The Thermal Comfort Properties of Certain Egyptian Stretched Knitted Fabrics

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Abstract:
In this work, the thermal comfort properties of some Egyptian stretch knitted fabrics made from synthetic and lycra yarns based single jersey were statistically investigated. These products are very common in Egyptian Market. For this aim, this paper has focused on the thermal comfort properties of samples; thermal comfort, thermal resistance, thermal absorptivity, thermal conductivity, water vapour permeability and air permeability measured by apparatus due to ASTM- D 1518-85. The research questions has been "What are the types of stretch knitted fabric that have highest thermal specifications?". The objectives has been to identify common thermal comfort properties of Certain Egyptian Stretched Knitted Fabrics.
The results indicate that each selected fabric can be used as good thermal insulators, have a high thermal performance and thermal response as insulators.
The effect of fabric thickness and weight on the fabric temperature variations has the obvious significance that higher thickness means good thermal insulation

Keywords:
- ***Stretch knitted fabrics,***
- ***thermal comfort,***
- ***thermal resistance,***
- ***thermal absorptivity,***
- ***thermal conductivity,***
- ***permeability.***

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1. Introduction:

Knits are an important part of every wardrobe because they are comfortable to wear and easy to care for. Over the last few years, there has been growing interest in knitted fabrics due to its simple production technique, low cost, high levels of clothing comfort and wide product range. Knitting technology meets the rapidly-changing demands of fashion and usage. **[15, 13]**

Knitted fabrics are widely used in clothing because of its unique, elasticity and stretchy behavior, which is fundamentally different from the behavior of woven cloth. **[9].**

Knitted garments not only posses stretch and provide freedom of movement, but they also do not require a lot of fitting, they shed wrinkles well, have good handle and easily transmit vapour from the body. Most Knits do not ravel, making them quick and easy to sew. Knits are versatile and can be seen in everything from the most casual wear to the dressiest of clothing attire. They come in a variety of fabrics that vary in texture, elasticity, fiber content, weight, and design. That’s why knitted fabrics are commonly preferred for casual wear, sportswear, and underwear. **[13, 15]**

"Stretch is not something that you see; it’s something that you feel, and once you’ve experienced it, you don’t want to go back".**[2]** Apparel designers and fabric manufacturers have combined function with design potential to create the concepts of "comfort-stretch" and "flex-fit" with the "feel good factor" and "soft stretch performance".

The most widely-used stretch fiber is spandex, used in proportions ranging from 1% to more than 10% to create fabrics that enable the consumer to feel the comfort of fit. Consumers expect comfort-stretch fabrics to maintain their original feel, and combine the aesthetic attributes of softness, comfort, stretch, and resiliency with today’s casual and business-casual styles.

Various consumers consider comfort as one of the most important attribute in their purchase of apparel products, therefore companies tend to focus on the comfort aspect nowadays [8].

The term comfort is defined as “the absence of displeasure or discomfort” or “a neutral state compared to the more active state of pleasure”,

Clothing comfort may be defined as a pleasant state of physiological, psychological and physical harmony between a human being and the environment **[17, 10].** Clothing comfort is defined by the tactile sensations felt by a subject through the mechanical interactions between the body and the garment **[11].**

Up to now, there has been no clear definition of comfort, since this subjective feeling differs from person to person.

The thermal comfort of man depends on combinations of clothing, climate and physical activity. ISO 7330 defines thermal comfort as that condition of mind, which expresses satisfaction with the thermal environment **[3].**

Extensive research has been carried out on the thermal behavior of textile materials. One of the first studies were carried out by Gibson **[4]** examined the influence of air permeability on heat and water vapour transport through woven and nonwoven fabrics. From this study, it has been pointed out that the air permeability of fabric becomes particularly important in the situation of an air space between fabric and sweating skin simulating surface.

Greyson **[5]** and Havenith **[7]** mentioned that heat and water vapour resistance increases with the increment of material thickness and air entrapped in the fabric. Milenkovic et al. **[11]** proved that fabric thickness, enclosed still air and external air movement are the major factors that affect the heat transfer through fabric. Shoshani and Shaltiel **[18]** noted that thermal insulation increases with decreases in the density of fabric. Schneider et al. **[16]** worked on the thermal conductivity of textile fabrics containing water. They showed that under moist conditions wool fabric had better insulating properties than porous acrylic, cotton and polypropylene. Thermal properties of 1×1, 2×2 and 3×3 rib knit fabrics were compared by Ucar and Yilmaz **[19].** They noted that a decrease in rib number leads to a decrease in heat loss; the use of 1×1 rib and tight structure would provide better thermal insulation. Due to the lack of information on the thermal properties of Egyptian stretch knitted fabrics; the thermal comfort properties of those products was investigated.

2. Research Questions:

1- What are the types of stretch knitted fabric that have highest thermal specifications?

3. Material and Methods:

3.1 Materials:

Five stretch knitted women's body fabrics 100% Egyptian Product, trade names as follow: Lady (A), lolyta (B), pourelle (C), Carina (D) and Sylvy (E). All specifications show in table (1).

Table (1) represents specifications of basic knitted structures.

Sample No.	**Loop Length (mm)**		**Density**		**Yarn Count**		**Thickness (mm)**	**Weight g/m²**
	Yarn1	**Yarn2**	**Wales**	**Course**	**Yarn1**	**Yarn2**		
A	**3.003**	**3.018**	**46**	**84**	**9.7**	**8.6**	**0.87**	**300**
B	**3.002**	**2.626**	**44**	**87**	**10**	**5.3**	**0.82**	**237**
C	**3.413**	**2.7**	**43**	**63**	**14.6**	**6.8**	**0.78**	**193**
D	**2.231**	**2.766**	**51**	**94**	**4**	**9**	**0.80**	**224**
E	**2.948**	**2.784**	**55**	**106**	**5.4**	**4.7**	**0.79**	**220**

Yarn 1= Yarn solution synthetic fibers + Lycra
Yarn 2= Yarn solution synthetic fibers
Yarn Sort= 1:1 (Yarn1:Yarn2)
Sample (C): Yarn1= twisted yarn, yarn sort; 1:1 (Yarn1: 1 lycra)

3.2 Methods:

- Preparations of specimens; they were cut large enough (20in.), they were allowed to come into equilibrium with the atmospheric conditions of temperature 20±2°C and relative humidity 65±2% RH, before the measurements on the samples were taken, each specimen measured 5 times.

- Fabric Weight per Unit Area; standard procedure for measuring GSM as per ASTM – D 3776-1996, IS: 1964-2001 was used.

- Fabric Thickness; of the fabric depends on the yarn count, knitted structure and relative closeness of the loops. Standard procedure for measuring thickness using Baker make J02 thickness tester as per ASTM – D 1777:197, IS: 7702:1975 was used.

- Thermal conductivity; is an intensive property of materials that indicates its ability to conduct heat. **[12]**

- Thermal resistance; is an indication of how well a material insulates. It is a measure of the body's ability to prevent heat from flowing through it based on the equation: **[6]**

$$R\ h/\lambda$$

Where: h: thickness (m) λ: thermal conductivity (W/m K)

- Thermal absorptivity; determines the contact temperature of two materials. Also it is the objective measurement of the warm-cool feeling of fabrics [10]. A warm-cool feeling is the first sensation. When a human touches a garment that has a different temperature than the skin, heat exchange occurs between the hand and the fabric. If the thermal absorptivity of clothing is high, it gives a cooler feeling at first contact **[14].**

- Relative water vapor permeability; is the ability to transmit vapour from the body. If the moisture resistance is too high to transmit heat, by the transport of mass and at the same time the thermal resistance of the textile layers considered by us is high, the stored heat in the body cannot be dissipated and causes an uncomfortable sensation **[6].**

- **Air Permeability;** is the volume of air in milliliters which is passed in one second through 10Os mm2 of the fabric at a pressure difference of 10mm head of water, and expressed as cm3/cm2/s. The specimens were measured according to ASTM standard D737-1996.

The apparatus that have been used to measure thermal conductivity, fabric thickness, thermal resistance, thermal absorptivity values; relative water vapor permeability were given by ASTM-D 1518-85, D 1518-57, D 1518-77. All measurements were repeated five times. The results of the tests were evaluated statistically and the importance levels of the relationship between the measured parameters were determined.

4. Results and Discussion:

4.1 Thermal conductivity

According to Figure 1, (specimen A) has the highest thermal conductivity values. This situation can be explained by the amount of entrapped air in the fabric structure. The amount of fiber in the unit area increases and the amount of air layer decreases as the weight increases.

4.2 Thermal resistance

As can be seen from Figure 2, as the fabric thickness increases the thermal resistance increases. So, the greatest values were obtained for the (specimen A).

4.3 Thermal absorptivity

From Figure 3, it is obvious that (specimen A) got the highest thermal absorptivity values, gave the coolest feeling at the beginning of skin contact. This situation is explained by the construction of the fabric surface. The surface area between the fabric and skin is bigger for smooth fabric surfaces and these structures cause a cooler feeling, as mentioned by Pac and his colleagues **[14].**

4.4 Relative water vapour permeability

It can be seen from Figure 4 that the highest value of relative water vapour permeability is (specimen C). The analysis of variance indicates that the effect of the knitted structure on relative water vapour permeability is statistically significant.

4.5 Air Permeability

The results indicate that the highest air permeability value is (specimen A) as shown in Figure 5.

5. Conclusions:

Based on the previously calculated and experimental results of the selected fabrics, the following conclusions can be drawn:

1. The laboratory experiments and calculation have shown that selected fabrics can be used as good thermal insulators.
2. The study concludes that the selected fabrics have high thermal performance and thermal response as insulators.
3. The effect of fabric thickness on the fabric temperature variations has the obvious significance that higher thickness means good thermal insulation.
4. Both the thermal conductivity and thermal resistance of all the selected fabric samples increases with the increase in fabric density.
5. Fabric thickness affects the transient fabric temperatures; fabric temperature variation decreases with increasing fabric thickness.

6- According to the statistical analysis ANOVA; specimen (A) has the highest thermal specifications.

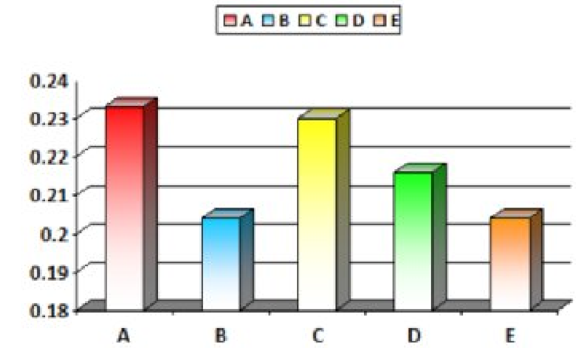

Figure 1. Thermal conductivity values of fabric samples.

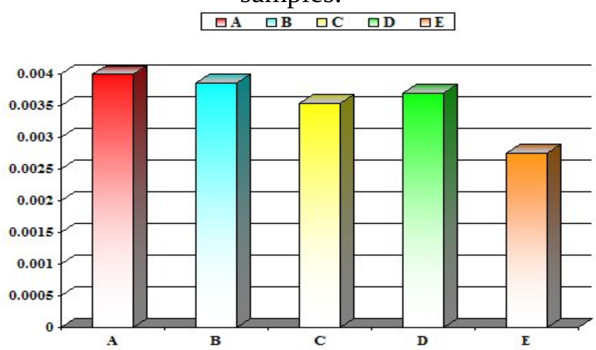

Figure 2. Thermal resistance values of fabric samples.

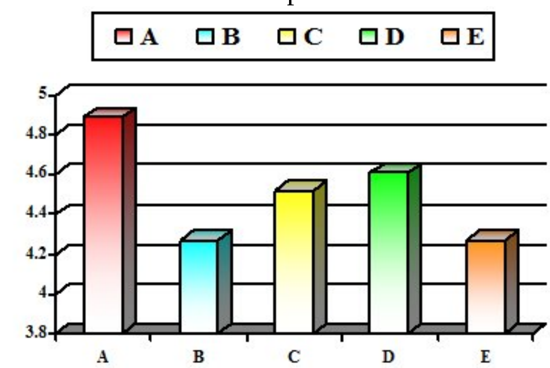

Figure 3. Thermal absorptivity values of fabric samples.

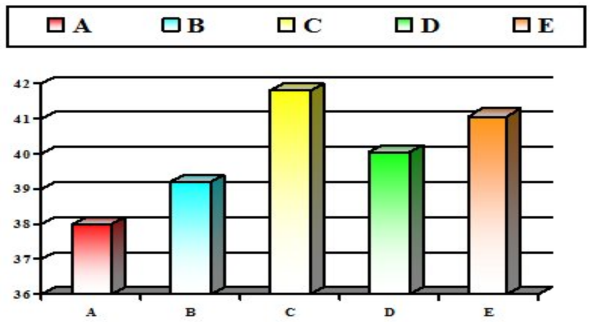

Figure 4. Relative water vapor permeability values of fabric samples

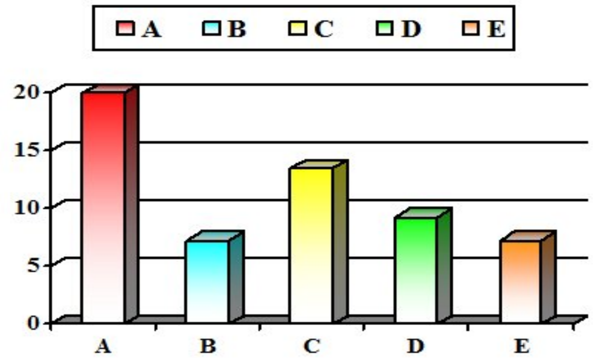

Figure 5. Air Permeability values of fabric samples.

6. Acknowledgment:

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