determine the effect of these blends on performance. The ANOVA test was conducted at a 95% confidence level ($\alpha = 0.05$) to determine whether there were statistically significant differences between the group means. For parameters where significant differences were observed, the effect size was interpreted in relation to fiber type and knit structure. All statistical calculations were performed using SPSS software (v26.0).

Table 2. Applied tests and international standards.

Tests	Unit	Standarts
Bursting Strength	kPa	ISO 13938-2
Air Permeability	mm/s	ISO 9237
Thermal Resistance (Rct)	m^2K/W	ISO 11092 (Sweating Guarded Hotplate Method)
Thermal Conductivity	W/m·K	ISO 8302
MVTR *(Moisture Vapor Transmission Rate)*	$g/m^2 \cdot 24$ h	ISO 15496(Procedure BW or BW-Desiccant)
Abrasion Resistance	Martindale (cycles)	ISO 12947-2
Dimensional Change *(Shrinkage)*	% shrinkage	AATCC 135 (After washing/ drying cycles)

3. Results

3.1. Fabric Bursting Strength Results

The one-way ANOVA analysis conducted for bursting strength revealed statistically significant differences among the knitted fabric groups with varying Ecocell/cotton blend ratios ($p < 0.001$). According to the results, fabrics composed of 100% Ecocell exhibited bursting strength values in the range of 500 kPa - 540 kPa, while those with a 70% Ecocell/30% cotton blend ranged between 460 kPa - 500 kPa. Fabrics with a 40% Ecocell/60% cotton composition showed values between 420 kPa - 460 kPa, and those made of 100% cotton dropped further to 380 kPa - 420 kPa. Based on average values, an apparent decrease in bursting strength was observed as the cotton content increased.

These differences are not solely attributable to measurement variance, but rather stem from the inherent physical and structural properties of the fibers used. The crystalline structure, fiber length, and smooth surface morphology of Ecocell fibers contribute to stronger fiber–fiber cohesion, resulting in more compact and mechanically robust fabrics. In contrast, cotton fibers, being shorter, more irregular, and less resistant to pressure, limit the performance of the fabric in this context. The ANOVA results clearly indicate that the observed differences arise from material composition and structural characteristics rather than random experimental variability. Additionally, comparisons among different knit structures supported these findings; interlock fabrics, due to their tighter and more balanced structure, demonstrated higher overall bursting strength.

As shown in **Figure 1**, the bursting strength of Ecocell™-blended knitted fabrics varies depending on both the fabric structure (Single Jersey, Interlock, 1 × 1 Rib) and the percentage composition of the fiber blends used. For all fiber compositions, interlock fabrics exhibited higher bursting strength compared to single jersey and rib structures. This can be attributed to the double-needle bed construction of interlock fabrics, which provides a tighter, more balanced, and symmetrical structure. Due to their higher yarn density, interlock knits create bulkier, less elastic, and more pressure-resistant fabrics, resulting in higher bursting strength [10]

Single jersey fabrics, on the other hand, displayed lower bursting strength due to their looser structure and single needle bed construction, which makes them less resistant to pressure. Although 1 × 1 rib fabrics offer better elasticity, their structure is not as compact as interlock, resulting in medium bursting strength under applied pressure.

In terms of fiber composition, fabrics made from 100% PET exhibited the highest bursting strength, with a value of 687.3 kPa for the interlock. The crystalline structure of PET fibers is associated with high tensile strength. The inherent strength of PET fibers contributes not only to resistance against breakage but also enhances the bursting strength of the knitted fabrics [11].

Fabrics made from 100% cotton demonstrated lower bursting strength compared to those containing PET. Increasing the cotton content generally reduces the bursting strength, since cotton fibers tend to deform more easily under high pressure due to their staple length and low elasticity. For instance, fabrics with 40% Ecocell™/60% cotton exhibited 80 kPa - 100 kPa lower bursting strength compared to those made with a 70% Ecocell™/30% PET blend, confirming this trend.

However, within the cotton blends, as the proportion of Ecocell™ increased, the bursting strength of the fabric improved. A similar pattern was observed in PET blends with higher Ecocell™ content (e.g., 70% Ecocell™/30% PET and 67% Ecocell™/33% PET), which also showed high bursting strength. This suggests that Ecocell™ contributes positively to the structural integrity of the fabric. The smoothness and length of Ecocell™ fibers appear to enhance fabric strength [12].

The obtained data indicate that fiber blends have a direct impact on the bursting strength of different knitted fabric structures. The highest strength values were observed in knitted fabrics composed of 100% Ecocell, while a systematic decrease in bursting strength was recorded with the reduction of the Ecocell content. These findings suggest that fabrics with a high Ecocell ratio offer a more suitable material option for technical textile applications where mechanical strength is critical.

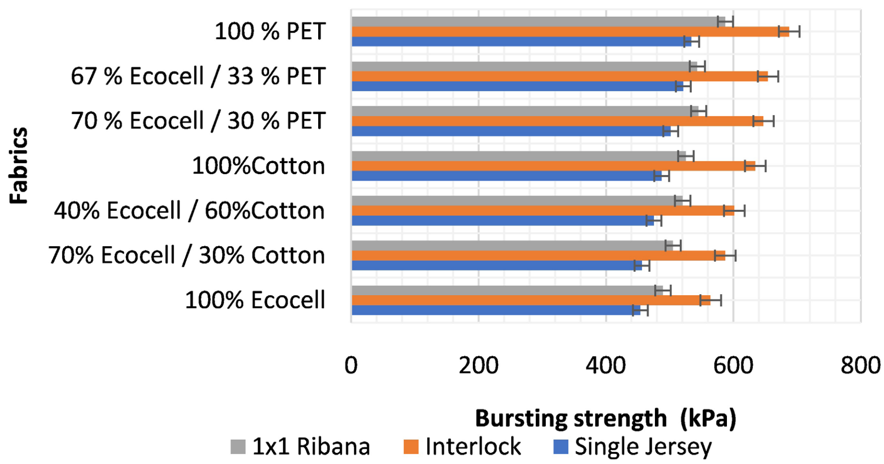

Figure 1. Bursting strength results of knitted fabrics.

3.2. Fabric Abrasion Resistance Test Results

As shown in **Figure 2**, the abrasion resistance of knitted fabrics made from various fiber compositions was evaluated. Fabrics made from 100% PET fibers demonstrated the highest abrasion resistance among all fabric structures (Single Jersey: 18; Interlock: 20; 1 × 1 Rib: 16.5). This exceptional performance is associated with the high crystallinity regions found in the polymeric structure of PET fibers, along with their low surface friction coefficient.

Conversely, fabrics composed entirely of Ecocell™ fibers showed the lowest abrasion resistance values (Single Jersey: 10.2; Interlock: 12.3; 1 × 1 Rib: 9), which can be attributed to the amorphous structure and lower mechanical strength of Ecocell™ fibers, making the fabric more susceptible to wear. However, blends with Ecocell™ and PET (e.g., 67% Ecocell™/33% PET and 70% Ecocell™/30% PET) demonstrated improved abrasion resistance compared to pure Ecocell™ fabrics, indicating a positive contribution from PET fibers.

Fabrics made from 100% cotton showed particularly low abrasion resistance, especially in the 1 × 1 rib structure. This can be attributed to the inherently lower abrasion resistance of cellulosic fibers, such as cotton, compared to synthetic fibers. Additionally, increasing the proportion of Ecocell™ in the blend resulted in a gradual improvement in abrasion resistance [13].

Among the knitted structures, interlock fabrics exhibited the highest abrasion resistance due to their compact and stable surface morphology, which enhances durability under repeated rubbing [14].

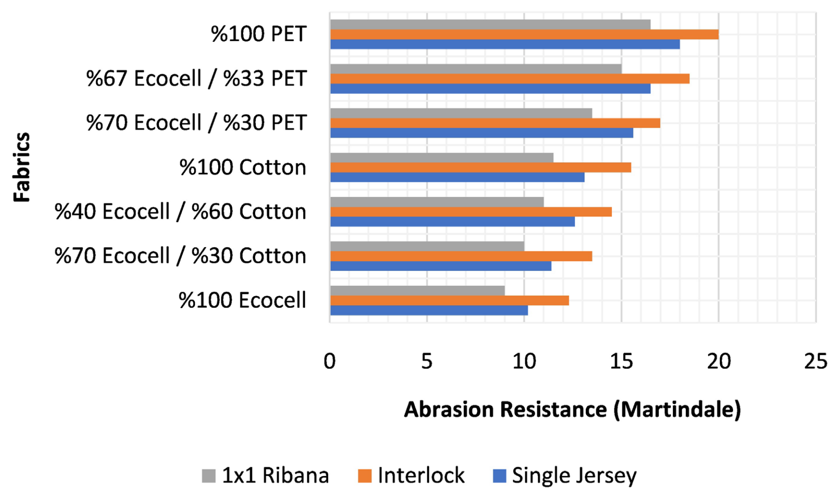

Figure 2. Abrasion resistance results of knitted fabrics.

3.3. Dimensional Change (% Shrinkage) Results

According to Figure 3, knitted fabrics made from different fiber compositions exhibited varying levels of dimensional change after laundering. Among all samples, fabrics made from 100% PET fibers demonstrated the lowest negative dimensional change, indicating high dimensional stability (e.g., −1% in Single Jersey fabrics). In contrast, fabrics composed of 100% cotton fibers showed significantly higher shrinkage values, reaching up to −5.4%.

The relatively low shrinkage observed in 100% PET fabrics can be attributed to the low moisture absorption capacity of polyester fibers, which ensures structural stability under wet conditions. On the other hand, the high moisture regains properties of cotton and Ecocell™ fibers lead to fiber swelling and structural reorganization during washing, resulting in increased shrinkage (e.g., −7.3% for 1 × 1 Rib fabric made from 100% Ecocell™).

Blended fabrics containing PET and Ecocell™ exhibited improved dimensional stability as the proportion of PET increased (e.g., 67% Ecocell™/33% PET). This can be explained by the rigid molecular structure of PET fibers counterbalancing the hygroscopic nature of Ecocell™ [15]. In terms of fabric structure, interlock fabrics showed the lowest shrinkage rates across all fiber compositions. This is due to their double-knit construction, which provides enhanced structural stability and resistance to shrinkage under tensile stress.

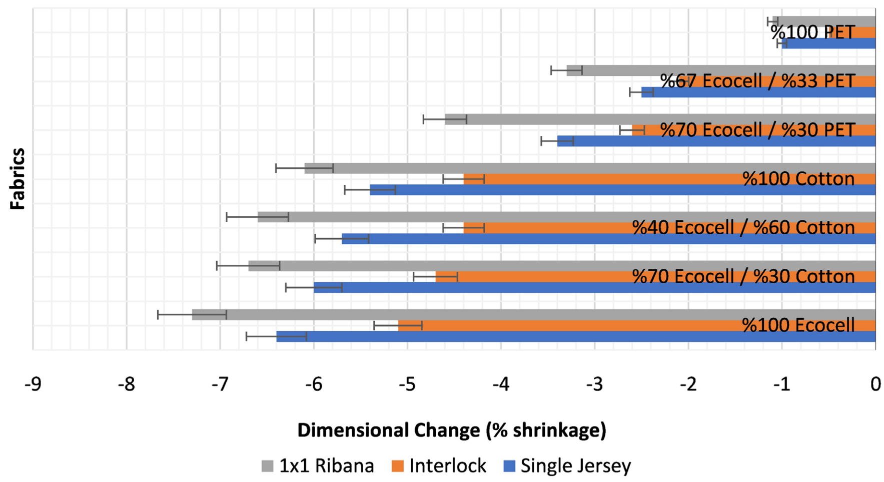

Figure 3. Dimensional change (% shrinkage) results of knitted fabrics.

3.4. Air Permeability Results

As shown in **Figure 4**, knitted fabrics made of 100% Ecocell™ fibers showed the highest air permeability values across all three knitting structures. This superior performance is attributed to the microporous structure of Ecocell™ fibers, which enhances airflow through the fabric [16].

In contrast, fabrics made with PET fibers exhibited significantly lower air permeability values. The relatively dense structure and smooth surface morphology of PET fibers contribute to tighter loop formation, which restricts air passage through the fabric [17].

When examining the fabric structures, Single Jersey fabrics demonstrated higher air permeability values compared to Interlock and 1 × 1 Rib fabrics. This is due to their single-layered and loosely knit structure, which allows for more open spaces for air to flow through. On the other hand, Interlock and 1 × 1 Rib structures consist of tighter and denser loop formations, resulting in reduced air permeability [18].

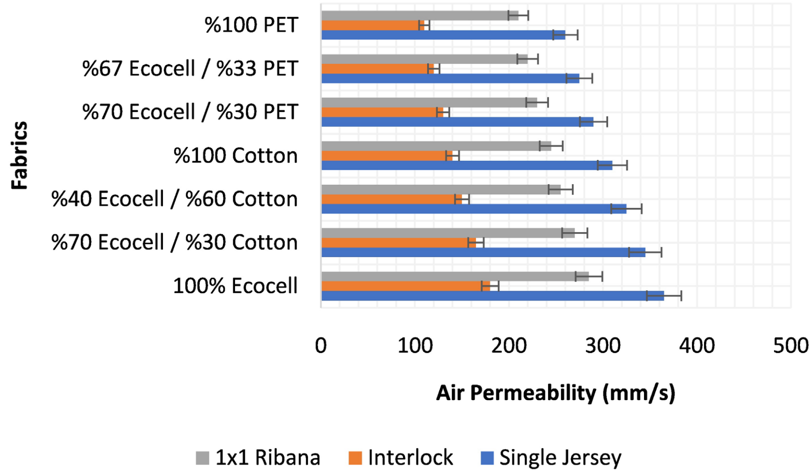

Figure 4. Air permeability results of knitted fabrics.

3.5. Thermal Conductivity Results

Figure 5 illustrates the thermal conductivity (W/m·K) values of the knitted fabrics. It is evident that the thermal conductivity increases with the increasing proportion of PET fibers in all knitted fabric structures. Conversely, the thermal conductivity decreases with higher content of Ecocell™ fibers and in the 100% Ecocell™ samples. This is attributed to the inherently low thermal conductivity of cellulosic fibers. The micro-porous structure of Ecocell™ fibers enhances air impermeability within the knitted surface, thereby limiting heat transfer [16].

Among the knitted fabrics containing 100% Ecocell™, the lowest thermal conductivity values were recorded as follows: Single Jersey at 0.032 W/m·K, Interlock at 0.040 W/m·K, and 1 × 1 Rib at 0.038 W/m·K. In contrast, the corresponding values for 100% PET fabrics were higher at 0.049, 0.057, and 0.052 W/m·K, respectively. This is due to PET fibers' low moisture absorption, thermoplastic nature, and higher fiber density, which collectively facilitate more efficient heat conduction [19] [20].

Among the fabric types, Interlock structures exhibited the highest thermal conductivity, while Single Jersey fabrics generally showed the lowest values. This is because Interlock fabrics have tighter loop formations with fewer air voids, allowing better heat conduction. These variations confirm that the fabric structure is a critical factor affecting heat transfer properties.

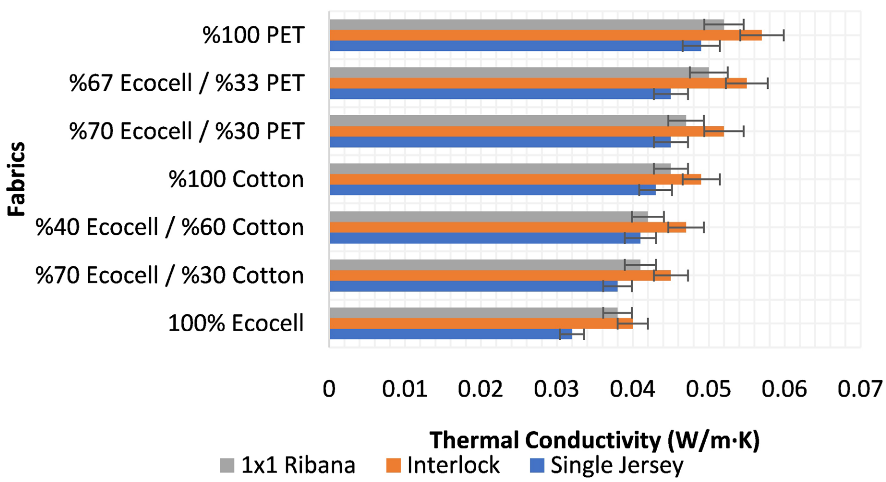

Figure 5. Thermal conductivity results of knitted fabrics.

3.6. Thermal Resistance Results

Figure 6 shows that knitted fabrics containing Ecocell™ fiber compositions demonstrate high thermal resistance [21] [22]. The highest thermal resistance was observed in the 100% Ecocell™ Single Jersey fabric, measured at 0.065 m^2K/W. As the Ecocell™ content decreases and PET fiber content increases, the thermal resistance correspondingly decreases to 0.061 and 0.049 m^2K/W [16] [23].

For Interlock fabrics, the 100% Ecocell™ sample showed a higher thermal resistance of 0.075 m^2K/W compared to Single Jersey. The thermal resistance decreased to 0.057 m²K/W for the 70% Ecocell™/30% PET blend. The Interlock structure enhances heat retention capacity, thereby increasing thermal resistance [24].

In 1 × 1 Rib fabrics, thermal resistance values are somewhat lower depending on Ecocell™ content. The 100% Ecocell™ Rib fabric exhibited a thermal resistance of 0.068 m²K/W, which decreased to 0.052 m²K/W for the 70% Ecocell™/30% PET blend. The more elastic and porous nature of the Rib structure influences heat transfer properties.

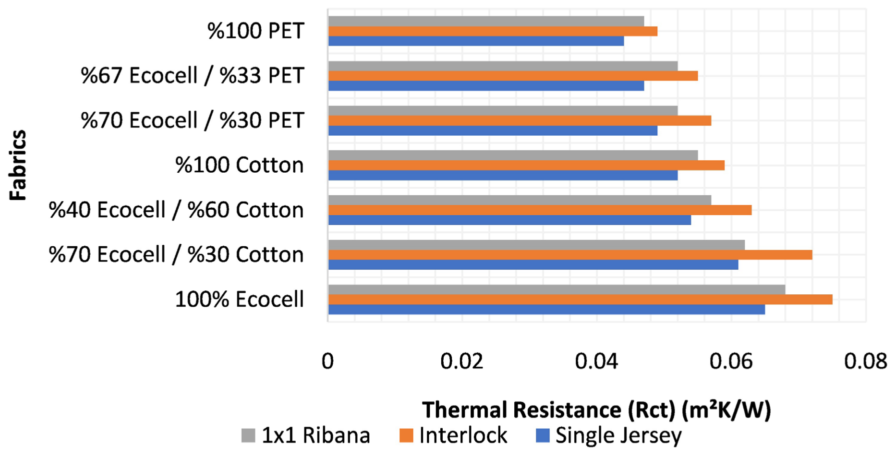

Figure 6. Thermal resistance results of knitted fabrics.

3.7. MVTR (Moisture Vapor Transmission Rate) Results

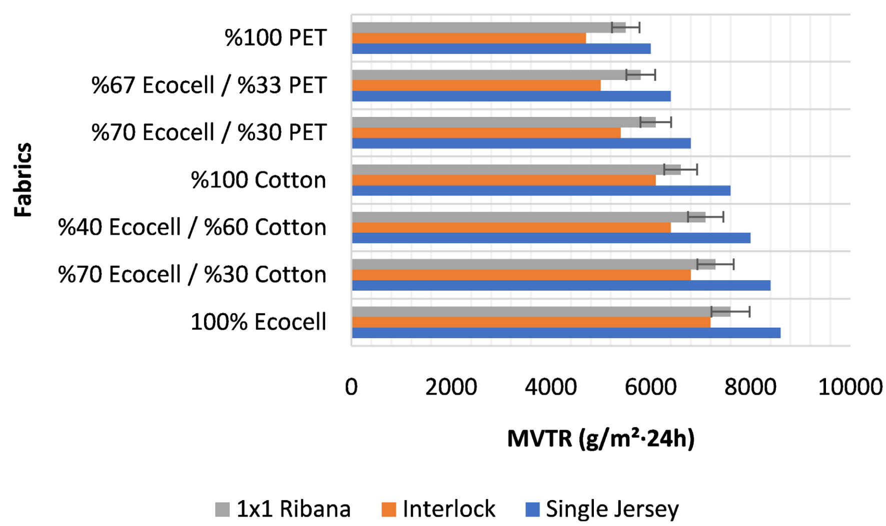

Figure 7. MVTR results of knitted fabrics.

Figure 7 illustrates that 100% Ecocell™ Single Jersey, Interlock, and 1 × 1 Rib knitted fabrics show moisture vapor transmission rates of 8600, 7200, and 7600 g/m²·24 h, respectively. The high water vapor diffusion and absorption capacities of Ecocell™ fibers optimize thermal comfort [25]. Despite cotton fibers having high moisture absorption capacity, they do not achieve the continuous moisture vapor transmission performance provided by Ecocell™. PET fibers, due to their hydrophobic nature, reduce MVTR values [26].

The structural differences of knitted fabrics significantly affect moisture vapor permeability. The loose structure of Single Jersey fabrics facilitates easy moisture passage, whereas the tighter structures of Interlock and 1 × 1 Rib reduce MVTR values [27]. Ecocell™ fiber-containing knitted fabrics in various structures improve moisture regulation while providing optimal durability performance.

4. Conclusions

In this study, the comfort properties of knitted fabrics with different fiber compositions (100% Ecocell™, Ecocell™/cotton, Ecocell™/PET, and 100% PET) and various knit structures (Single Jersey, Interlock, 1 × 1 Rib) were evaluated in terms of garment production. Based on the experimental results, the following conclusions were drawn:

1) The data indicate that knitted fabrics containing Ecocell™ fibers exhibit superior performance in terms of air permeability, thermal resistance, and moisture absorption (MVTR).

2) 100% Ecocell™ fabrics possess high moisture absorption capacity due to their hydrophilic nature. This characteristic enhances vapor permeability and provides softness on skin-contact surfaces, thereby reducing irritation risk and improving wearer comfort.

3) In terms of thermal conductivity, 100% Ecocell™ fabrics contribute to more effective thermal insulation.

4) Regarding abrasion resistance and bursting strength, PET-containing blends (e.g., 70% Ecocell™/30% PET and 67% Ecocell™/33% PET) demonstrate superior mechanical performance; however, their air permeability and moisture transfer values are relatively lower.

5) Dimensional stability tests showed that 100% PET fabrics exhibit minimal deformation, whereas shrinkage values increased with higher proportions of cellulosic fibers after washing.

In conclusion, 100% Ecocell™ fabrics provide optimal solutions for comfort-focused applications, while PET-blended knitted fabrics are more suitable for areas requiring enhanced durability.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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