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FABRIC COMFORT: NEW MEASUREMENT TECHNIQUES

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Abstract

In this paper, we present a new approach to characterizing fabric and garment comfort. This approach is based on using a single index of comfort expressed by the ratio between the actual area of fabric/skin contact and the corresponding apparent area. This index is called "Area-Ratio". The use of a single index may seem to be a very radical approach to characterizing a phenomenon that can be typically described by hundreds of parameters. However, extensive analysis of the nature of this index revealed that it correlates extremely well with all the basic aspects of comfort, namely: psychological, thermo-physiological, and neurophysiological. On the other hand, single/simple index is what a consumer needs to reflect the overall judgment of garment comfort. The essence of this approach, however, stems from the particular value of this index that is suitable for a certain application. This paper will briefly show that the Area-Ratio is correlated significantly to many of the comfort-related fabric and yarn parameters.

Introduction

A feel-good fabric has become one of the most commonly used jargons in the textile and fashion market. Nowadays, consumers want their clothing to not only look good but also feel good. On the other hand, the rapidly increasing development of information technology and Internet has made a huge impact on consumer shopping habits. Taking these new habits into consideration will stimulate the textile and garment market.

Although comfort has been one of the key attributes of consumers' desirability to apparel products in all markets, there is no objective unified way to characterize comfort that can reflect the overall human perception. More seriously, there are no standard procedures to produce comfort by design rather than by guesswork. With the inevitable increase in internet shopping, consumers will increasingly demand more objective characterization of fabric and garment comfort; characterizations that can substitute for the physical feel and touch of traditional intimate shopping.

In the research field, there are hundreds of parameters that can be used to characterize clothing comfort. Furthermore, there are hundreds of different design guidelines from fiber-to-garment that can assist in producing different comfort levels. What is lacking, however, is an integrated approach that coordinates all these efforts to produce very reliable, yet very simplified ways of characterizing comfort that even amateur consumers can understand.

In this study, we report a brief discussion on a 'Design-Oriented Comfort Model' that we developed to establish highly objective design criteria for production of different levels of fabric comfort depending on usage applications. The result of this model will be 'Optimum Comfort' which is a function of application requirements.

The contributors of clothing comfort are environment, human health status, physical activity and applications. For the development of a design-oriented fabric comfort model, these parameters have to be analyzed in detail. The model developed in this study is based on three aspects: The first aspect is psychological aspect, which means to provide complete unawareness of clothing and good protection. The second one is thermo-physiological aspect, which means to provide optimum accommodation to the surrounding media. The third aspect is neurophysiological aspect, which means to provide optimum interaction with the skin. The different parameters considered in our model are summarized in Figure 1.

The Comfort Model

The model developed in this study aims at using a single-index to characterize human feel of fabric comfort. The use of a single index may seem to be a very radical approach to characterizing a phenomenon that can be typically described by hundreds of parameters. However, extensive analysis of the nature of this index revealed that it correlates extremely well with all the basic aspects of comfort, namely: psychological, thermo-physiological, and neurophysiological. On the other hand, single/simple index is what a consumer needs to reflect the overall judgment of garment comfort. The essence of this approach, however, stems from the particular value of this index that is suitable for a certain application. The comfort index used is the ratio between the true fabric/skin area and the corresponding apparent area (see Figures 2 and 3). This index is expressed as follows:

$$Area - Ratio = \frac{A_{true}}{A_{apparent}}$$

Theoretical analysis of the Area-Ratio revealed that it correlates to many comfort-oriented parameters as shown in Figure 4. Note the different fiber-to-garment design parameters illustrated in the Area-Ratio equation. Also note that this is an over-simplified version of the Area-Ratio Model.

Experimental

In this study, the experimental approach is divided into two phases:

1. Fiber-to-Fabric Analysis
2. Fabric-to-Garment Analysis

In this paper, we report few results from the first phase. In this regard, we tested 8 woven fabrics and 3 knitted fabrics were tested (see Tables 1 and 2).

Many classic tests of fibers, yarns, and fabric physical characteristics were performed. In addition, many tests using innovative measuring techniques were also performed. Some of these techniques are available commercially and others were developed at Auburn University laboratory. Classic tests include: warp/weft count, warp/weft twist, fabric thickness, fabric weight, fabric pattern, number of warp & weft /inch, warp / weft tenacity (for yarn), warp / weft elongation (for yarn), warp / weft tenacity (for fabric), warp / weft Young Modulus (for fabric). Special tests include: air permeability, thermal conductivity, thermal diffusivity, thermal absorptivity, thermal resistivity, peak heat flow density ratio, peak heat flow density, friction properties, handle properties, drape coefficient and fabric/skin contact area.

We will only report some of the results obtained from the experimental analysis for woven dress-shirt fabrics are shown in Figure 5 through Figure 14.

Summary of the correlations obtained for woven dress-shirt fabrics are shown Table 3. The key point here is the significant extent of correlation between the different comfort-related parameters and the two coefficients m and • determined from the following true area-later pressure relationship:

$$\frac{A_{true}}{A_{app}} = C_M \, K^{-\gamma} \, M_a^{1-\gamma} \, P^{\alpha}$$

$$or$$

$$\frac{A_{true}}{A_{app}} = m \, P^{\alpha}$$

Figures 15 and 16 show the different values of the coefficient m and • for some of the plain-weave fabrics. These are the coefficients that will be used determine the design criteria suitable for producing a certain level of comfort.

Conclusions

This paper provides a very brief discussion of the new approach to characterizing fabric or garment comfort. The following observations as revealed by the results shown here:

1. The A-Ratio represented by the coefficients m and □ has good correlations with basic yarn parameters such as yarn count and yarn twist.
2. The A-Ratio represented by the coefficients m and □ has good correlations with basic fabric parameters such as thickness, weight, and fabric count.
3. The A-Ratio represented by the coefficients m and □ has good correlations with comfort-related fabric characteristics such as air-permeability, thermal parameters, fabric flexibility, drape, handle, and fabric friction.

Obviously, what we reported here is simply a snapshot of the immense results we obtained. For more information on other results, please contact Dr. El Mogahzy at (yehiae@eng.auburn.edu).

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Table 1. Woven fabrics.

ID	Raw Material	Pattern
1	100% Cotton	plain
2	100% Cotton	satin (5)
3	100%polyester	plain
4	100%polyester	plain
5	100%polyester dress-shirts	plain
6	65% PES 35%Combed Cotton	plain
7	65% PES 35%Combed Cotton spring	plain
8	100% Acetate Dress-shirts	satin(5)

Table 2. Knitted fabrics.

ID	Raw Material	Pattern
A	100% Cotton	Pique
D	100% Cotton	Interlock
C	100% Cotton	Jersey

Table 3. Summary of the correlations obtained for woven dress-shirt fabrics.

Woven Fabrics		m	α
Yarn Structural Parameters:			
• Warp Twist		↑	↓
• Filling Twist		↑	↓
• Warp Count		↑	↓
• Filling Count		↑	↓
Fabric Structural Parameters:			
• Fabric Thickness		↑↑	↓↓
• Fabric Weight		↑↑	↓↓
• W.P.I		↑↑	↓↓
• F.P.I		↑↑	↓↓
Fabric Physical Parameters:			
• Air Permeability		↓	↑
• Thermal Conductivity		↑↑	↓↓
• Fabric Modulus (W)		↓	↑
• Fabric Modulus (F)		↓	↑
Fabric Handle & Drape:			
• First Handle (F)		↓	↑↑
• Second Handle (F)		↑↑	↓↓
• First Handle (B)		↓↓	↑↑
• Second Handle (B)		↑	↑
• Drape Coefficient		↓	↑
Fabric Friction:			
μ (Fabric-Friction)		↑↑	↓↓

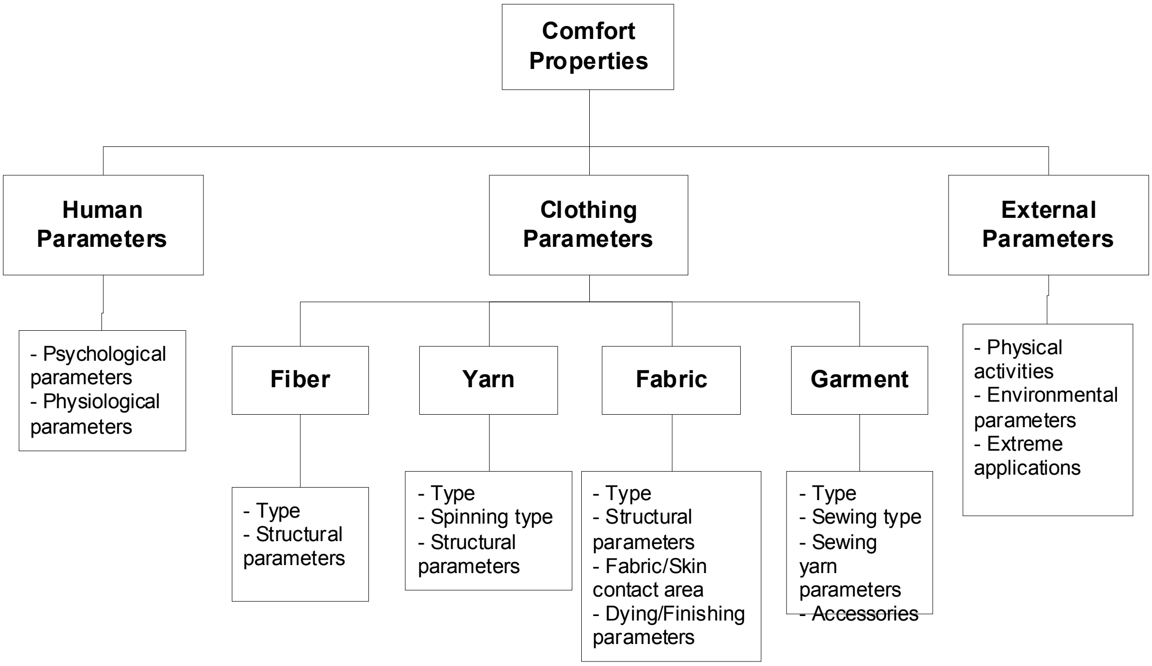

Figure 1. Different Parameters considered in developing the “Design-Oriented Comfort Model.”

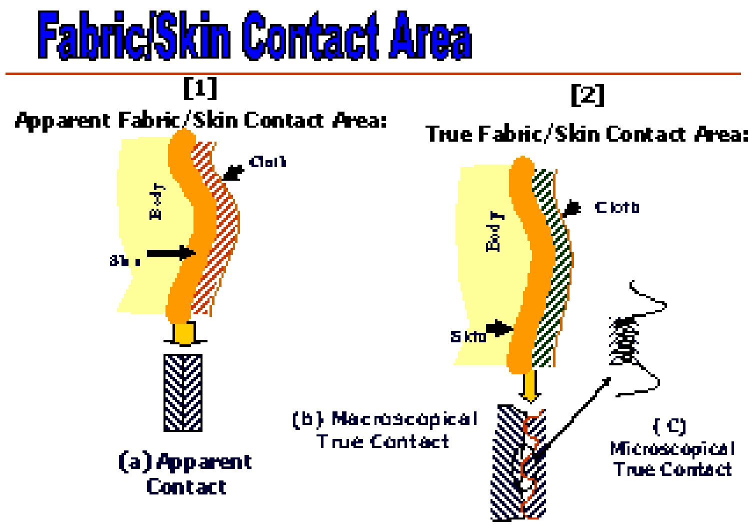

Figure 2. Apparent and True Fabric/Skin Contact areas.

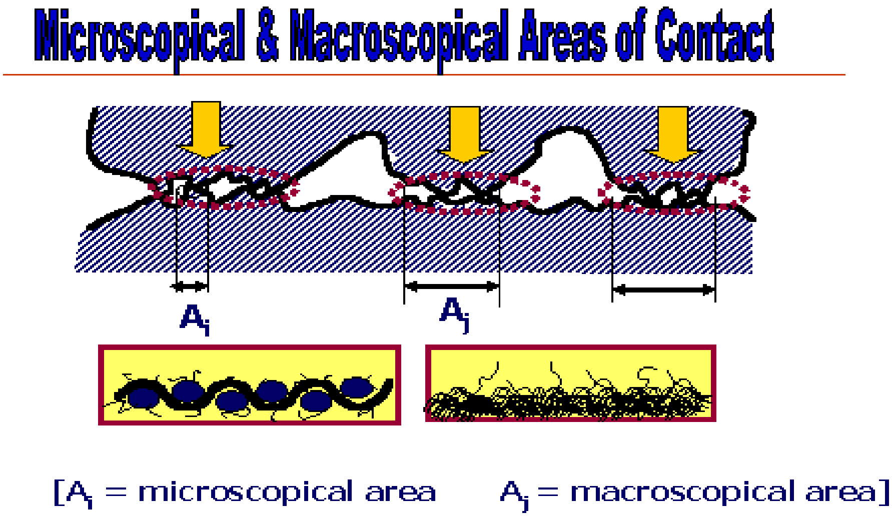

Figure 3. Microscopical and Macroscopical areas of comfort.

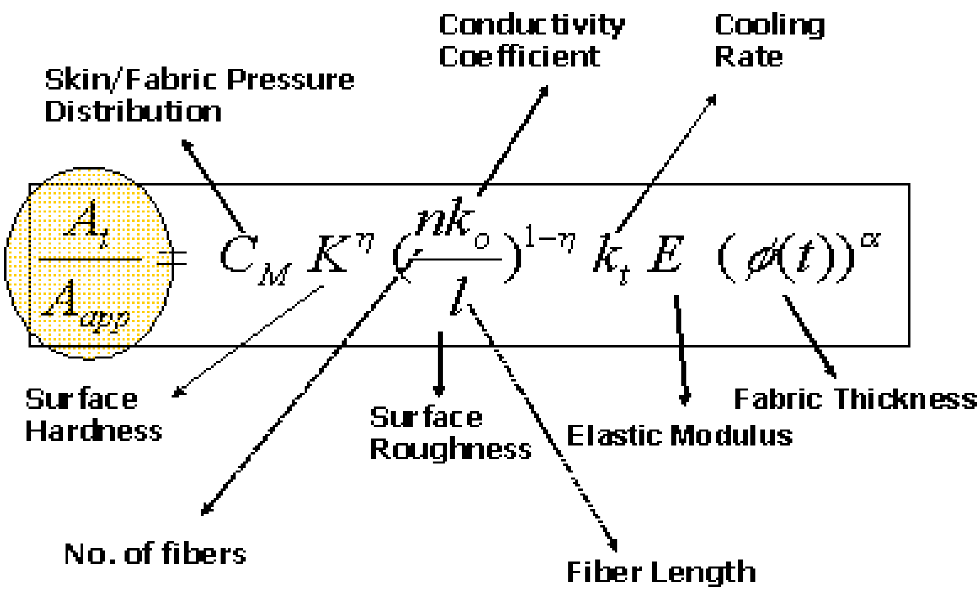

Figure 4. Theoretical model for fabric comfort.

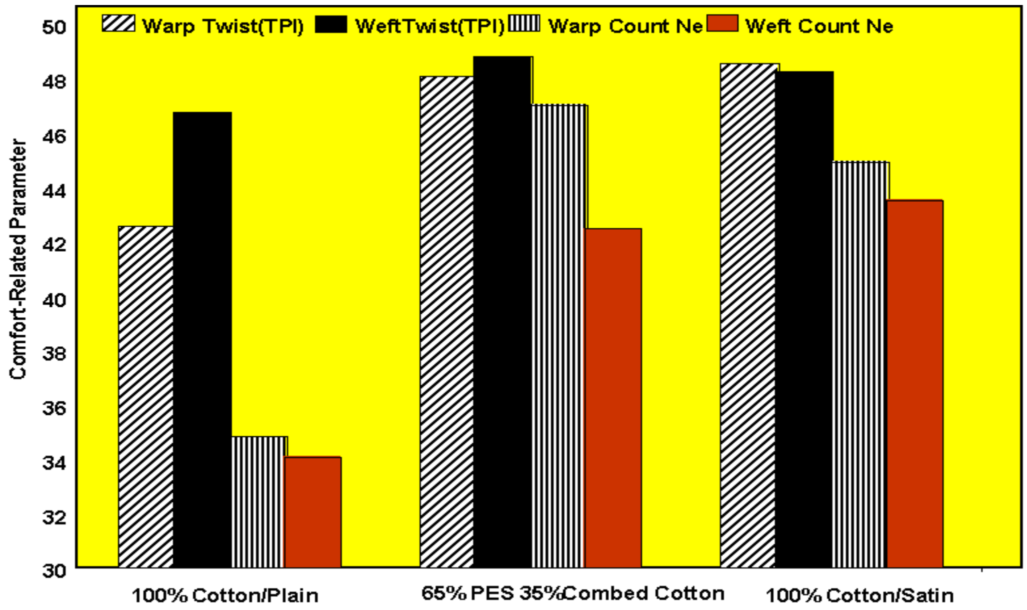

Figure 5. Warp/weft twist and warp/weft count (Ne) for different fabric styles.

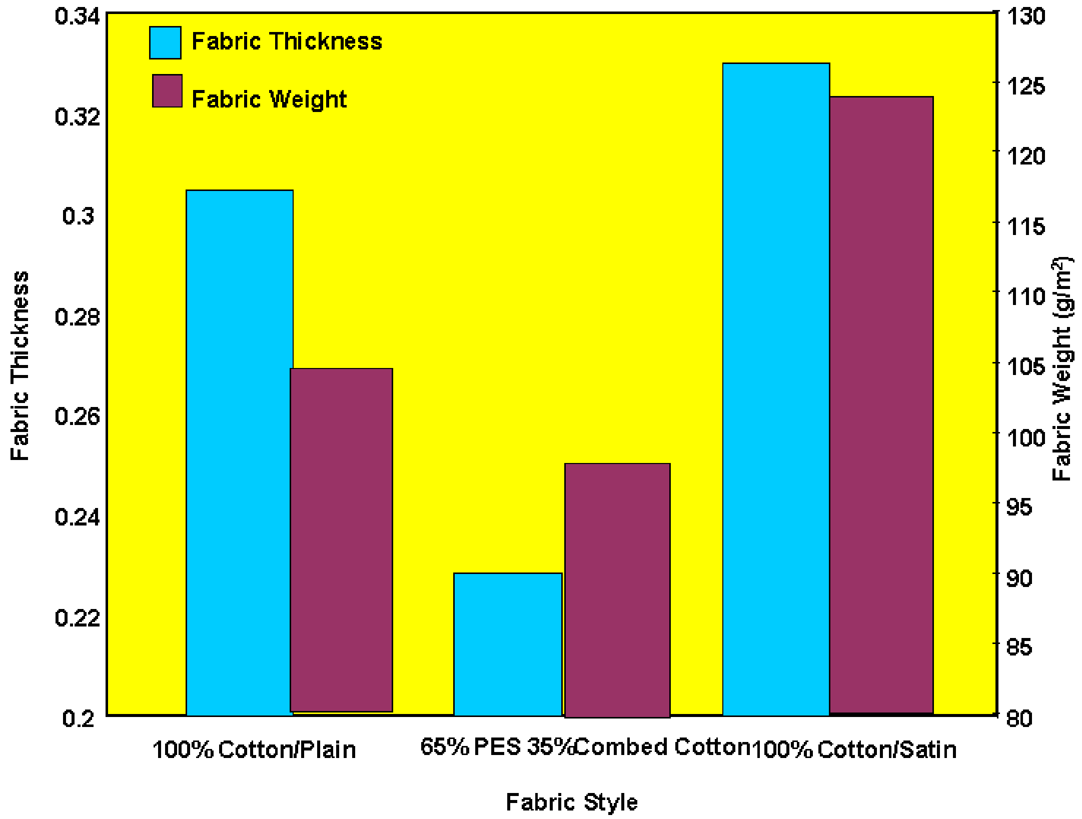

Figure 6. Fabric thickness and fabric weight for different fabric styles.

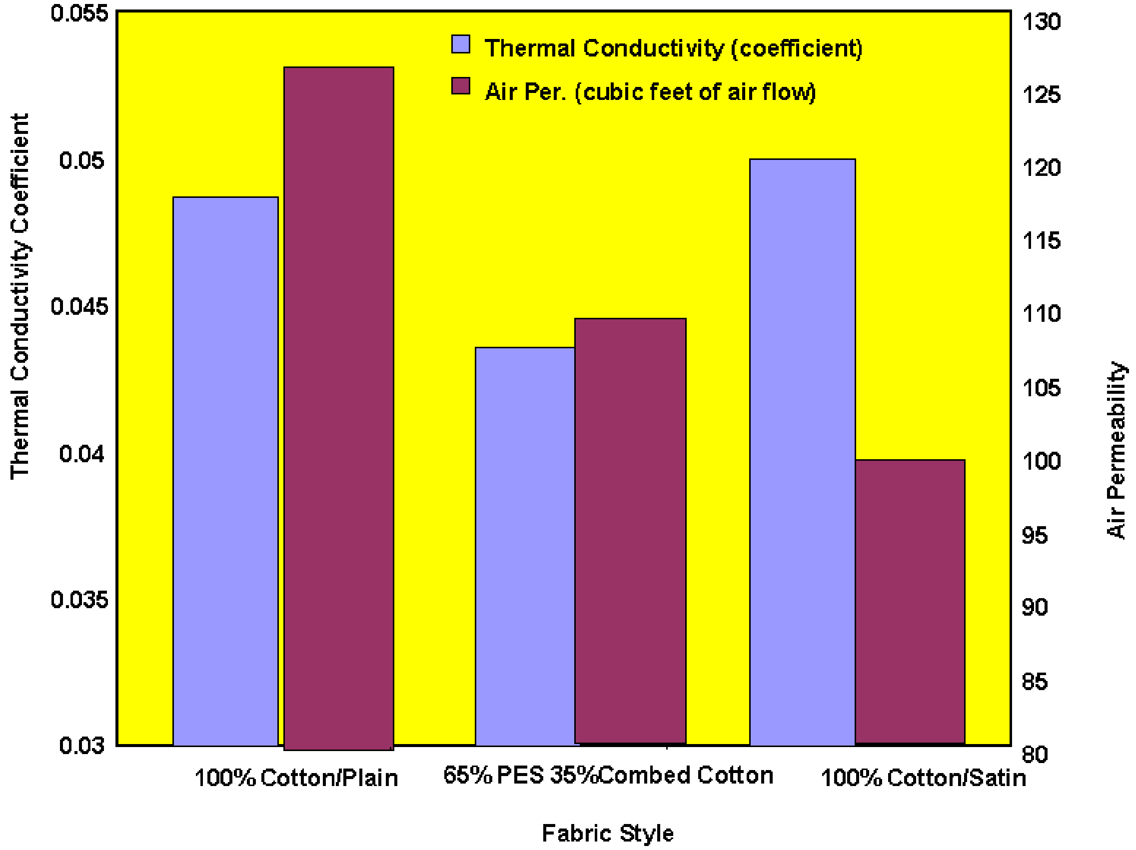

Figure 7. Thermal conductivity (coefficient) and air permeability for different fabric styles.

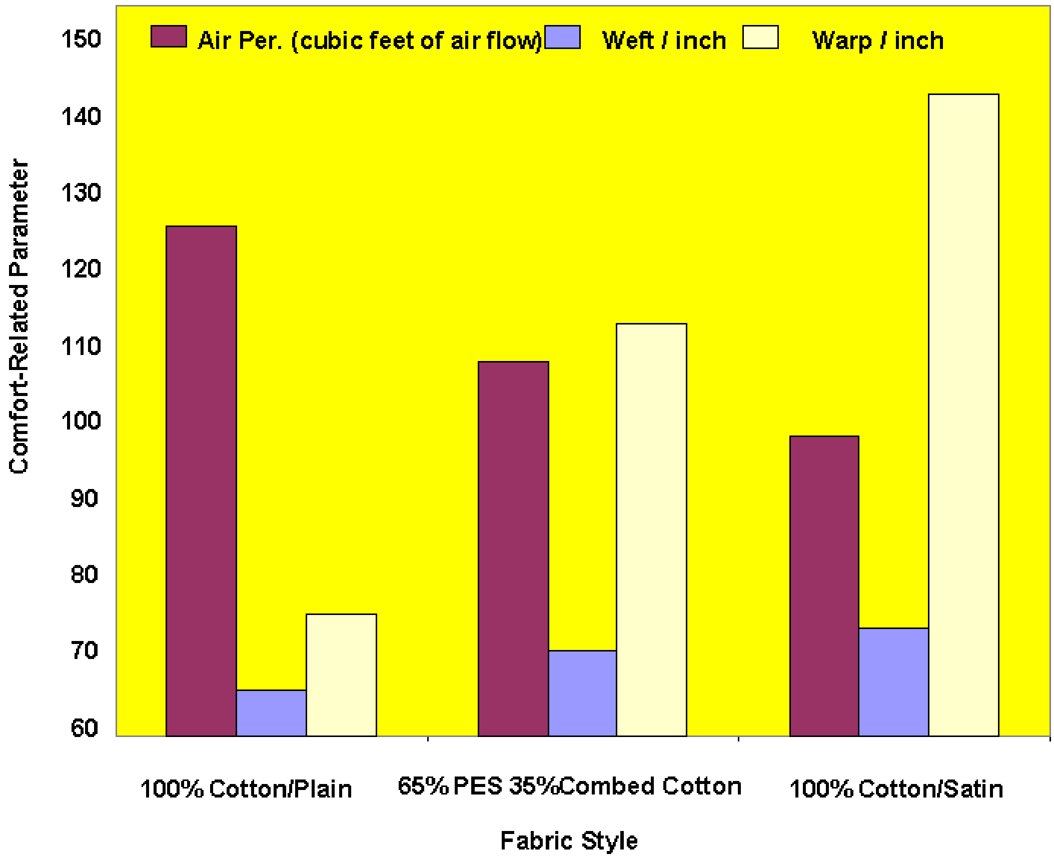

Figure 8. Air permeability and the number of warp and weft/ inch for different fabric styles.

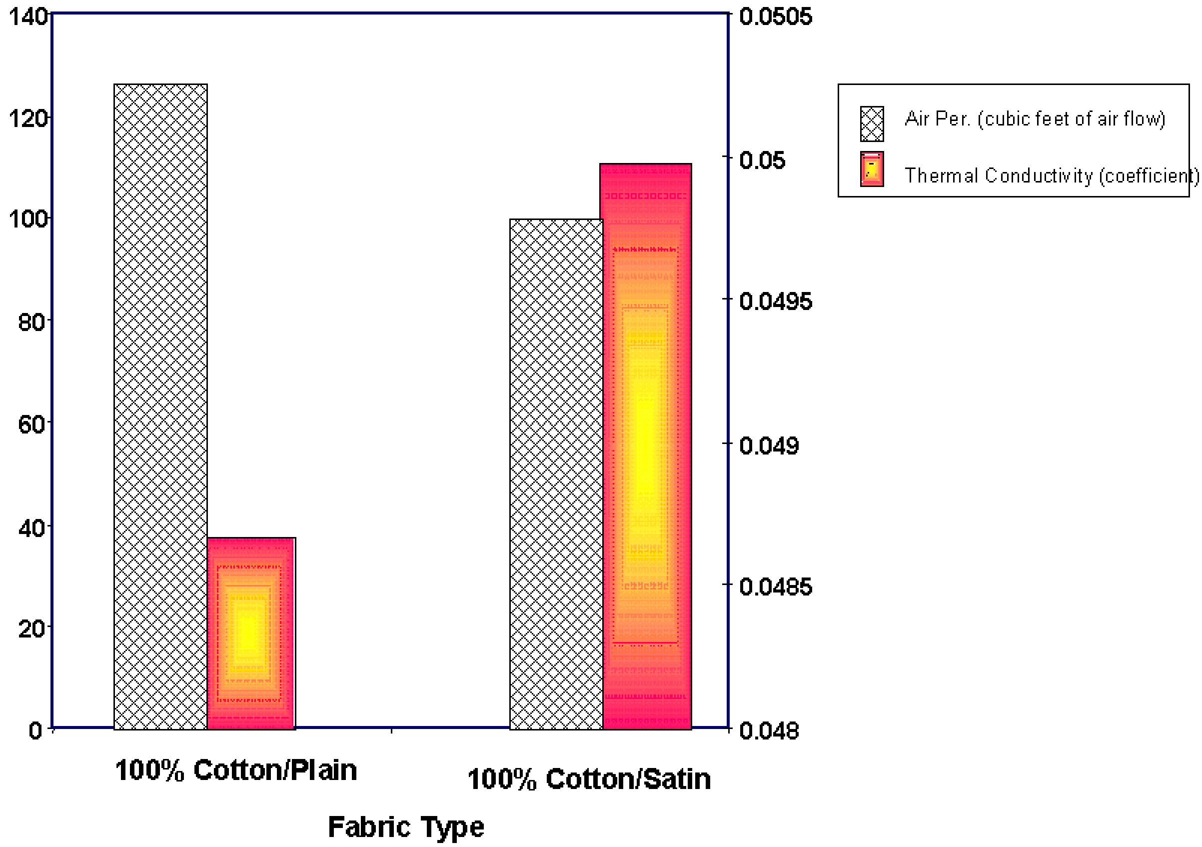

Figure 9. Air permeability and thermal conductivity for different fabric patterns.

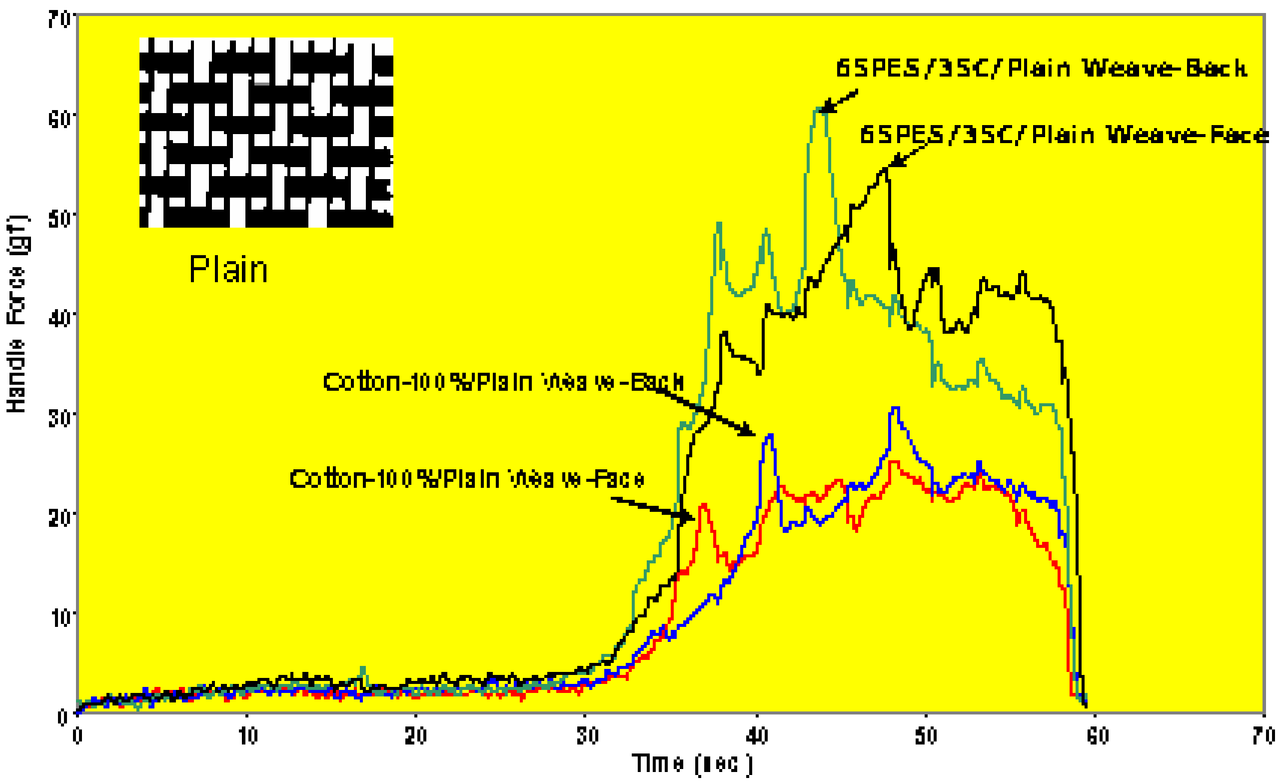

Figure 10. Change in handle force in time (sec) for different plain fabrics produced from different type of yarns.

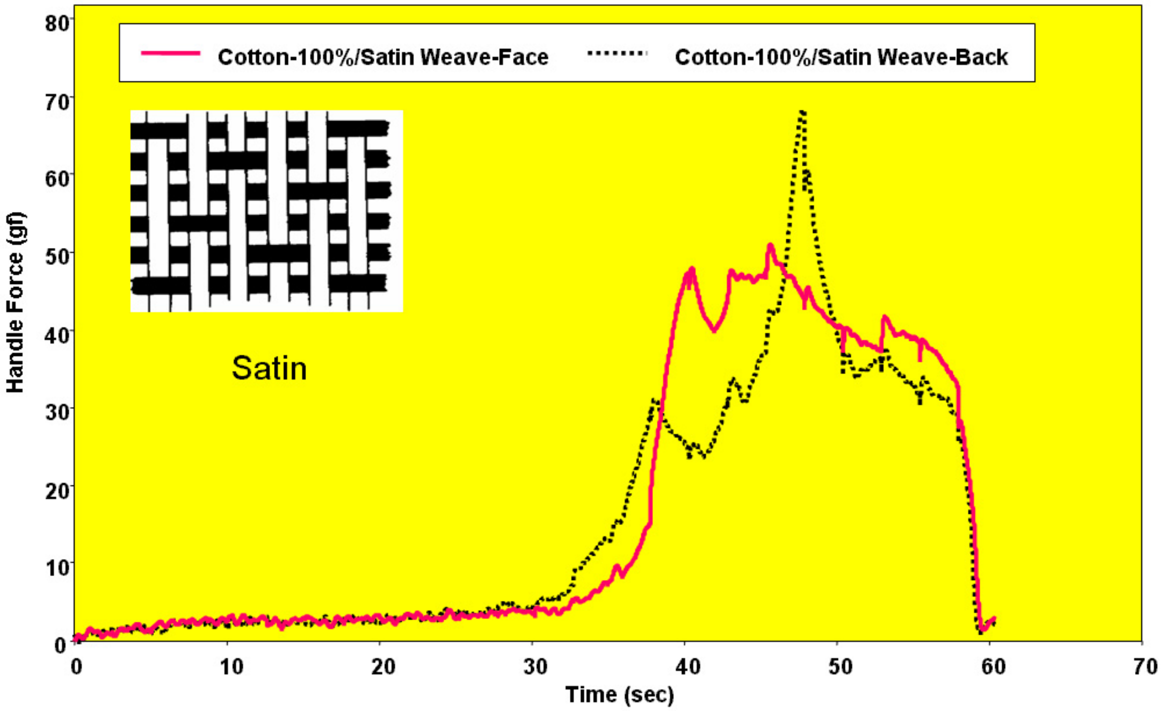

Figure 11. Change in handle force in time (sec) for Satin 100% Cotton fabrics.

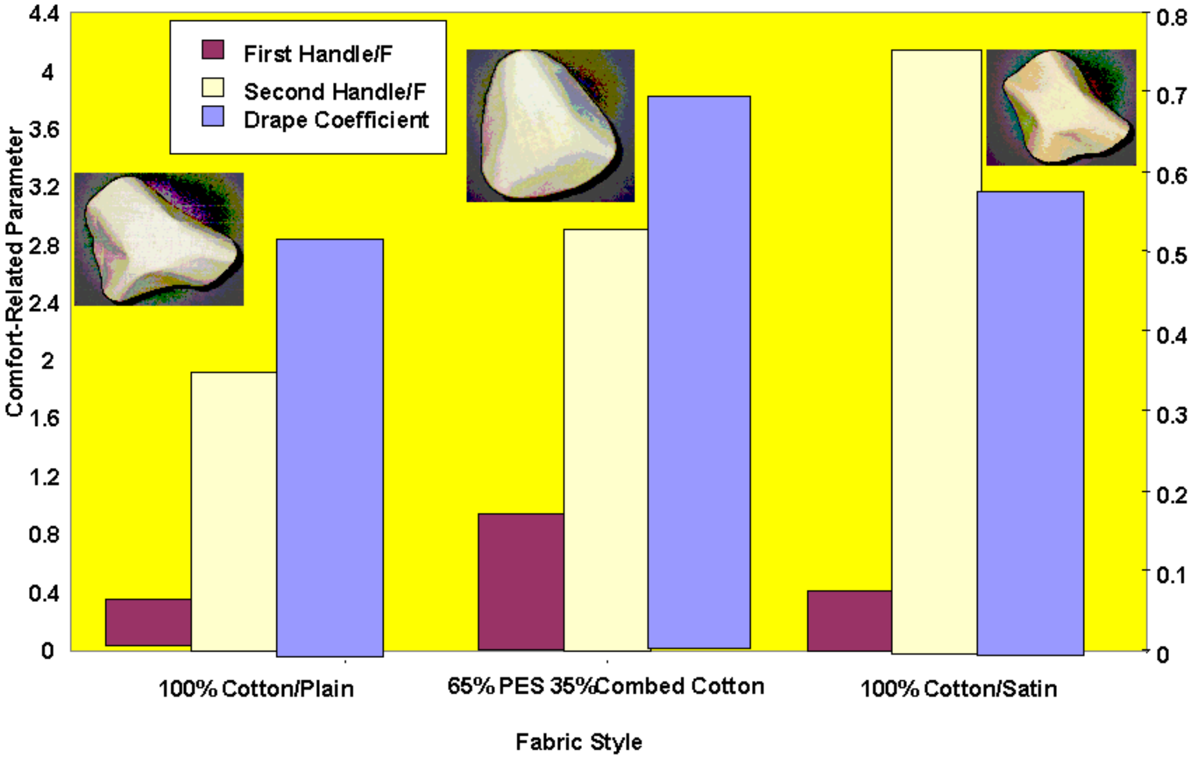

Figure 12. Drape coefficients and first and second handle coefficients (fabric face used) for the different fabric styles.

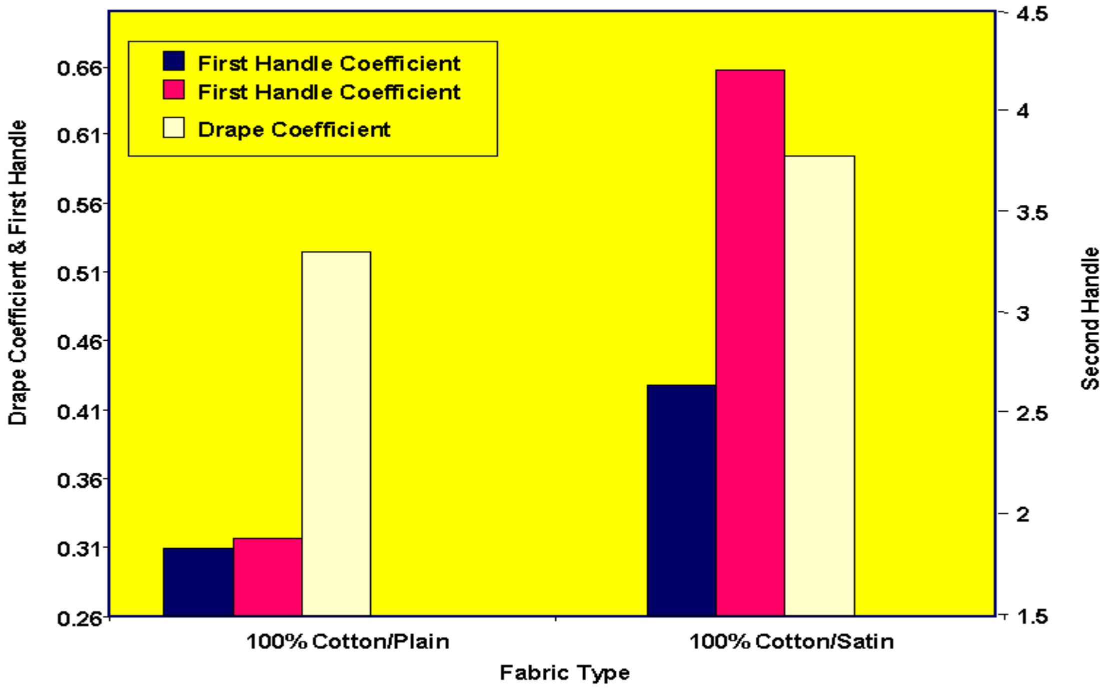

Figure 13. Drape coefficient and first and second handle coefficients (fabric face used) for the different fabric patterns produced from 100% Cotton fibers.

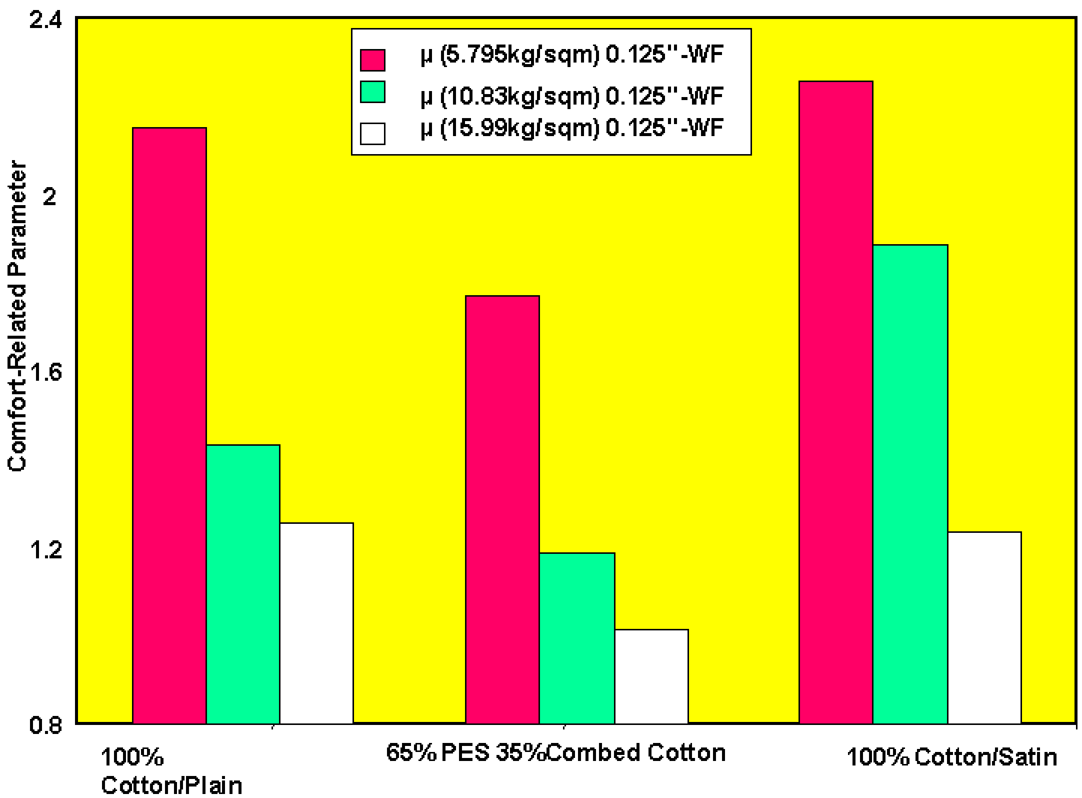

Figure 14. Friction coefficients for the different fabric styles.

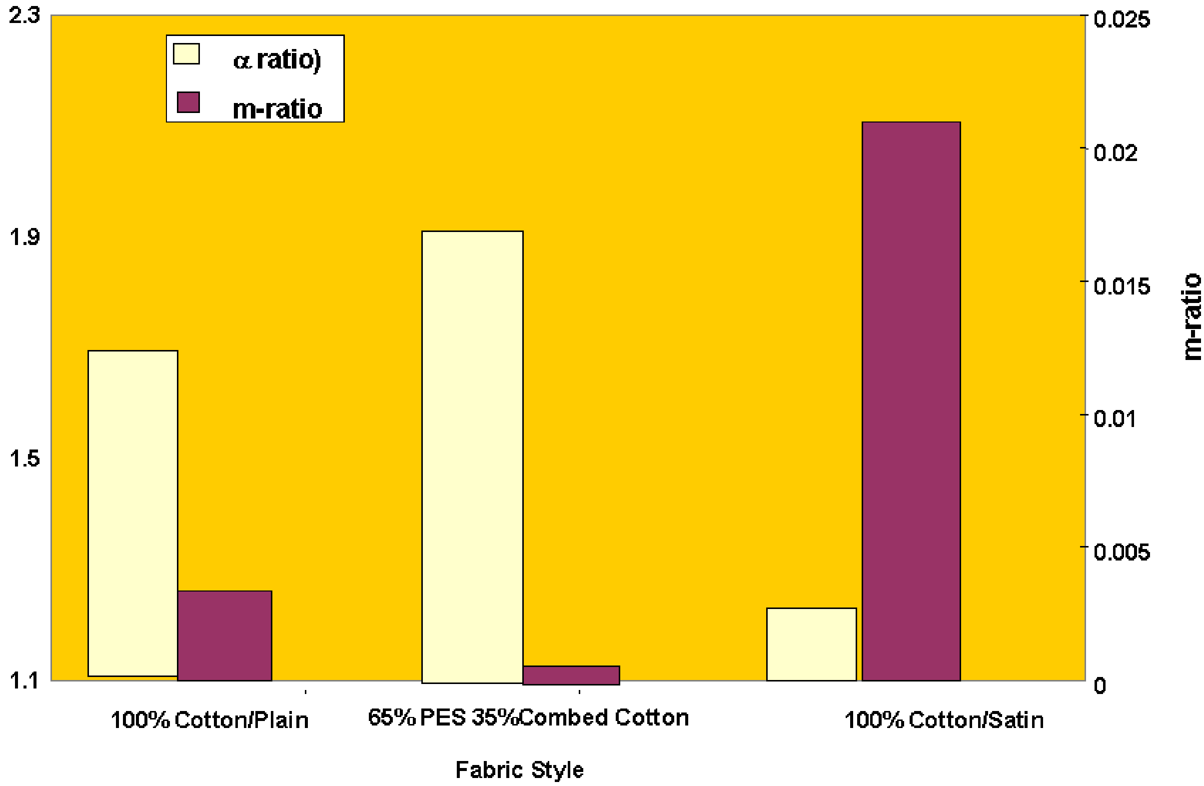

Figure 15. Different values of the coefficient m and • for some of the fabric styles.

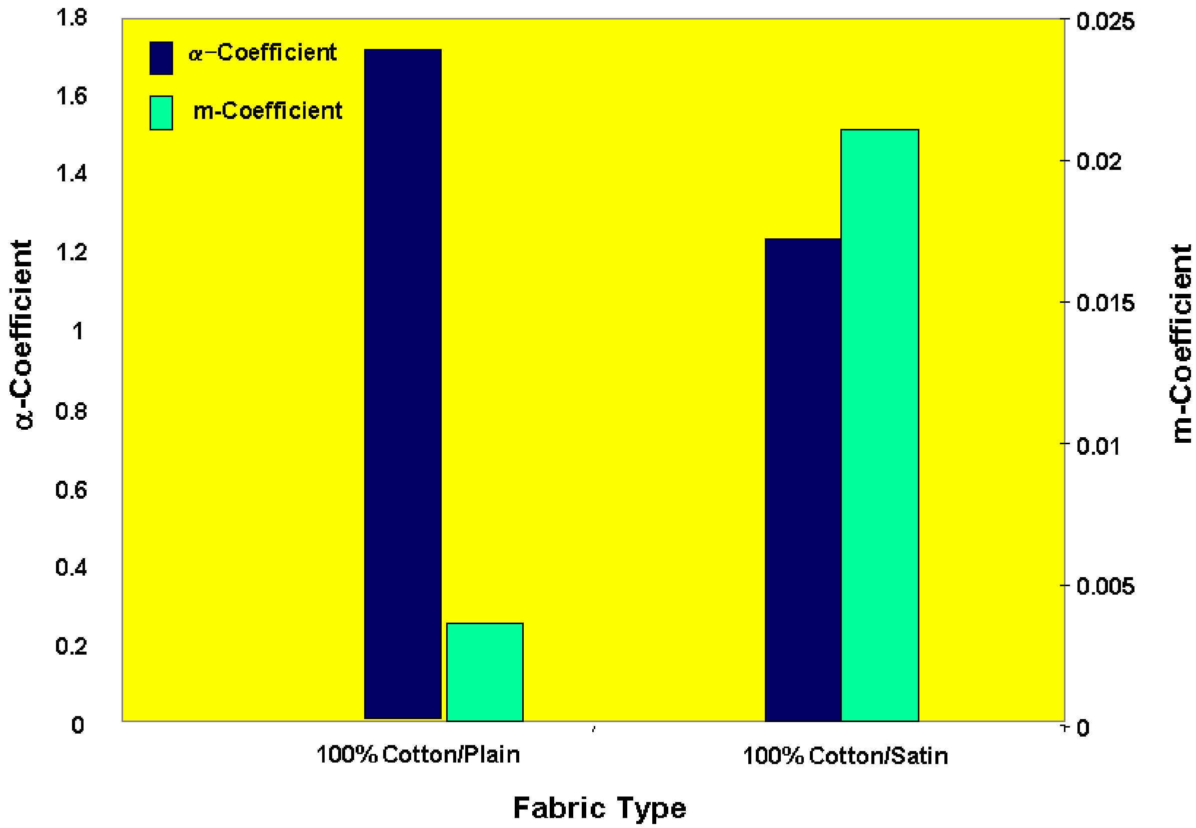

Figure 16. Different values of the coefficient m and α for different patterns produced from 100 % Cotton fabrics.