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Research Article

The Effect of Cashmere Fibres on the Thermal Comfort Properties of Worsted Fabrics

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Abstract: In this study, the effects of cashmere fibre using on the air permeability, thermal conductivity, thermal diffusivity, thermal absorptivity and thermal resistance of the worsted fabrics were investigated in detail. For this purpose, worsted fabrics having five different cashmere/wool blend were produced systematically. The test results have revealed the using of the cashmere fibre in the structure of worsted fabrics causes better thermal comfort in terms of end user.

Keywords: *Cashmere, wool, worsted fabric, air permeability, thermal comfort*.

Kaşmir Liflerinin Kamgarn Kumaşların Termal Konfor Özelliklerine Etkisi

Özet: Bu çalışmada, kamgarn dokuma kumaşların hava geçirgenliği, termal iletkenlik, termal yayılım, termal emicilik ve termal direnç özelliklerine kaşmir lifi kullanımın etkileri detaylarıyla araştırılmıştır. Bu amaçla, beş farklı kaş mir/yün karışım oranlarına sahip kamgarn dokuma kumaşlar sistematik üretilmiştir. Test sonuçlar kamgarn kumaş yapısında kaşmir lifi kullanımının son kullanıcı açısından daha iyi termal konfor özellikleri verdiğini göstermiştir.

Anahtar Kelimeler: *Kaşmir, yün, kamgarn kumaş, hava geçirgenliği, termal konfor.*

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1. Introduction

Cashmere, which is characterized by its fineness, lightness and softness, is the downy hair collected from cashmere goats (Capra hircus) in spring. A maximum of 200-250 g of fibre can be taken from an animal [1]. In this respect, cashmere fibre, which is famous for its high performance and rareness, is quite expensive compared to other wool and animal fibres in identical diameter [2].

There are some important researches in the literature [3-7], but studies on the effect of cashmere fibres on thermophysiological comfort properties of the worsted fabrics are still needed. In this research worsted fabrics blended with cashmere are examined, thermal comfort properties of the fabrics are determined. In this way, the thermal comfort characteristic of the cashmere/wool worsted fabric is identified and explained with literature background.

2. Materials and Method

In this study, five types of worsted fabrics having cashmere/wool blending in different rate were systematically produced with plain weaving type on Dobby weaving by Dornier HTV6/SD machine rapier picking mechanism. Nm 40/2 45% Wool - 55% Polyester yarns were utilized for warp, while Nm 48/1 five different cashmere/wool blend yarns were used for weft. The basic properties of the weft yarns used in the study are given in Table 1. The production plan of the fabrics, which were coded according to the changing weft yarns, is shown in Table 2.

Table 1. The basic properties of the weft yarns used for the production of worsted fabrics

Blend Ratio of Weft Yarn	Yarn Count (Nm)	Twist Level (TPM)	Breaking Strength (cN)	Breaking Elongation (%)
80% Wool - 20% Cashmere	49.49	698	159	18.1
90% Wool - 10% Cashmere	48.6	670	163	16.3
95% Wool - 5% Cashmere	48.16	692	155	13.99
97.5% Wool - 2.5% Cashmere	47.48	680	163	17.4
100% Wool	48.32	667	179	18.2

Table 2. Properties of worsted fabrics produced in the study

Sample Code	Weft Yarn Construction	Warp Yarn Construction	Weft Density	Warp Density	Weight (g/m^2)	Thickness (mm)
80W/20C	80% Wool 20% Cashmere	45% wool 55% Polyester	25.7	29.8	147	0.286
90W/10C	90% Wool 10% Cashmere		26.1	30.2	149	0.296
95W/5C	95% Wool 5% Cashmere		26.3	30.4	150	0.309
97.5W/2.5C	97.5% Wool 2.5% Cashmere		25.9	30.0	149	0.317
W	100% Wool		26.3	30.4	151	0.345

The fabrics used in the study were preconditioned in a conditioning room at standard atmospheric conditions (20 ± 2°C, 65 ± 2% RH) for 24 hours The air permeability tests of fabrics were made for a test pressure drop of 100 Pa (20 cm² test area) by using Tex-test FX 3300 Air Permeability Tester. By using Alambeta, which was invented by Hes et al.8, was utilized to measure the thermal conductivity, thermal diffusivity, thermal absorptivity and thermal resistance properties of the woven fabrics. IBM SPSS Statistics 22.0 software was utilized for all statistical analyses.

3. Results and Discussion

In this study, air permeability, thermal conductivity, thermal diffusivity, thermal absorptivity and thermal resistance of worsted fabrics having five different blends of cashmere/wool fibres were investigated.

The air permeability of the fabrics is one of the important features that should be taken into consideration during the fabric design phase by affecting the comfort and performance characteristics of the garment and according to the place of use. The air permeability of the fabrics is influenced by the external environment conditions, such as temperature and pressure differences, and the properties of the material passing through the fabric, particularly the fabric porosity, which varies depending on the structural parameters of the fabric. The results of the air permeability measurements are presented in Fig. 1.

As seen from air permeability results, the fabrics produced from 20% cashmere fibres have the highest values, while 100% and 97.5% wool fabrics have the lowest values among all fabrics. When the cashmere fibres are examined microscopically, it is seen that the fibre diameter is smoother and has a much thinner structure than wool fibres [9]. This situation may have caused the pores to be more clear and prominent in the fabrics with high cashmere content. Thus, the increase in porosity increased air permeability. It was confirmed that the differences in air permeability were statistically significant ($p<0.05$), when the fabrics have different cashmere content according to the variance analysis.

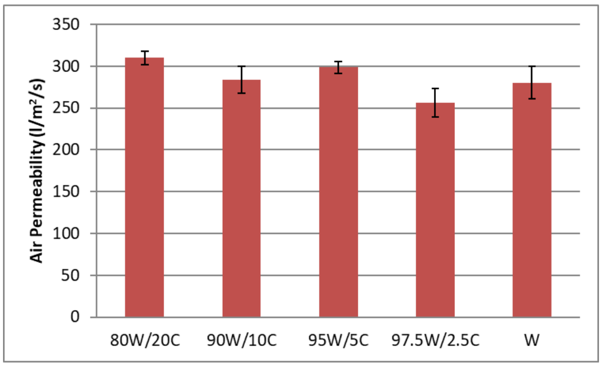

Figure 1. Air permeability results of the fabrics

The thermal conductivity is the amount of heat transferred from the unit thickness of the material to the unit surface area under steady state conditions and when heat transfer is only dependent on the temperature difference. The results of the thermal conductivity measurements are given in Fig. 2.

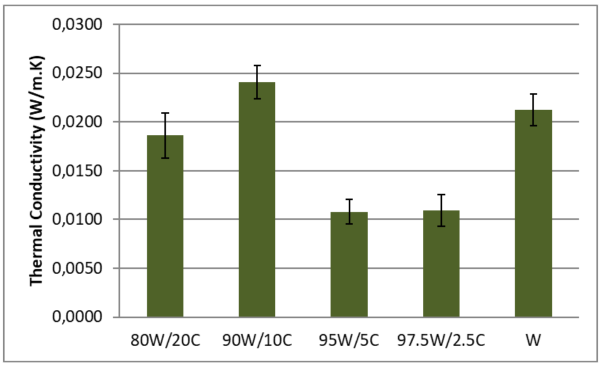

Figure 2. Thermal conductivity results of the fabrics

As seen in the results, the highest thermal conductivity is observed in the 90W/10C coded fabric, and these fabrics are followed by W coded fabrics. Although the differences between the thermal conductivity values of the fabrics were found to be statistically significant ($p<0.05$), no specific trend can be revealed from the results. Considering the thickness of the material in the calculation of the thermal conductivity coefficient is thought to cause this situation.

Thermal diffusion is related to the ability of the heat flow through the air within the fabric structure. Thermal diffusivity of textile materials is the temporary thermal characteristic of textiles. The results of the thermal diffusivity measurements are illustrated in Fig. 3.

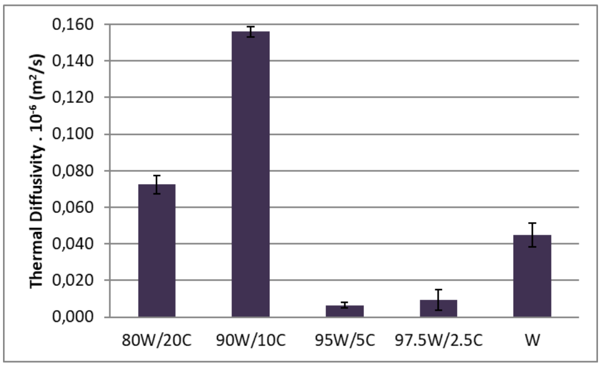

Figure 3. Thermal diffusivity results of the fabrics

When the results are examined, it is observed that the presence of high rate of cashmere in the fabric structure increases thermal diffusion. Considering that the air permeability values of these fabrics are also high, it can be interpreted that the heat passing through it is higher as these fabrics are more porous. In this case, these fabrics can expel the heat inside.

The thermal absorptivity is an objective measurement parameter of the warm or cool feeling of human skin when it first comes into contact with any object such as textile material [8]. While fabrics with low thermal absorption value give a warm feeling, those with high values give a cool feeling. The results of the thermal absorptivity measurements are shown in Fig. 4.

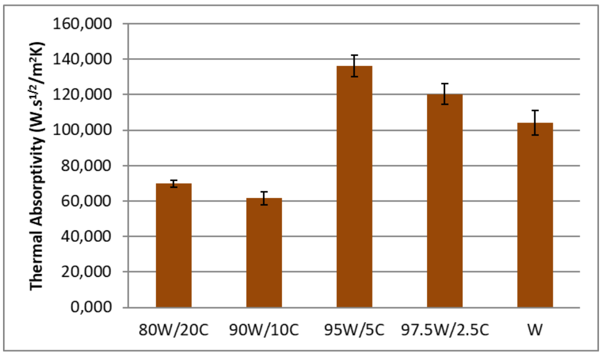

Figure 4. Thermal absorptivity results of the fabrics

The measurement results show that the fabrics with 10% or more cashmere use have lower thermal absorptivity values and therefore give a warmer feeling to these fabrics at the time of first contact. The thermal absorptivity results were obtained statistically significant ($p<0.05$).

Thermal resistance refers to the temperature difference corresponding to the unit area of the material in the unit heat energy flow passing through a unit thickness of a material. Thermal resistance, which can also be defined as resistance to heat flux, is an important comfort parameter especially in cold weather so that the garment can protect the person from cold. The results of the thermal resistance measurements are presented in Fig. 5.

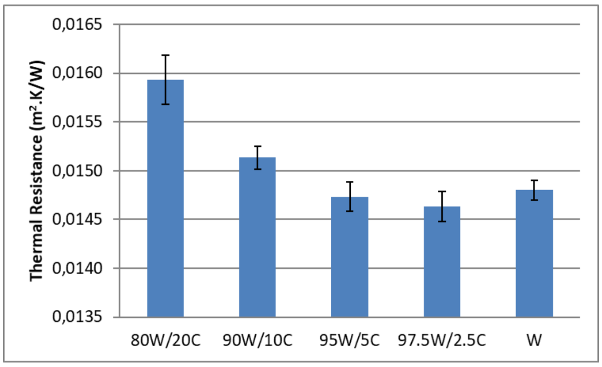

Figure 5. Thermal resistance results of the fabrics

According to the findings, it is observed that the use of cashmere fibre in fabric, in particular from 10% content, causes increase in thermal resistance value. When the cashmere fibre is added to the fabric structure, it is seen that the thermal resistance value increases critically. This condition shows that it is appropriate to use cashmere fibres in cold protection clothing. The thermal resistance results were obtained statistically significant ($p<0.05$) in accordance with variance analyses.

4. Conclusions

This study focuses at examining and evaluating the impact of cashmere fibre using on the thermal comfort properties of the worsted fabrics. The findings of this study are important for determining the optimum use amount of cashmere fibre, which is a very expensive fibre. The test results have revealed the using of the cashmere fibre in the structure of worsted fabrics causes better thermal comfort in terms of end user. According to the findings, especially 10% and more use of cashmere fibre has been found to contribute to the improvement of comfort properties of the worsted fabric significantly.

For further studies, design and measuring the performance of worsted fabrics having different amount of luxury fibres with different setting and weaving types are planned. Particularly, analysing performance properties of worsted fabrics blended with other luxury fibres may be interesting besides examination of thermal comfort properties

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