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The Effect of Plasma and Enzyme Treatment on the Comfort Properties of Organic Cotton Woven Fabric

V.Shrivarthini[1], Dr.Bhaarathi Dhurai[2]

[1]M.Tech Scholar, Department of Fashion Technology, Kumaraguru College of Technology, Coimbatore
[2] professor, Department of Fashion Technology, Kumaraguru College of Technology, Coimbatore

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Abstract - *In this study , atmospheric air pressure plasma and cellulase enzyme were treated with plain woven organic cotton fabric. The important part of doing this surface modification is to study the comfort properties of the effect made by plasma and enzyme treated organic cotton fabric. More attention was given to evaluating the air permeability, water vapour permeability, and wickability of the surface modified fabric. The results show that the plasma treated fabric outperforms the enzyme treated and untreated organic cotton fabrics in terms of air permeability and wickability in the warp and weft directions with a 5 minute interval time. But in enzyme treated fabric ,water vapour characteristics reveal the better characteristics compared to the others .Thus, this research work helps in understanding the comfort properties of surface modified organic cotton fabric.*

Key Words*: *Organic Cotton Fabric, Plasma Treatment, Enzyme Treatment, Cellulose Enzyme, Air Permeability, Wickability

1.INTRODUCTION

One of the main current concerns of textile and garment manufacturers is the comfort of clothing. The human sensory response to clothing materials serves as the foundation for comfort, which is influenced by a number of thermal, physiological, and mechanical factors. Textiles have many comfort features that make clothing comfortable, including heat transfer, thermal protection, air permeability, moisture permeability, water absorption, water repellency, size and fit. In order to meet unique requirements for a variety of applications, the surface of textiles provides an important platform for functional modifications. The surface of textiles can be altered using a variety of methods, from conventional solution treatment to biological methods. Here, organic cotton fabric has been treated with plasma with atmospheric air and a cellulosic enzyme called cellulose to meet the variety of applications along with comfort properties such as air permeability, water vapour permeability, and wickability. Why organic cotton ? Since organic cotton is grown naturally without using any pesticides or harmful fertilizers, The growing of organic cotton preserves a secure working environment for farmers and other negative effects on the ecosystem. The use of organic cotton in the manufacture of high-end fabrics is growing in popularity because of its wholly natural origin and lack of toxicity. The atmospheric air plasma was done on the fabric with system frequency of 60KHZ in aluminium electrode with the electrode gap of 7.5 cm at room temperatur and cellulose enzyme was treated in the organic cotton fabric which is cellulosic in nature with the help of Master Linen's Inc., Karur. In this paper we are going to discuss whether the comfort qualities of organic cotton fabric have been impacted by surface modifications.

2. LITERATURE REVIEW

"Organic cotton" is cotton grown without the use of genetically modified (GMO) seeds, dangerous pesticides, synthetic fertilisers, or chemicals. Organic cotton production reduces soil erosion and other detrimental effects on the ecosystem while maintaining a safe working environment for farmers and clean freshwater sources close to farms. Due to its complete natural origin and lack of toxicity, organic cotton is becoming increasingly popular in the production of high-end fabrics. Organic cotton fashion products are produced in large part by the apparel industry. Consumer demand for more organic clothing will force clothing manufacturers to use more organic cotton. Many domestic and foreign brands are choosing to produce their clothing from organic cotton. This paper discusses various environmentally friendly methods and suggestions for growing, processing, and producing organic cotton clothing.(1)

Consumers today are drawn to clothing that feels good in addition to looking good. Comfort is being emphasised as a critical factor in clothing.A pleasant state of psychological, physiological, and physical harmony between a person and their surroundings is called comfort. In this paper, the comfort property of the cotton woven fabric was studied, specifically its water vapour transmission was studied.The water vapour transmission was specifically induced by the combimation and characteristics of the fibres. The result shows that polyester cotton blend fabric has a higher water transmission rate than polyester viscose. However, the combination of natural fibre and synthetic fibre results in superior comfort when compared to the combination of two synthetic fibres.(2)

The major focus of this paper is to study the characterization of organic cotton and conventional cotton fibres . The fibre properties include surface morphology, surface chemical composition, surface elemental composition, and internal fibre structure, with organic cotton fibre having a better surface elemental composition than conventional cotton. The remaining properties were similar to each other. (3)

This study compared the airpermeability of ASTM D737-04 conventional and organic cotton used in single jerseys and the moisture management of standard ASTM D737-04. The statistical analysis showed that their comfort characteristics differed noticeably. Compared to conventional cotton, organic cotton demonstrated better air permeability and moisture management abilities.(4)

Vacuum oxygen plasma was used in this study to increase the comfort features. Evaluations of wickability, water vapour permeability/resistance, air permeability, and surface characterization received more focus. Results showed that, aside from air permeability of experimental runs at 1O2 and 7O2, all plasma treated comfort properties improved. In particular, the warp and weft directions saw at least a 43.25% and a 37.63% increase in the wickability of the fabric.(5)

The most common polymers used in the textile industry are synthetic fibres, specifically polyethylene terephthalate (PET), polyamide (PA), polyacrylonitrile (PAN), and polypropylene (PP). Along with their positive traits, they also have a number of drawbacks, including hydrophobicity, poor wear comfort, poor dyeability, accumulation of electrostatic charge, pilling propensity, challenges during finishing, and inadequate washability due to their hydrophobic nature. To enhance their properties in this situation, various physical and chemical techniques are used. The application of recent techniques for the modification of synthetic textiles using vapour deposition, surface grafting, enzymatic modification, sol-gel technique, layer-by-layer deposition of nanomaterials, and aqueous methods is the main focus of this review.(6)

One of the fundamental textile characteristics that affects how comfortable clothing is to wear is air permeability. This is especially true for wind-protective clothing, such as motorcycle and ski sport overcoats, where low air permeability is required. Conversely, summer clothing needs to be sufficiently permeable to the air in order to improve heat transfer through ventilation. The porosity and thickness of the fabric as well as the spatial geometry of the pores all play major roles in air permeability. The thickness and structure of woven fabrics then play a key role, with the latter being influenced by the weave type, type of yarns, linear density of the yarns, warp/weft density, finishing, and other factors. Although most studies refer to fabric permeability under standard laboratory conditions, fabrics are also used in real life under various climatic conditions.(7)

According to the literature research, organic cotton fabric's comfort qualities will undoubtedly have an impact on the treatment of plasma and enzymes.

3. METHODOLOGY

3.1. Air Permeability:

An air tronic tester with model number 3240A and ASTM D737 (figure 2) is used to test air permeability. It has a volumetric counter with a minimum capacity of 50 litres per hour and a maximum capacity of 5800 litres per hour. It is also available with different testing areas of 20, 20, 10, 5, 2 cm2. We tested organic cotton fabric that had been plasma and enzyme treated versus untreated using a test area of 10 cm2 with a pressure drop of 100 Pa and a measuring volume of 10 litres per minute, and readings were recorded.

Fig -1: Air tronic tester

3.2. Water vapour Permeability :

The testing of fabrics in the Water Vapour Permeability Tester Model M261(figure 3) with the specifications of ASTME 96 is used with 46ml of water at 20 °C±2 °C in each open dish predetermined from the dimensions of the dish to give an air layer which is 10±1mm deep between the surface of the water and the underside of the supported specimens. The specimens were placed over the turn table and the water vapour permeability readings of different fabrics were calculated.

Fig -2 Water vapour permeability tester (cup method M261)

3.3.Wickability

The wickability test was conducted manually. In this test, a strip of fabric is suspended vertically in distilled water with its lower edge exposed. The rate of rise of the water's leading edge is then measured at various intervals. The test fabric's capacity to wick moisture is directly measured by the height of the rise that is observed over time. One way to account for this is to weigh the fabric after the test to find out how much water it has absorbed. After that, the readings were evaluated and the mass, which is equivalent to the measured height of water rise, could be expressed as a percentage of the mass of the length of dry fabric.

4. PHYSICAL PROPERTIES OF ORGANIC COTTON FABRIC :

Table -1: Physical Properties of Organic cotton Fabric

Properties / fabric	Plain Organic cotton fabric
Thickness (mm)	17
Fabric GSM (g/m2)	100
Fabric weave type	Twill weave

5.RESULTS AND DISCUSSION

5.1. Air Permeability

The air permeability of the fabric samples was tested and the results are given in table no 2.The result shows that plasma treated organic cotton fabric has slightly higher air permeability characteristics when compared to the untreated organic cotton fabric, while the enzyme treated fabric has fewer air permeability characteristics than both the plasma treated and untreated organic cotton fabric samples. Hypothesis testing (T-Test) was carried out for the plasma treated and enzyme treated organic cotton fabrics with untreated fabrics and the results were analysed.

Table -2: Air Permeability of the Fabric samples

Fabric type (plain woven organic cotton fabric)	Air permeability (lit/min)
Plasma treated fabric	15.26
Enzyme treated fabric	13.76
untreated fabric	14.38

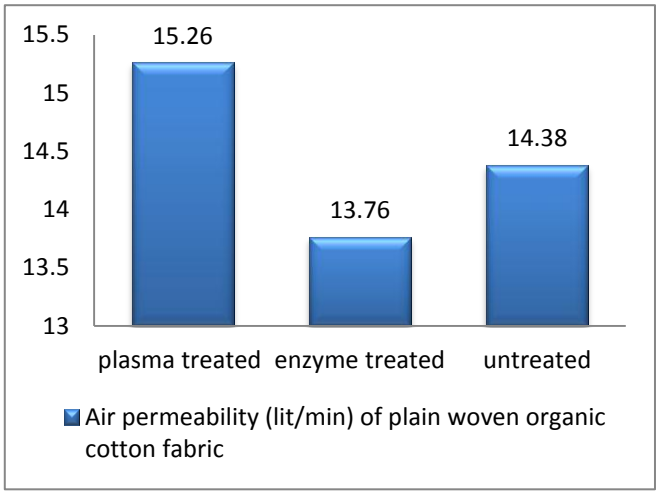

Chart -1: air permeability of the fabrics samples

By using a PAIRED T-TEST with one tail at the 95% significant level to compare the means of plain woven organic cotton fabrics that have been plasma treated and those that have not, P value = 0.089784>0.05 Consequently, there is no significant difference between plain woven organic cotton fabrics that have been plasma treated and those that have not.

By using the PAIRED T-TEST with one tail at the 95% significant level: P value = 0.002585< 0.05 to compare the means of plain woven organic cotton fabrics that have been enzyme treated and those that have not. The plain woven organic cotton fabric that has been enzyme treated as opposed to untreated shows a significant difference as a result.

5.2. Water Vapour Permeability

The water vapour permeability of the fabric samples were tested and results were given in table no 3.The result shows that enzyme treated organic cotton fabric has the higher water vapour permeability when compared to the plasma treated and untreated organic cotton fabric.plasma treated fabric has the poor water vapour characteristic when compared to the others.

By using a PAIRED T-TEST with one tail at the 95% significant level to compare the means of plain woven

organic cotton fabrics that have been plasma treated and those that have not, P value = 0.004463<0.05. Consequently, there is a significant difference between plain woven organic cotton fabrics that have been plasma treated and those that have not

Table -3: Water vapour Permeability of the Fabric samples

Fabric type (plain woven organic cotton fabric)	Water vapour permeability (g/m2/24 hr)
Plasma treated fabric	1164.96
Enzyme treated fabric	2117.04
Untreated fabric	1785.88

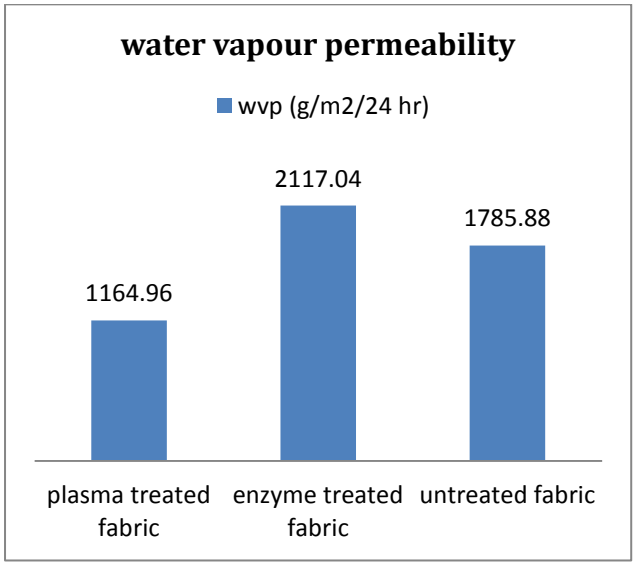

Chart -2: water vapour permeability of the fabrics samples

By using the PAIRED T-TEST with one tail at the 95% significant level: P value = 0.011583< 0.05 to compare the means of plain woven organic cotton fabrics that have been enzyme treated and those that have not. The plain woven organic cotton fabric that has been enzyme treated as opposed to untreated shows a significant difference as a result.

5.3. Wickability

The wickability of the fabric samples was tested, and the results are given in table no 4 and 5. The result shows that plasma treated organic cotton fabric has a higher wickability property when compared to enzyme treated and untreated organic cotton fabric. Hypothesis testing (T-Test) was carried out between the plasma treated,enzyme treated and untreated organic cotton fabric.

Table - 4: wickability of the fabric sample in warp direction

Time in minutes	Wickability of Plasma treated organic cotton fabric (cms)	Wickability in Enzyme treated organic cotton fabric (cms)	Wickability in untreated organic cotton fabric (cms)
1 min	2.4	0.4	0.9
3 min	3.7	1.4	1.8
5 min	4.6	2	2.3

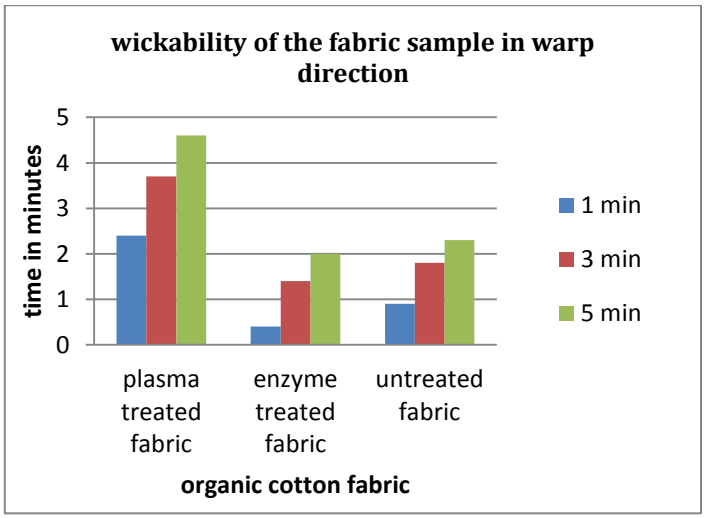

Chart -3: wickability of the fabric sample in warp direction

By comparing the means of plasma treated and untreated plain woven organic cotton fabrics using PAIRED T- TEST with one tail at 95% significant level:P value = 0.007227<0.05 Result: there is significant difference between the plasma treated and untreated plain woven organic cotton fabrics in the warp direction .

By comparing the means of enzyme treated and untreated plain woven organic cotton fabrics using PAIRED T- TEST with one tail at 95% significant level: P value = 0.010102<0.05 Result: there is significant difference between the enzyme treated and untreated plain woven organic cotton fabrics in the warp direction.

Table - 4: wickability of the fabric sample in weft direction

Time in minutes	Wickability in Plasma treated organic cotton fabric (cms)	Wickability Enzyme treated organic cotton fabric (cms)	Wickability in untreated organic cotton fabric (cms)
1 min	2	0.3	0.7
3 min	3.6	1.1	1.4
5 min	4.4	1.5	1.9

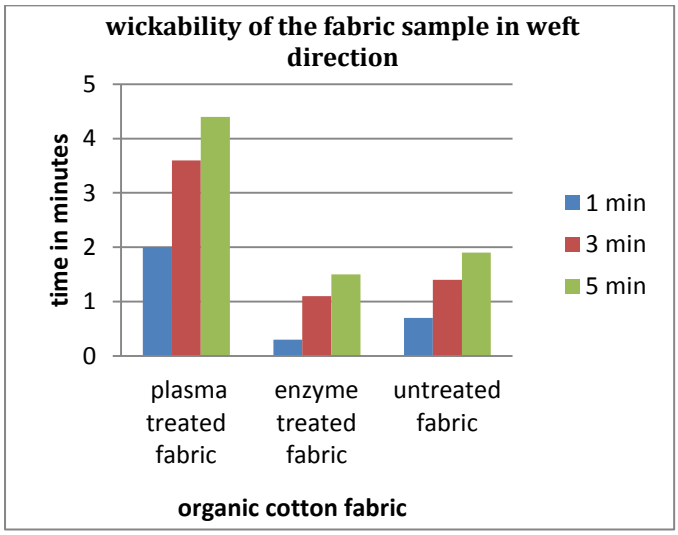

Chart -4: wickability of the fabric sample in weft direction

By comparing the means of plasma treated and untreated plain woven organic cotton fabrics using PAIRED T- TEST with one tail at 95% significant level:P value = 0.015498<0.05 Result: there is significant difference between the plasma treated and untreated plain woven organic cotton fabrics in the warp direction .

By comparing the means of enzyme treated and untreated plain woven organic cotton fabrics using PAIRED T- TEST with one tail at 95% significant level:P value = 0.004082<0.05 Result: there is significant difference between the enzyme treated and untreated plain woven organic cotton fabrics in the weft direction.

6.CONCLUSION:

From the analysis of the results, it is found that the plasma treated organic cotton fabric has a higher air permeability property. In the water vapour permeability test, enzyme treated fabric performed the best of the others, and at least in the wickability test, the warp direction and weft direction of the plasma treated fabric had the higher wicking property. Thus, this study demonstrates that there are slight changes that occur in the comfort properties of surface modified fabrics, and each surface modified fabric performs differently in each comfort property such as air permeability, water vapour permeability and wickability.

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