An Investigation Of Knitted Fabric Performances Obtained From Different Natural And Regenerated Fibres

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Abstract-Although synthetic fibres are widely used in clothing production, they can never provide the comfort properties as much as that of the natural fibres. Therefore, natural fibres keep going their importance. On the other hand, nowadays, new generated synthetic fibres having different structure are produced and introduced under different trade names by different firms. They all claimed that these synthetic fibres offer comfort performance as that of the natural fibres. In this study, we aimed to determine some using performance properties of the fabrics knitted from natural fibres such as cotton, wool and regenerated fibres such as bamboo, and also conventional and new generated synthetic fibres such as Coolmax polyester etc. For this aim, we focus on air permeability, water vapour permeability, water absorption, fire retardant property and also pilling behaviour of these fabrics. In the scope of the study, we used the yarns with the same yarn count and twist level to compare the fabric performance properties. Also all yarns were knitted with the same fabric structure and loop density.

Keywords- Cotton, bamboo, new generated fibres, air permeability.

Farklı Doğal Ve Rejenere Elyaflardan Elde Edilen Örme Kumaş Performansları Üzerine Araştırma

Özet-Sentetik lifler giysi üretiminde yaygın olarak kullanılmalarına rağmen doğal liflerinki kadar konfor sağlamamaktadırlar. Bu nedenle doğal lifler önemini korumaktadır. Öte yandan, günümüzde farklı yapılara sahip yeni nesil sentetik lifler üretilmekte ve farklı firmalar tarafından farklı ticari isimler tanıtılmaktadırlar. Söz konusu firmalar bu sentetik liflerin doğal liflerinki kadar konfor performansı sunduğunu iddia etmektedirler. Bu çalışmada, pamuk ve yün gibi doğal ve bambu gibi rejenere ve ayrıca Coolmax polyester gibi yeni nesil sentetik liflerden mamul örme kumaşların son kullanım performanslarının belirlenmesini amaçladık. Bu amaçla, kumaşların hava geçirgenliği, su buharı geçirgenliği, su emiciliği, güç tutuşurluğu ve ayrıca boncuklanma davranışlarına odaklandık. Çalışma kapsamında kumaş performans özelliklerini karşılaştırmak için aynı numarada ve aynı büküm katsayısına sahip iplikleri kullandık. Ayrıca tüm iplikler aynı kumaş yapısında ve ilmek sıklığında örüldü.

Anahtar Kelimeler- Pamuk, bambu, yeni nesil lifler, hava geçirgenliği.

1. INTRODUCTION

It is demanded that clothing should have different protection properties against to outer effects such as hot, cold, wind, rain, UV radiation of sun, microbial attack etc. according to their usage area in addition to covering of the body. In addition to all of these properties, nowadays, it is expected that cloths should also give comfort to user. Therefore, production of clothings having comfort properties and so offering high life quality is getting more popular. For this aim, both of scientific researches and studies and big investments of private textile producers have been realized. One of these attempts focused on the fibre spinning field. Nowadays, synthetic fibre producers have been producing new generation, functional fibres that offer comfort to user beside covering and protection such as UV, antimicrobial etc. Although these new generation fibres are made of polyester polymer, they have just special cross section. It is claimed that these fibres improve the factors effecting clothing comfort with their physical structural changes.

In this study, the fabrics produced from some natural and synthetic fibres such as bamboo, cotton, wool, acrylic and also new generation polyester Coolmax® and Thermolite® were tested to determine the properties that affect the fabric comfort such as water absorption, quick dry, air permeability and pilling behaviour during the usage.

In the literature, there are the studies about the thermal comfort properties of the one or multi layer fabrics produced from different fibres and their mixture with other fibres. In these studies, it was especially focused on the analysis of test methods for the evaluation the comfort properties of these fabrics and all parameters affecting the fabric comfort (1, 2). However, this study focuses on comparing the properties of fabrics produced from different fibres affecting to clothing comfort.

2. MATERIAL AND METHOD

2.1. Fabric Production

To determine the comfort properties of the fabrics, it was used eight different yarns produced from natural fibres such as cotton, wool and regenerated fibres like bamboo and also synthetic fibres such as acrylic and new generated synthetic fibres such as undyed and dyed Coolmax and Thermolite. Therefore, eight different fibre types were used. All the yarns have the same yarn count (Ne 20/1) and also the same twist multiplier (αe=3,6). The yarns were knitted into plain-jersey fabrics on the same circular sock knitting machine having the same fabric density.

2.2. Test Methods

Pilling Behaviour

Pilling is a very serious problem for the fabrics that arises after the usage of the fabric. Pills are formed by a rubbing action on loose fibres. They are present on the fabric surface and cause an unpleasant appearance (3). Pilling behaviour of all fabrics was tested on the Nu-Martindale Abrasion Tester according to TS EN ISO 12945-2. According to the pilling test, the fabric is mounted both in the holder and on the base plate so that it is rubbed against itself. After a certain cycle, the fabric from the holder is usually assessed and given a scale according to standard fabric photograph. The scales start from grade 5 (no pilling) to grade 1 (severe pilling).

Air Permeability

The air permeability of a fabric is a measure of how well it allows the air passage through the fabric. Air permeability is defined as the volume of air in millilitres which is passed in one second through 100 mm^2 of the fabric at a different pressure (3). Ten tests were done on Textest FX 3300 air permeability test instrument for each fabric type at the same air pressure (100 pascal) according to test method of TS 391 EN ISO 9237.

Water Vapour Permeability

Perspiration is an important mechanism which the body uses to lose heat when its temperature starts to rise. However perspiration disturbs the comfort of person. There are two forms of perspiration. These are insensible and liquid. Insensible sweat is transported as a vapour and it passes through the air gaps between yarns in a fabric. On the other hand liquid perspiration occurs at higher sweating rates and it wets the clothing. The insensible perspiration removing ability of a fabric is measured by its moisture vapour permeability in grams of water vapour per square metre per 24 hours. The fabric having low moisture vapour permeability is unable to pass sufficient perspiration and this leads to sweat accumulation in the clothing and hence discomfort (3). Water vapour permeability of fabrics was tested by using Labthink TSY-W1 Water Vapour Permeability tester. Water vapour permeability values were measured according to test method ASTM E 398.

Water Absorption

In order to keep the wearer dry and hence comfortable, clothing should have the absorbing ability of the liquid sweat in contact with the skin. In this study, it was used the static immersion method to evaluate water absorption amount according to BS 3449 and calculated the water absorption in terms of following equation (3). Eight specimens were tested for each fibre type. The mean percentage of water absorption is calculated.

$$\text{Water absorption} = \frac{AbsorbedWaterMass[g]}{DryMass[g]} \quad (1)$$

Drying Behaviour

Moisture transfer is a critical factor of thermoregulation of the body heat. Moisture on the skin or clothing increases the heat loss of the body and also affects the overall performance and endurance of the body. As it is mentioned above, clothing should have the absorbing and also quick dry abilities. To determine the drying behaviour of the fabrics, the fabrics got wet according to static immersion method were dried in drying oven at 30ºC for 30 minutes to simulate the natural drying. After they were taken out, the fabrics were weighed and the amount of water loss is calculated as the differences in wet and dry mass. And also, the drying time of the fabrics were determined according to the method which the wet fabrics reach their dry mass.

Flame Retardant Properties

Flame retardant properties of fabrics were determined by using 45^0 inclined flame retardant BV AFC Auto test instrument referenced by ASTM D1230-94(2001). According to method, a flame is applied to the fabrics for 2 seconds. If the burning starts, the burning time is recorded and the fabric is classified according to this time.

In the study, all the test results were analysed statistically according to the multiple comparisons method of One Way ANOVA to determine any significant differences.

3. RESULTS AND DISCUSSION

3.1. Pilling Behaviour

Table 1 shows the differences in the pilling rates of the fabrics produced from different fibres.

Table 1. Pilling behaviour of the fabrics obtained from different fibres

	Cotton	Bamboo	Coolmax (Undyed)	Coolmax (Dyed)	Wool	Acrylic	Thermolite (Undyed)	Thermolite (Dyed)
125 cycles	4-5	4-5	3-4	3-4	5	5	4-5	3-4
500 cycles	3	4	2-3	3	5	3-4	4	3
1000 cycles	2-3	3-4	2	3	5	3-4	3-4	3
2000 cycles	2	3	1-2	2-3	4-5	2-3	2-3	2-3
5000 cycles	1-2	2-3	1-2	2	4-5	2	3	2-3
7000 cycles	1	2	1	2	4-5	1-2	2-3	2

Pilling rate results show that wool fabric has the best pilling resistance while the fabrics obtained from cotton, undyed-Coolmax and acrylic fibres have severe pilling. On the other hand, bamboo, dyed/undyed-Thermolite and dyed-Coolmax fibres are similar pilling behaviour and the rates are better than that of the cotton, undyed-Coolmax and acrylic fabric.

The differences in pilling behaviour of the fabrics can result from the differences in the fibre structure, especially fibre surface. Especially, scales on the wool fibre surface might improve pilling resistance while fibre surface consisting of the small channels of the Coolmax fibre might lead to lower pilling resistance.

3.2. Air permeability

As it is seen in Figure 1, undyed-Thermolite fabric has the highest air permeability values while acrylic fabric has the lowest values and the differences between the values of these fabrics are also statistically important. On the other hand, the air permeability values of dyed-Thermolite and bamboo are similar and they follow that of the undyed-Thermolite fabric. Although undyed/dyed-Coolmax has a bit higher air permeability values than that of the cotton and wool, the values are statistically similar.

Thermolite fibre is a synthetic fibre, like Coolmax, acrylic. But its structure is developed as hollow-core to provide warmth and to trap the air for greater insulation (4). Therefore, this hollow-core structure might give higher air passage. On the other hand, bamboo fibre also gives higher air permeability values because of the micro spaces in the fibre structure.

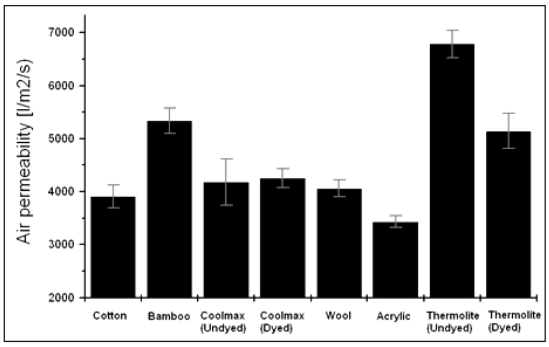

Figure 1. Air permeability values of the fabrics measured at the pressure of 100 Pa

3.3. Water Vapour Permeability

The water vapour permeability results of the fabrics are given in Table 2.

Table 2. Water vapour permeability values of the fabrics produced from different fibres

Fabric Type	Water Vapour Permeability (g/m^2 24h)
Cotton	4843,29
Bamboo	4217,85
Coolmax (undyed)	7606,16
Coolmax (dyed)	6115,88

Wool	4368,49
Acrylic	6054,11
Thermolite (undyed)	5795,17
Thermolite (dyed)	5795,17

According to Table 2, undyed/dyed Coolmax fabrics have the highest water vapour permeability values while bamboo, wool and cotton fabrics have the lowest ones. Physical channels on the fibre surface of Coolmax may give rise to higher water vapour permeability. On the other hand, the fibre structure having micro spaces or hollow core can not affect the water vapour permeability.

3.4. Water Absorption

Water absorption amounts of the fabrics were determined according to the Equation 1 and given in Figure 2.

As it is seen in Figure 2, undyed-Coolmax fabric has the highest water absorption amount while the wool fabric has the lowest amount in comparison with that of all the fabrics. On the other hand, dyed-Coolmax and undyed/dyed-Thermolite have statistically similar values and their values follow that of the undyed-Coolmax fabric.

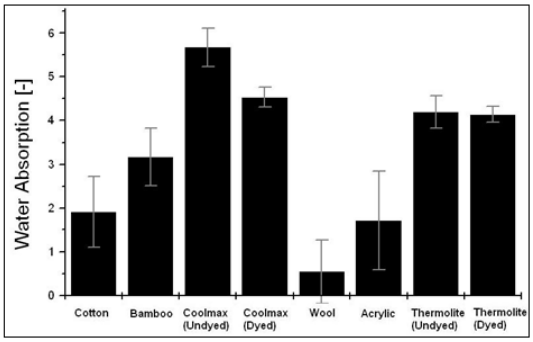

Figure 2. Water absorption of the fabrics produced from different fibres

The results show that the fabrics produced from new generated fibres such as Coolmax and Thermolite have better water absorption ability compared to that of the fabrics obtained from the natural and regenerated fibres due to their fibre structure. The specially designed fibre structure consisting of four or six channels of Coolmax fibers and hollow-core of Thermolite fibres increase the surface area and so water absorption, in another words moisture/sweat absorption improves (4-5). Similar structure which is defined as micro spaces of bamboo fibre gives rise to higher water absorption than that of the cotton and also wool. Contrary to the expectations, the fabrics obtained from natural fibres such as cotton, wool can take up the water with lower amount compared to the fabrics produced from new generated fibres.

3.5. Drying Behaviour

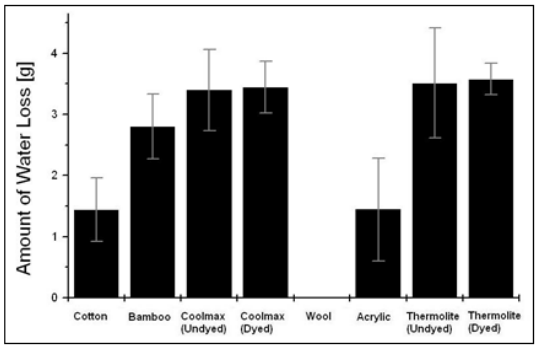

Figure 3. The amount of water loss of different fabrics dried at 30 Cº for 30 minutes

As it is seen in Figure 3, undyed/dyed-Coolmax and Thermolite fabrics have the highest water loss amount while cotton and acrylic have the lowest amount. This result indicates that Coolmax and Thermolite fabrics absorb more water and also dry more quickly compared to cotton and acrylic fabrics. Special fibre structure and also higher air permeability values might lead to evaporate the water so quickly.

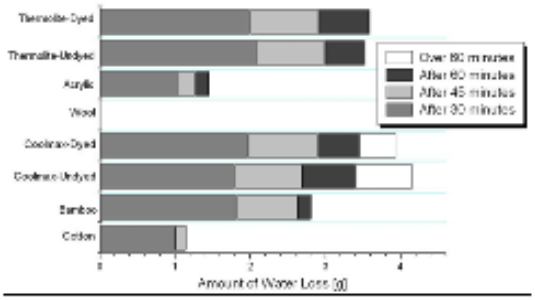

Figure 4. Drying time of different fabrics dried at 30 Cº in drying oven

From Figure 4, water is lost from the fabrics obtained from Coolmax, Thermolite and bamboo fibres more than that of the acrylic and cotton fabrics after 30 and 45 minutes. Especially, dyed-Coolmax and undyed-Thermolite can remove more than the half of the absorbed water after the first 30 minutes. Therefore, the wearer can not be disturbed due to wet clothing.

On the other hand, the drying time of Coolmax and Thermolite fabrics is about an hour and they dried later than the cotton fabric. However, Coolmax and Thermolite absorb more water and drying time is a bit longer than the others.

3.6. Flame Retardant Properties

To determine flame retardant properties of the fabrics, a flame is applied to the fabrics for 2 seconds. If the burning starts in the fabric, the burning time is record and the fabric is classified according to the burning time. In this study, it was found that there is not any burn in all the fabrics and this result indicates that all the fabrics can be classified as Class I which these textiles are considered by the trade to be generally acceptable for apparel.

4. CONCLUSION

Nowadays, protection properties of fabrics such as hot, cold, wind, rain, UV radiation of sun, microbial attack and also comfort properties are getting more importance. Therefore, there are many attempts to produce the clothes having functional properties and also providing high life quality. In this study, the comfort properties of new generated fibres were compared with that of the natural and other fibres.

Differences in the physical structure of fibres lead to differences in the fabrics properties regarding to air permeability, water and water vapour transports. Hollow-core structure of Thermolite fibres allows more air passage while channels of Coolmax fibres increase water vapour permeability. On the other hand, this hollow-core structure of Thermolite fibres and the channels of Coolmax fibres give rise to absorb more water and so dry so quickly. Similarly, micro spaces in its structure lead to get better air permeability, water absorption values compared to that of the other natural fibres although bamboo is a kind of natural fibre. On the other hand, this special designed structure, especially channels lead to increase the pilling tendency. Contrary to the expectations, the fabrics obtained from natural fibres such as cotton and wool can take up the water with lower amount, allow less air passage compared to the fabrics produced from new generated fibres of Coolmax and Thermolite. These findings indicate that the clothing on the user made of new generated fibres can absorb much more sweat, perspiration move quickly from skin to outside and so user can feel dry and comfort compared to the clothings made of natural and other fibres.

Especially, the clothing obtained from Coolmax fibers keeps the body cool and because the channels in Coolmax fiber works as a transport system. On the other hand, hollow-core structure of Thermolite fibers offers greater insulation and surface area and so the body is kept dry and warmth. Therefore, they can be used for casual wearing and also for underwear, socks, next-to-skin operational garments, sport wears, medical fabric, army clothes, police and security forces wherever comfort is demanded.

Acknowledgement

The authors are thankful to Budak Çorap Ltd. Şti. for supporting the yarn samples and knitting process and Pelsan Tekstil Ürünleri San. ve Tic. A.Ş. for offering testing services.

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