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ORIGINAL ARTICLE

Influence of Tencel/cotton blends on knitted fabric performance

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Abstract The requirements in terms of wearing comfort with sportswear, underwear and outerwear are widely linked to the use of new fibers. Today, Tencel fiber is one of the most important developments in regenerated cellulosic fiber. However, the relation between Tencel fiber properties and fabric characteristics has not been enough studied in the literature especially the influence of fiber materials on mechanical, Ultraviolet Protection Factor (UPF) and absorption properties. Therefore, in this study, knitted fabric samples were manufactured with eight different yarns with two fabric types (single jersey and single jersey with Lycra). 30/1-Ne yarns from natural and regenerated cellulosic fibers: 50% Tencel-LF/50% cotton, 67% Tencel-LF/33% cotton, 67% Tencel-STD/33% cotton, 70% bamboo/30% cotton, 100% bamboo, 100% Modal, 100% Micro-Modal and 100% cotton were employed. Then, all the produced fabrics were subjected to five cycles laundering and then flat dried. The results show that 67% Tencel-LF/33% cotton has more flexural rigidity and withdrawing handle force than 67% Tencel-STD/33% cotton fabric, while 67% Tencel-STD/33% cotton has a merit of durability during bursting test. Blending Egyptian cotton fibers with bamboo and Tencel as in 70/30% bamboo/cotton and 50/50% Tencel-LF/cotton improve UPF of the produced fabric.

1. Introduction

Regenerated cellulose fibers are increasingly used in apparel production driven by the continuous improvement of their inherent qualities and introduction of new brands in the market like TENCEL. This study aimed at studying and comparing Tencel fibers to other regenerated cellulosic fibers and their blends with cotton.

The natural and regenerated cellulose fibers maintain their reputation, where it provides apparels the best softness, strength and good appearance.

Cellulose fibers are included in the group of high comfort fibers. One of the essential developments in new regenerated cellulosic fiber technology is "TENCEL Fibre Process" which is the recorded trademark of Courtaulds Fibres Ltd. Company that uses N-methyl-morphine-N-oxide (NMMO) that is used to dissolve cellulose. The generic name for Tencel is Lyocell [1].

The versatility of this fiber produces outstanding fabrics for both men's and women's casual and tailored wear, as well as women lingerie. Furthermore, the reason for its current emer-

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gence on the market is that Lyocell fiber has the advantage of being used in a less contaminant spinning process than the one for conventional viscose [2–5].

Lyocell is produced from wood pulp using a solvent spinning process. More than 99% of the solvent is recycled within the process, making the fiber production really environmentally accountable. The standard fiber produced is 1.4 dtex, 38 mm, but it can be produced in a range of linear densities and staple lengths. The fiber has a smooth surface and a round cross section, giving high luster in the raw state [6].

The Tencel fiber has a circular cross-section and it has a smooth surface as a result of its spinning process, where the cellulosic fibers undergo quick and high penetration of solvent which leads to consistent coagulation. The special spinning method of Tencel from conventional viscose fiber causes the formation of very long exclusive crystalline arrangement of its cellulose units which are extremely greatly oriented in the longitudinal axis of the fiber [7].

These factors cause significant differences in fiber properties. Tencel fibers have a high degree of crystallinity and are composed of elementary fibrils, oriented nearly parallel to the fiber axis. Between some of the fibrils are long thin voids. When the fiber as a whole is hydrated, swelling occurs, which changes the void size shape and orientation. This leaves spaces in the structure across "filled amorphous regions" with which the crystalline units are connected by hydrogen bonding [6,8].

Lyocell fibers are characterized by their high strength in both dry and wet states. Standard Lyocell fibers, in comparison with other cellulose fibers (viscose), have a higher breaking strength, either wet or dry. In the wet state, Lyocell keeps 85% of its dry strength and is the only man-made cellulosic fiber which is stronger than cotton at the wet state. Also, enormous differences exist between Lyocell and cotton in both thermal transmission and vapor permeability [1,5].

Lyocell fibers absorb moisture and have a high modulus that causes small shrinkage in water. Like all cellulose fibers, Lyocell fiber absorbs water perfectly and gives hygienic properties to textile products. Tencel fabrics and garments exhibit superior stability when washed [1,5,6].

Additionally, fabrics in Tencel are characterized by their silky handle, distinctive drape and fluidity. Tencel is an outstanding alternative to cotton and plays an important position in the textile market for fashion wear, bed linen, towels, etc. Tencel can be successfully used in the production of underwear and apparels. They can also be used in technical textiles, nonwovens and foils. Tencel fibers show huge advantages in adapting to the requirements of the end product both when spun alone and in different blends particularly with cotton. The additions of Tencel to cotton have also a positive impact on yarn mechanical properties especially tenacity and elongation, and on spinning stability [1,5,9].

Textile fabrics made of Lyocell staple fibers undergo controlled fibrillation and defibrillation by specific finishing processes. Fibrillation is one of the mainly essential physical properties of Tencel fiber. Lyocell fibers are distinguished by their specific ability to fibrillate in a wet state under the impact of external mechanical effects. Fibrillation means the detachment of fibrils along the fabric surface of individual fibers swollen in water, which is caused by mechanical aggression action.

Swelling of the porous regions of the fiber breaks the hydrogen bonds connecting the crystalline units and forces them away from each other. Mechanical action causes the external crystalline regions to break and peel away from the foremost fiber. These peelings are called fibrils. The fibrillation effect can be applied to benefit from generating fabrics of good-looking appearance and attractive handle "peach skin effect" [10,11].

Dziworska et al. [12] and Ibbett and Hsieh [2] studied the effect of liquid swelling on the structural rearrangement of Lyocell twill fabrics using different techniques. Fabrics with Tencel fiber wefts were distinguished by superior crease resistance in comparison with fabrics with cotton and viscose wefts. Furthermore, fabrics with Lyocell weft fiber showed greater air permeability in comparison with fabrics with cotton and viscose wefts.

Bamboo fiber is a kind of regenerated cellulose fiber, generated from bamboo pulp. Bamboo fiber is famous as the natural, green and eco-friendly textile material. Bamboo fiber has some distinctive properties such as natural anti-bacteria and breathable. Bamboo fibers are also important for clothes and other textile applications such as filters and medical [13,14].

While some good studies have been made to investigate and evaluate the properties of Tencel fiber blended yarns, there is a lack of in depth study on the performance of Tencel fabric properties. Consequently, the aim of this present study was to produce knitted fabrics with better comfort properties by utilizing the excellent characteristics of Tencel fibers. For this aim, we focus to explore some mechanical, ultraviolet protection and moisture transport behavior of these knitted fabrics.

2. Material and methods

2.1. Material

In this study, 30/1, 50% Tencel LF/50% cotton, 67% Tencel LF/33% cotton, 67% Tencel STD/33% cotton, 70% bamboo/30% cotton, 100% bamboo, 100% Modal, 100% Micro Modal and 100% Egyptian cotton yarns are used to knit single jersey and single jersey with Lycra knitted fabrics. The properties of the Egyptian cotton Giza 88 used in this research work are given in Table 1. Also, the properties of the Tencel, Bamboo, Modal and Micro Modal fibers are cleared in Table 2. Moreover, Table 3 shows the properties of the yarns applied in this work.

2.2. Fabric manufacture

The single jersey and single jersey with Lycra samples were produced on the same knitting machine with 24 gauge, Santoni S.P.A., SJ-B model, 18-in. diameter, 54 feeders and with total number of needles equal to 1356.

The loop length was kept constant at 2.8 mm value for all the knitted samples. Also, the yarn input tension was kept constant at a value equal to 5 CN.

After that, all fabric samples were subjected to a repeated laundering process (five cycles) under AATCC standard and then flat-dried. The specifications of all the knitted fabric samples are shown in Table 4.

Table 1 Cotton fiber properties.

	Length	Uniformity %	Strength	Elongation %	MIC	Rd	b+	Trash count	Maturity %
Cotton Giza 88	35.1	87.3	45	3.78	3.96	67.1	11.5	40	85

Table 2 Regenerated fibers properties.

Fiber type	Fiber length (mm)	Fiber fineness (dtex)
Tencel (LF-STD)	38	1.3
Bamboo	38	1.6
Modal	39	1.3
Micro modal	39	1

2.3. Methodology

The influence of the experimental factors such as fiber material and fabric structure on the fabric mechanical, ultraviolet protection and moisture transport properties is evaluated for significance using the analysis of variance.

2.4. Fabric testing

After keeping the finished samples 72 h in standard conditions (relative humidity = 65 + 2% – temperature = 20 + 2 °C), the fabric properties were measured.

The fabric ball burst strength and air permeability (at 125 Pa) were evaluated in accordance with the standards of ASTM D6797 and ASTM D737 respectively. Abrasion resistance was evaluated according to ASTM D4158 (at a pressure of 500 grams and abrasion wheels CS-10). Flexural rigidity was determined according to ASTM-D1388 (Heart Loop Test). The sample dimension was 20 cm stripe length and 2.5 mm width. A strip of the fabric was formed into a heart shaped loop, where the length of the loop is increased after hanging vertically under its own mass. Record the loop length and convert its reading to bending length by using a standard table directly. Lastly, Flexural rigidity is expressed by using the following equation:

$$\text{Flexural rigidity ``}\mu\text{J/m''} = \text{fabric g/m}^2 \times \text{bending length (cm)} \times 1.421 * 10^{-4}$$

Additionally, ultraviolet protection factor was measured according to AS/NZS 4399 standard. A fabric's ability to keep its wearer from ultraviolet radiation is described as its Ultraviolet Protection Factor (UPF). UPF is a measure that linked to the time taken before human skin begins to redden after exposure to ultraviolet light. When radiation attacks a textile surface some components are reflected, some are absorbed, and some pass through it. The more the amount of radiation able to pass across the textile, the lower the UPF. In addition, water vapor permeability was measured using ASTM E 96 – "Standard Test method for Water Vapor Transmission of materials" – cup method. The circular sample was put firmly covering a cup filled with distilled water. Under the action of a difference of concentration (pressure), water vapor is passed out from inside of cup to environment (outside of cup). Finally, handle force was measured by the fabric hand-meter using the principle of the withdrawing the fabric sample through a circular ring where there is a force generated during withdrawing the sample through this ring. The maximum value of the force happens when the whole specimen has almost passed through the ring.

3. Results and discussion

The influence of the fiber material and fabric type on some fabric properties was discussed for significance using R statistical program by applying the ANOVA analysis as shown in Table 5.

It is obvious from the statistical and experimental evaluation that all the studied properties such as flexural rigidity, abrasion resistance, ultraviolet protection factor, air permeability and water vapor permeability values are significantly affected at 5% significance level by fiber type and fabric type.

3.1. Bursting strength

The bursting strength of all studied fabrics is influenced by fiber type and fabric type as shown in Fig. 1. The fiber type and fabric type have significant effect on bursting strength of all knitted samples. The single jersey fabrics made from Tencel/cotton blended yarns show maximum bursting strength compared with all other studied fabrics. The structural

Table 3 Yarn properties.

	Cotton 100%	Bamboo 100%	Modal 100%	Micro modal 100%	Bamboo/cotton (70:30%)	Tencel LF/cotton (50:50%)	TENCEL LF/cotton (67:33%)	TENCEL STD/cotton (67:33%)
Yarn count (Ne)	30/1	30/1	30/1	30/1	30/1	30/1	30/1	30/1
TPI	19.6	19	20.3	19.7	21.16	18.15	20.29	20.29
Irregularity (CV %)	9.52	9.23	10.8	11	12.93	8.00	11.65	9.41
Thin places (−50%)	2	0	0	0	0	0	0	0
Thick places (+50)	18	14	6	9	11	26.3	18	7
Neps	67	45	20	38	32	39.6	57	25
CN/Tex	17.16	13.11	26.4	27	14.61	20.53	21.59	20.19
Elongation (%)	5.22	12.66	11	11.5	7.26	4.73	5.04	7.04
Hairiness (H)	6.23	4.7	6.4	6	4.87	5.26	6.18	5.93

Table 4 Specification and properties of the knitted fabric samples.

Sample no.	Fiber type	Fabric structure	Courses (cm)	Wales (cm)	Fabric weight (g/m^2)	Thickness (mm)
1	50% Tencel LF 50% cotton	SJL	36	18.8	336.5	0.768
2	100% Bamboo	SJL	37.6	21.2	346	0.917
3	67% Tencel STD 33% cotton	SJL	37.2	18.4	348.5	0.783
4	70% bamboo 30% cotton	SJL	38.4	18.8	364.5	0.81
5	67% Tencel LF 33% cotton	SJL	34.4	18	349.5	0.813
6	100% Modal	SJL	34	20.4	398	0.785
7	100% Cotton	SJL	34.4	18	295	0.726
8	100% MicroModal	SJL	38.4	20	411	0.826
9	100% MicroModal	SJ	20	16	141.5	0.4415
10	100% Cotton	SJ	24	15.6	177	0.577
11	100% Bamboo	SJ	22.8	16	154.5	0.4295
12	100% Modal	SJ	21.2	14.8	133	0.559
13	70% bamboo 30% cotton	SJ	23.6	16.4	177.5	0.4326
14	67% Tencel STD 33% cotton	SJ	23.2	16.4	168.5	0.582
15	50% Tencel LF 50% cotton	SJ	22.4	16	160	0.502
16	67% Tencel LF 33% cotton	SJ	22.4	16.4	163	0.542

characteristics of Tencel fibers reveal their good mechanical properties. The special properties of Tencel fibers are higher strength, high degree of crystalline and molecular orientation in comparison with other fiber types [15].

Moreover, the fibrils covered the 67% Tencel STD/33% cotton fabric gives a protective layer against bursting stress than 67% Tencel LF/33% cotton single jersey fabric.

Furthermore, single jersey with Lycra samples gives less bursting strength values than plain single jersey for all studied samples despite its higher g/m^2 and thickness. The compactness characteristics of single jersey with Lycra fabrics makes the fabric to be stiffer which weaken the fabric during penetrating it.

3.2. Abrasion resistance

According to the statistical analysis and Fig. 2, there is a significant relationship between the fiber type and the single jersey fabric abrasion resistance. Fig. 2 indicates the relationship between fabric abrasion resistance and fiber type. Where, it is observed that single jersey 67% Tencel LF/33% cotton and 50% Tencel LF/50% cotton have a higher abrasion resistance than 100% cotton fabrics. This is due to the highest tensile strength of Tencel fiber against cotton which makes it to be more durable during abrasion test. The Tencel fibers have merits of smoothness and softness against cotton fiber.

The surface fibers of standard Tencel STD are fibrillated to produce a luxurious, soft-touch fabric with a peach skin surface and this is the usual recognized quality of the fiber. So, Fibrillation features of Tencel STD are observed. As a result, during the abrasion resistance test, the resultant friction force between the abraded paper and the Tencel STD fabric will be high, which decreases the abrasion resistance of this fabric.

The micro fibers constituting the micro modal fabric affect negatively the abrasion sustainability of this finest fabric. These fibers are finer and as a result are more prone easily to be destroyed under abrasion force.

Single jersey with Lycra fabric has a higher abrasion resistance than single jersey fabric without Lycra. This is due to the higher density and thickness of this fabric.

3.3. Flexural rigidity

Single jersey fabric produced from 100% cotton has higher flexural rigidity values than the other studied fabrics, Fig. 3. Also, the variance analysis obviously clears that the fiber material does play an important role in influencing flexural rigidity of the studied fabrics. In addition, it is noticed that 100% bamboo, 100% modal and 100% micro modal fabrics have a lower flexural rigidity than 50% Tencel LF/50% cotton, 67% Tencel LF/33% cotton, 67% Tencel STD/33% cotton and 70% Bamboo/30% cotton. This case could be due to the fact that blending of regenerated fibers with cotton fibers decreases the flexural rigidity of the resultant fabric. As well, the cotton yarns have the greatest hairy level and flexural rigidity, so, the knitted loops cannot be compressed by far in this manner increasing the fabric thickness. Also, the fabrics produced from cotton fiber have a higher g/m^2 and thickness than others knitted from other regenerated fibers. Furthermore, the Tencel, bamboo, and micro modal yarns have the least hairy level and flexural rigidity than cotton.

Table 5 ANOVA test results.

Process factors	Fabric properties						
	Bursting strength	Abrasion resistance	Fabric flexural rigidity	Handle force	U.P.F	Air permeability	Water vapor permeability
Fiber type	S	S	S	S	S	S	S
Fabric type	S	S	S	–	–	S	S

S = significant at 95% confidence level, NS = non significant at 95% confidence level.

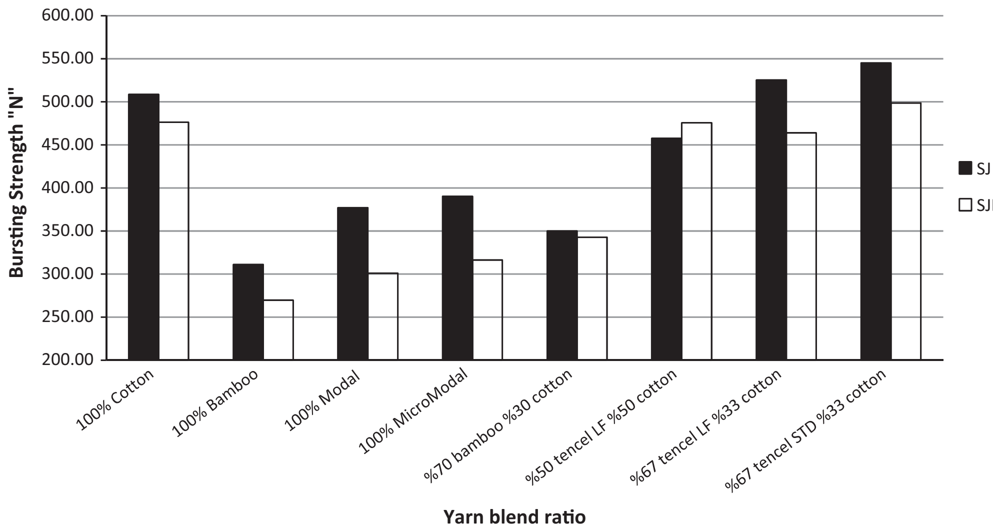

Figure 1 Bursting strength at different fiber types for different fabric types.

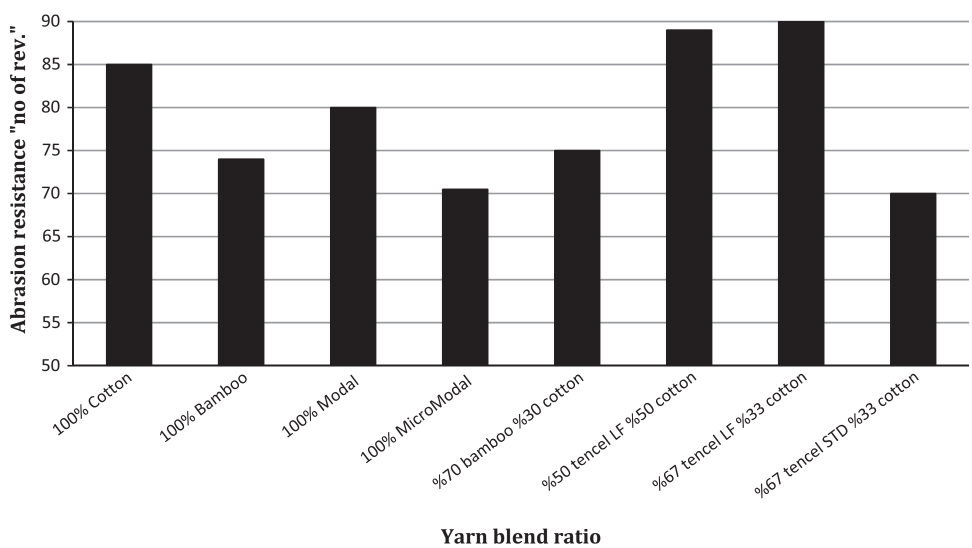

Figure 2 Fabric abrasion resistance at different fiber types for different fabric types.

Additionally, 67% Tencel LF/33% cotton fabric has more flexural rigidity than 67% Tencel STD/33% cotton fabric. The contribution of the fibers inside the yarn for the Tencel LF blend could be the reason of that trend.

On account of its higher thickness, the single jersey with lycra fabrics demonstrates extra flexural rigidity than single jersey samples. This tendency is clarified by the effect of the more material which contained in this fabric and makes the fabric thickness to be heightened.

3.4. Handle force

For this test property, the fabric specimen was pulled through a highly polished stainless steel cylindrical ring attached to the load cell. The load that is required to withdraw the fabric through the hole is measured and this gives a measure of handle force. The fabric is folded, compressed and rubbed against the interior wall of the ring during withdrawal and squeezed it to the dimension of the ring. This pulling force has a strong relation with the fabric weight, bending properties, the coefficient of friction and work of compression. The maximum withdrawal force can be taken as a measure of fabric handle force [16].

Cotton rich blends give higher values of withdrawal force as shown in Fig. 4. For fabrics containing Tencel/cotton blends, a marked improvement in withdrawal force is evident. As it can be seen the handle force for all Tencel/cotton blend fabrics is less than the 100% cotton which is referred to the higher fiber length and lower yarn hairiness level of this regenerated/cotton blends yarns. The smoothness degree accompanied with Tencel fibers decreases the friction between the fabric and ring surface during withdrawing the fabric through the ring.

Additionally, the greatest decrease for withdrawing force occurred in 100% micro-modal knitted fabrics. 70/30 Bamboo/cotton blended fabrics show the least improvement in handle compared with other 70/30 Tencel/cotton blends. This

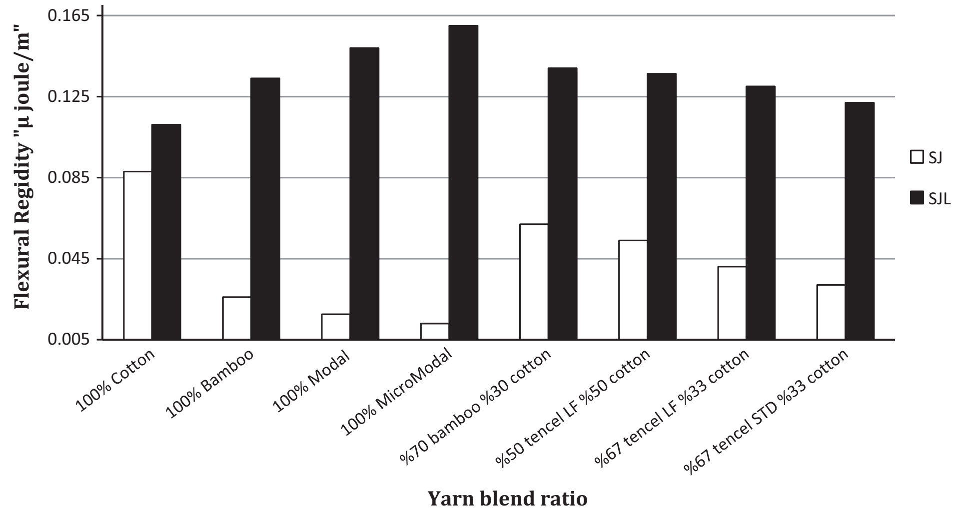

Figure 3 Flexural rigidity at different fiber types for different fabric types.

proves the high drapability behavior of the micro-modal and Tencel products and their low initial shear modulus.

There was no handle force values for single jersey with Lycra fabric, because the weight of this fabric is above the capacity of the ring.

3.5. Ultraviolet Protection Factor (UPF)

From Fig. 5, it could be seen the values of UPF "Ultraviolet Protection Factor" for single jersey with respect to fiber type. It is observed that blending Egyptian cotton with Tencel and bamboo fibers as obvious in all blended ratios, improves UPF characteristic of the final produced fabric. The possible reason of this is the highest ultraviolet protection property of the *naturally Egyptian cotton*. Also, the higher thickness and cover factor of these cotton fabrics could be the reason of this trend.

By investigating UPF of 70% Bamboo/30% cotton, 67% Tencel LF/33% cotton and 67% Tencel STD/33% cotton results, the Bamboo fibers have extra merits of resisting ultraviolet radiations compared to Tencel fibers. By comparing 100% bamboo with 100% modal and 100% micro modal values, the same conclusion could be reached.

Also, the fibrils covered the 67% Tencel STD/33% cotton fabric gives more layer of protection against UPF than 67% Tencel LF/33% cotton single jersey fabric.

There was no UPF chart for single jersey with Lycra fabric, because values of UPF are above the measuring limits of the device. The explanation of this behavior could be referred to the lycra fabrics that have a higher cover factor and density than single jersey fabric.

3.6. Air permeability

The results indicate that the air permeability of the single jersey 100% modal, 100% micro modal and 100% Bamboo samples is higher than the other fibers produced from cotton or blended with cotton as noticed in Fig. 6. Cotton convolutions are ribbon-like twists that characterize cotton. When cotton fiber matures, lumen dries out and collapses which makes

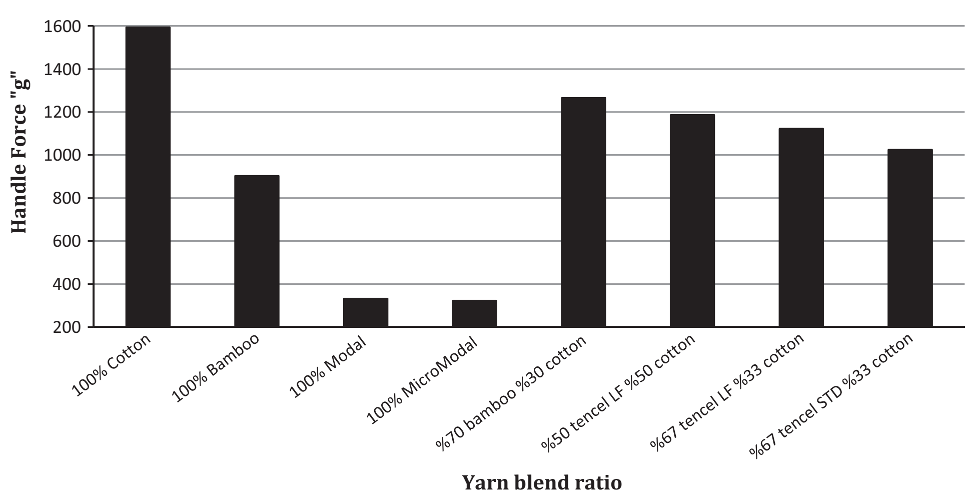

Figure 4 Handle force at different fiber types for different fabric types.

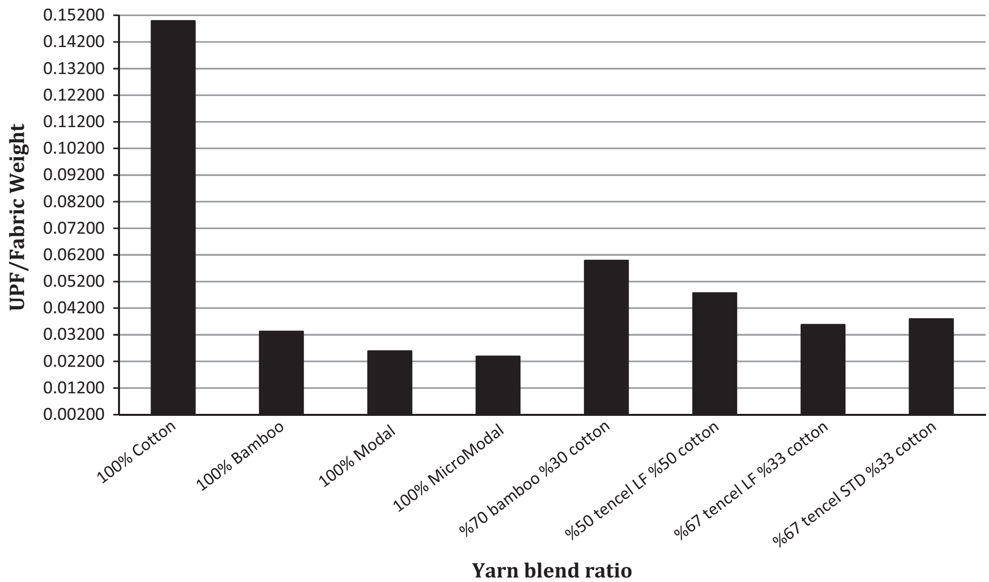

Figure 5 UPF at different fiber types for different fabric types.

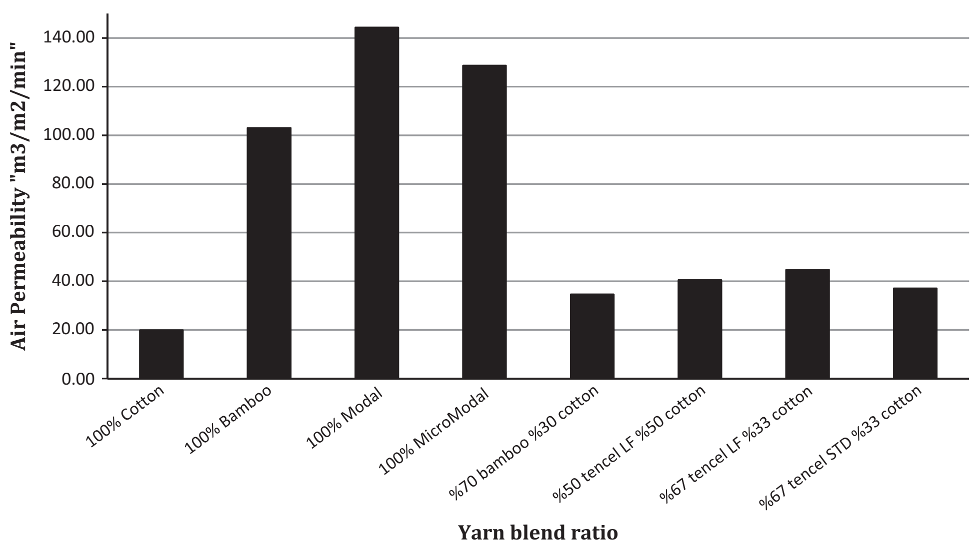

Figure 6 Air permeability at different fiber types for different fabric types.

secondary wall start to twist. These fibers convolutions besides extra cotton yarn hairiness enhance the air resistance of the cotton samples. Furthermore, blending cotton with Tencel fibers worsens the air permeability level of the produced fabric with the knowledge that the Tencel fiber has its air conditioning naturally.

The air permeability reduces with the increase of the fiber fineness. Therefore, the air permeability for the 100% micro modal fabrics is lower than the 100% modal fabrics having the coarsest fibers. It is normally acknowledged that the air permeability of a fabric depends on the air porosity that affects its openness. The more porosity the fabric has, the extra the porous fabric is acquired. For the 100% micro modal, the space inside the yarn reduces due to the existence of the high number of fibers/yarn cross-section. Thus, the fabrics knitted from these yarns have less open and permeable structures and consequently less air permeability values.

The air permeability value of the 100% bamboo fabric is lower than that of the modal sample. This may be partly attributed to the fact that bamboo fibers have some striated cracks distributed over the longitudinal surface, and they have many voids in their cross section [7]. This might have heightened the friction between the fiber surface and the air, creating a reduction in the air permeability of fabrics knitted from these fibers.

Single jersey with Lycra fabrics has less air permeability than normal single jersey fabric. This is because Lycra reduces air gabs in fabric.

3.7. Water vapor permeability

Water vapor permeability is the ability of the fabric to transfer the perspiration in the form of moisture vapor throughout it. This property is measured by observing the amount of water vapor passing through a square meter of fabric per

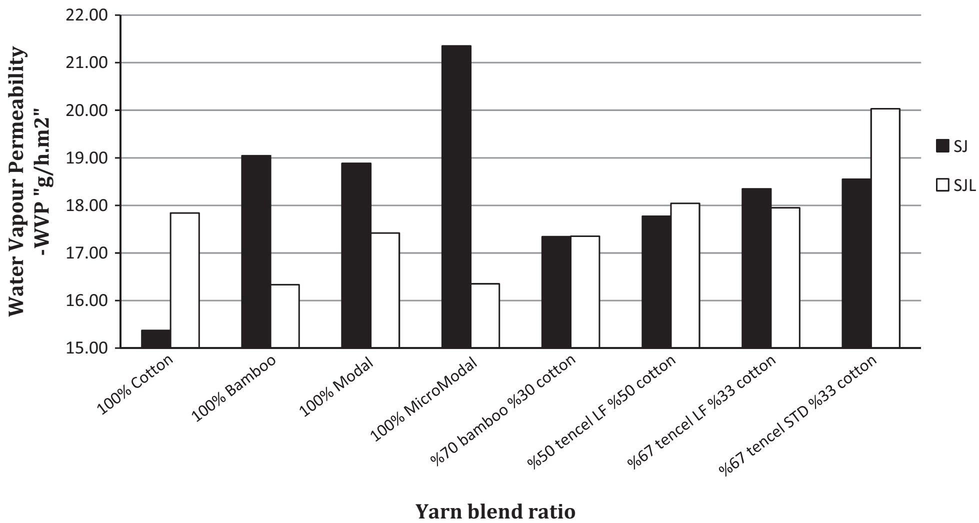

Figure 7 Water vapor permeability for different fiber types at different fabric types.

twenty-four hours. A fabric with less water vapor permeability is incapable to transfer enough moisture, leading to sweat accumulation and discomfort.

From Fig. 7, it could be seen the values of fabric water vapor permeability with respect to fiber type for different fabric types. It is observed that the single jersey knitted fabric produced from 100% micro modal yarn has the highest water vapor permeability. This fiber type is the best to get the superior water vapor permeability. The fiber fineness of the micro modal affects the smoothness of its fabrics. The increase in the fiber fineness guarantees smoother fabrics. A smooth surface increases the contact area of a fabric with a skin and consequently it has influence on its sensation level and provides cool feeling effect.

The overall water vapor transport is a sum of the water vapor transmission throughout air space existing as voids formed at yarn interstices, and air between fibers and yarns and moisture absorbed by fibers [17]. In a fabric composed of significantly finer fibers, more fibers can be accommodated in a given space than an equal volume of coarse fibers [18]. The hydrophilic nature of the Tencel fibers for the 67% Tencel LF/33% cotton and 67% Tencel STD/33% cotton against 70% Bamboo/30% cotton yarns might have enhanced the easy passage of water vapor molecules through the yarn interior. This might be the reason for the high water vapor transfer rate obtained for these Tencel blended fabrics.

Moreover, the water vapor transfer rate was mainly affected by the regain of the fabrics. Accordingly, the highest water vapor transfer rate, obtained for 100% Bamboo fabric, could be attributed to its highest regain. Also, single jersey with Lycra fabrics has less water vapor permeability than single jersey fabric.

4. Conclusion

The single jersey fabrics made from Tencel/cotton blended yarns show maximum bursting strength compared with all other fabrics. Also, the fibrils covered the 67% Tencel STD/33% cotton fabric gives a protective layer against bursting stress than 67% Tencel LF/33% cotton single jersey fabric.

Single jersey with Lycra samples gives less bursting strength values than plain single jersey for all studied samples despite its higher g/m^2 and thickness.

67% Tencel LF/33% cotton and 50% Tencel LF/50% cotton have a higher abrasion resistance than 100% cotton single jersey fabrics. Moreover, fibrillation features of Tencel STD fabric decrease the abrasion resistance of this type of fabric.

The single jersey fabrics produced from Tencel and Bamboo/cotton blends or from 100% cotton have higher flexural rigidity than all other fabrics. 67% Tencel LF/33% cotton has more flexural rigidity than 67% Tencel STD/33% cotton fabric, which is related to the contribution of the fibers inside the yarn for the Tencel LF blend.

The high drapability behavior of the micro-modal and Tencel products and their low initial shear modulus show decrease for handle withdrawing force compared with 100% cotton single jersey sample.

Blending Egyptian cotton with Tencel and bamboo fibers improves UPF characteristic of the final produced fabric. Bamboo fibers have extra merits of resisting ultraviolet radiations compared to Tencel fibers as cleared in all 70/30 blended ratios. The same conclusion could be reached for all 100% studied fibers.

Fibrils covered the 67% Tencel STD/33% cotton fabric gives more layer of protection against UPF than 67% Tencel LF/33% cotton fabrics.

Blending cotton with Tencel fibers decreases the air permeability level of the produced fabric although the merit of the Tencel fiber has its air conditioning naturally. The air permeability reduces with the increase of the fiber fineness as obvious for the 100% micro modal fabrics compared with 100% modal fabrics.

Single kersey knitted fabric produced from 100% micro modal yarn has the highest water vapor permeability, where this fiber type is the best to get the superior water vapor permeability. The hydrophilic nature of the Tencel fibers for the 67% Tencel LF/33% cotton and 67% Tencel STD/33% cotton against 70% Bamboo/30% cotton yarns enhanced the easy passage of water vapor molecules through the yarn interior.

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