EFFECT OF DIFFERENT WET PROCESSING STAGES ON PHYSICAL PROPERTIES OF COTTON WOVEN FABRICS

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Abstract: *This paper sheds light upon the influence of pretreatment as one of the most important wet processing stages on cotton woven fabric properties. Throughout this study a part of the woven fabrics were in a grey form while the second part of fabrics subjected to desizing and scouring and the third part subjected to desizing, scouring and bleaching respectively. All the pretreated fabrics will be compared to each other and to grey woven fabrics of the same characteristics. The findings of the experimental results revealed that physical and mechanical properties of woven fabrics have been influenced significantly with wet processing stages especially tensile strength, air permeability and tearing strength.*

Keywords*: wet processing, woven fabrics, physical properties, tensile strength, breaking elongation, air permeability.*

1 INTRODUCTION

Textile industry includes various and distinguished processes such as spinning, weaving, wet processing and garment industry. Wet processing includes pretreatment, dyeing and finishing processes. A pretreatment is a group of processes that precede fabric dyeing and comprises singeing, desizing, scouring and bleaching. These distinguished processes have a remarkable influence on fabric appearance and its physical properties.

Singeing is one of an important part of the pretreatment process. Its objective focuses on the elimination of loose fibers from yarn and/or fabric surfaces using burning-off. If the burning-off of the protruding fiber ends from yarn and/or fabric surface doesn't properly done, it will results in an unclear pattern, mottled and pilled fabric surface [1]. Singeing process was found to have a reducing effect on yarn hairiness by about 87%. However, it increases and reduces unevenness and imperfection values of spun yarns respectively for all counts [1]. Because of compact spinning eliminates hairiness significantly from compact spun yarn surface, the singeing process can be eliminated considerably [2-5].

The second processing step after singeing in pretreatment stages of cotton and blended woven fabrics is called desizing. The main goal of this process is to remove sizing ingredients from warp yarns of grey fabrics. After performing desizing, woven fabric become ready for processing in subsequent stages. According to the type of size ingredients, desizing process is executed using different methods [6-9]. Generally, desizing process can be done in many ways such as acid steep, rot steep and enzymatic. Because of its advantages such as eco-friendly, selectivity and speed, enzymatic is the most dominating and enzymes are used efficiently to remove sizing materials from fabrics, especially, which are sized with non-soluble starches [10-13].

Scouring is an essential pre-treatment of woven fabrics. The main object of this process is to obtain sufficiently hydrophilic fabrics. This is done by removal of pectins, waxes, hemicelluloses and other impurities present in the cotton fabrics [14]. Conventional scouring process of cotton fabrics is carried out using sodium hydroxide at 100°C temperature and alkaline medium, namely pH 10-12. Because of alkaline scouring consumes a large amount of water and energy, enzymatic scouring finds itself as an effective and efficient alternative for cotton fabric scouring. In general, scouring of cotton fabrics using enzymes is called bio-scouring. In this process, low temperature, i.e. 50-65°C and pH ranges between 7.9-9 are used [15, 16].

To remove the natural pigments of cotton fibers, bleaching is the process that follows scouring directly. Generally, cotton fabrics are mostly bleached using hydrogen peroxide (HP) in an alkaline path, i.e. pH 10-12 and at 100°C temperature. There is no ecological consideration in using hydrogen peroxide. But, because of a large quantity of water that are utilized to neutralize and rinse pretreated woven fabrics, a large quantity of energy and a large amount of salts produced, several types of enzymes and biotechnology were found to be good alternatives to hydrogen peroxide as a bleaching agent [17, 18]. For instance, pectinases were an efficient alternative to sodium hydroxide to remove non-cellulosic materials from cotton fabric surface. In this process a moderate temperature and a slightly alkaline medium are used. Also, the fiber surface doesn't deteriorate during this process [19, 20]. Peracetic acid was also found to be a good alternative to hydrogen peroxide. Because of its low concentration, low temperature, its degradability and slightly alkaline medium, it was also considered as an effective bleaching agent [21, 22].

Because of swelling of cotton fibers when treated with aqueous solution of sodium hydroxide, mercerization is mainly used to improve cotton fabric properties such as tensile strength, smoothness, dye affinity and dimensional stability [23, 24]. This treatment is generally carried out in slack or tight states. Mercerizing cotton fabrics in slack condition increases their stretch properties, whereas tight mercerization enhances tensile strength and luster properties. With mercerization, all these features stem from fiber swelling which in turn increases crystallinity, unit cell structure, accessibility, and fiber orientation, i.e. orientation of fibrils along fiber axis [25, 26]. Although there are a variety of chemical agents used for mercerization, caustic soda remains the best one [27, 28]. It was reported that hot and cold mercerization are the most commonly used types of mercerization. In normal type, woven fabrics are treated with caustic soda at 15-20°C temperature, while temperature can be raised up to 90°C in hot mercerization [29].

There are many research papers have been published [30-36] regarding the influence of weaving and spinning parameters on the cotton woven fabrics properties. By contrast, there are few numbers of them which examining the influence of pretreatments altogether on the woven fabrics properties. The effects of pretreatments on the cotton woven fabrics properties will be undertaken throughput this study

2 MATERIALS AND METHODS

Throughout this study, rapier weaving machines of model – was used to weave the grey fabric samples during this study. Warp and weft yarns of count 24 Ne and with 66 ends/inch and 58 picks/inch respectively were utilizes to weave the fabric samples. Egyptian cotton of type Giza 86, which is considered one of the best worldwide, was used to spin warp and weft yarns. After weaving, fabric samples were classified into three sections. The first section was left as it is, namely it did not subject to any pretreatments. The second fabric section subjected to desizing and scouring processes only. The third section of fabric samples subjected to desizing, scouring and bleaching processes respectively. The chemical and auxiliaries used to pre-treat the greige woven fabric samples were listed in Table 1. The temperature used for scoring ranges between 100 and 125°C, while for bleaching it reaches to 95°C.

Table 1 Chemicals and auxiliaries used in the pretreatments of woven fabrics

Chemicals and auxiliaries	amount [g/l]
alkali (NaOH)	5
soda ash	1
wetting agent	1
detergent	2
hydrogen peroxide (H_2O_2)	2

After weaving and pretreatments, fabric samples were left in a standard conditioned environment for one day at temperature 20±2°C and relative humidity 65±2%. After that these fabric samples were laboratory tested for their weight, breaking strength, breaking elongation, tearing strength and air permeability. For each property, five individual-readings were obtained and averaged. Tensile properties of fabrics under study were tested and assessed using Instron tensile tester of model 4411 (Instron Inc., USA) in accordance with ASTM standard D5035-11(2015) (strip method). Air permeability of griege and treated woven fabrics were evaluated using Shirely-Air permeability tester in accordance with ASTM standard D737-18. While according to ASTM standard D1424-09(2013), tearing strength of fabrics under study was also measured using Intensity tearing tester (Elmendorf). The mass per unit area of griege and treated woven fabrics were measured using a standard balance according to D3776M – 09a(2017).

2.1 Statistical analysis

In order to examine the significance impact of pretreatments on fabric characteristics, the Analysis of Variance of type One-Way (ANOVA) was implemented. The statistical analysis in this study was performed using SPSS statistical package version 25. The significance level, $0.01 \leq \alpha \leq 0.05$ was utilized to assess the significant influence of pretreatments on woven fabric characteristics.

3 RESULTS AND DISCUSSION

3.1 Fabric weight

The results of fabric weights at different pretreatment processes were displayed in Figure 1. The statistical analysis results were also listed in Table 2. From the ANOVA results, it is clear that pretreatment processes have a significant effect on fabric weight at 0.01 significant level. It can be seen from Figure 1 that fabric weight has increased progressively by wet processing. That is fabric weight has increased by desizing and scouring processes compared to grey fabric weight and that it continues to increase with the bleaching process. Scouring and desizing process led to increasing grey fabric weight by approximately 6% and this ratio has been raised to 11% at bleaching process. The positive influence of wet processing on fabric weight may be due to fabric shrinkage in weft direction because of this wet processing.

Table 2 ANOVA results of the effect of pretreatment processes on fabric weight

Variation source	SS	df	MS	F	P-value	F crit
Variation between groups	840	2	420	32.30769	0.000	3.885
Variation within groups	156	12	13			
Total	996	14				

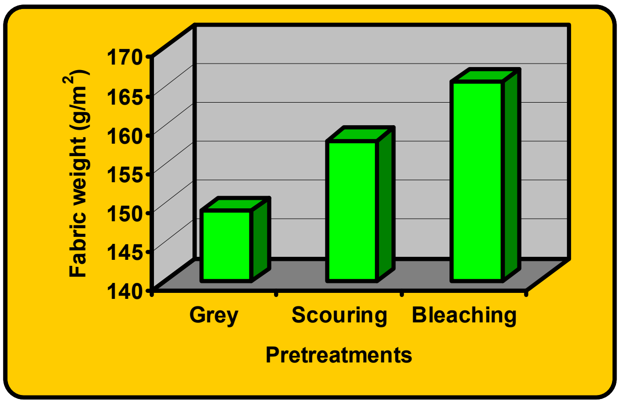

Figure 1 Effect of pretreatment processes on woven fabric weight

3.2 Effects on fabric tensile strength

Values of grey and pretreated fabrics' tensile strength were depicted in Figure 2. The statistical analysis results were also listed in Table 3.

Table 3 ANOVA results of the effect of pretreatment processes on fabric tensile strength

Variation source	SS	df	MS	F	P-value	F crit
Variation between groups	74.533	2	37.267	7.1667	0.009	3.885
Variation within groups	62.4	12	5.2			
Total	136.933	14				

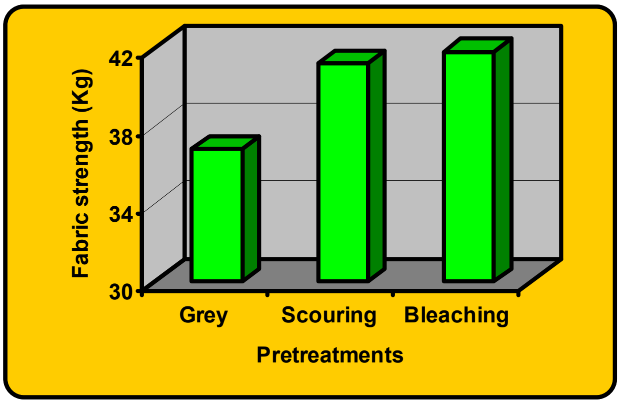

Figure 2 Effect of pretreatment processes on woven fabric tensile strength

From the ANOVA results, it can be seen that wet processing stages statistically significant influence the fabric tensile strength. An increasing trend was detected confirming that pretreatment processes have a positive influence on fabric tensile strength. The scouring process has a pronounced influence on the fabric tensile strength. While fabric tensile strength slightly increased due to the bleaching process. The average values of fabrics' tensile strength were 36.8 kg, 41.2 kg and 41.8 kg for grey, scoured and bleached fabric samples respectively. The increased breaking tensile strength of pretreated woven fabrics probably be ascribed to the reduction of internal stresses and to somewhat the de-convolution of the fibers in the woven fabrics due to the effect of caustic soda.

3.3 Effects on breaking elongation

Figure 3 shows the influence of pretreatment processes on breaking extension of woven fabrics. Statistical analysis results were listed in Table 4.

Table 4 ANOVA results of the effect of pretreatment on fabric weight

Variation source	SS	df	MS	F	P-value	F crit
Variation between groups	23.333	2	11.667	6.364	0.013	3.886
Variation within groups	22	12	1.833			
Total	45.333	14				

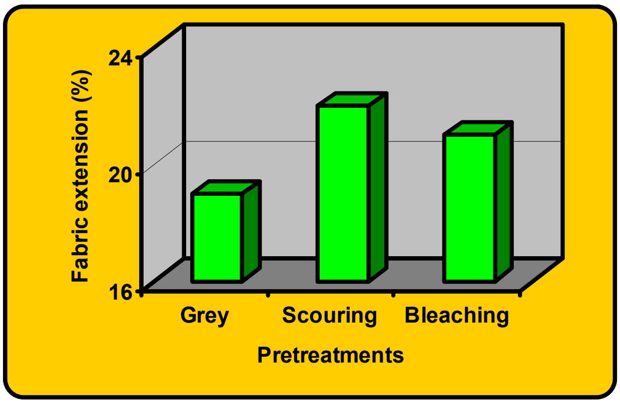

Figure 3 Effect of pretreatment on woven fabric breaking elongation

From ANOVA results it can be concluded that fabric breaking elongation has been affected significantly by pretreatment processes at 0.05 significant level. By contrast to tensile strength results, high breaking extension values were accompanied by scoured woven fabric samples, whereas the low ones were associated with the grey woven fabric. The statistical analysis proved that scouring process increased the breaking elongation of grey woven fabrics by about 15.8%, while the bleaching process diminished the breaking elongation of scoured woven fabric by less and non-significant value, i.e. 4%.

3.4 Effects on tearing strength

Figure 4 portrays the influence of wet processing stages on woven fabric tearing strength; and the findings of the statistical analysis were also introduced in Table 5. It was proved that pretreatment processes have a significant influence on fabric tearing strength. From this figure it can be observed that after wet processing, tearing strength of woven fabrics have been reduced significantly. The influence of the scouring process decreased tearing strength of greige woven fabrics by approximately 6.7% and continued to decrease the tearing strength up to 26.7% due to the impact of the bleaching process. The negative influence of wet processing on fabric tearing strength may be attributed to fabric shrinkage and compactness after wet processing which leads to diminishing the fabric tearing strength.

Table 5 ANOVA results of the effect of pretreatment processes on fabric weight

Variation source	SS	df	MS	F	P-value	F crit
Variation between groups	1036000	2	518000	62.16	0.000	3.886
Variation within groups	100000	12	8333.333			
Total	1136000	14				

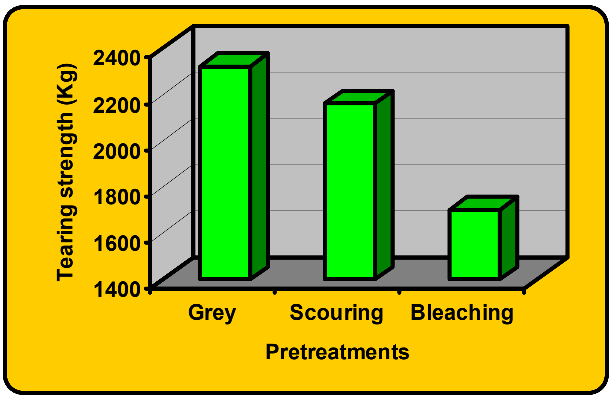

Figure 4 Effect of pretreatment processes on woven fabric tearing strength

3.5 Effects on air permeability

Air permeability values versus the types of wet processing are shown in Figure 5. Also, Table 6 represents the findings of the statistical analysis. From this figure and table, it can be observed that air permeability values of woven cotton fabrics were significantly affected by the different types of pretreatment processes. As shown in this figure pretreatment process has a negative influence on woven fabric air permeability. Grey fabrics were found to have high air permeability. By contrast, lower values of the air permeability were associated scoured with woven fabrics. The air permeability values of wet processed woven fabrics were 75, 28 and 32.5 $cm^3/cn^2.s$ for grey, scoured and bleached woven fabric respectively. The negative influence of pretreatment processes on fabric air permeability can be ascribed to increasing the fabric weight and thickness after these wet processes.

Table 6 ANOVA results of the effect of pretreatment processes on fabric air permeability

Variation source	SS	df	MS	F	P-value	F crit
Variation between groups	6747.658	2	3373.829	2090.944	0.000	3.88529
Variation within groups	19.36252	12	1.613543			
Total	6767.02	14				

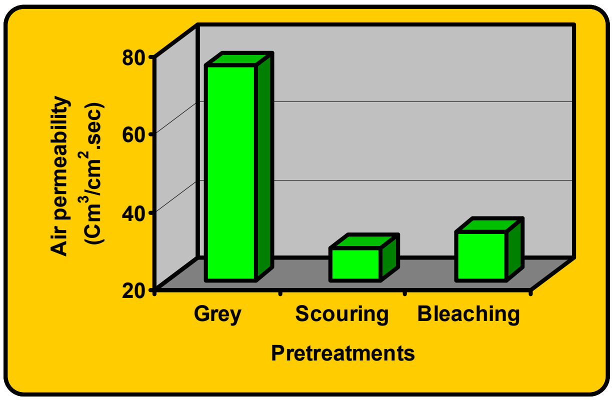

Figure 5 Effect of pretreatment processes on woven fabric air permeability

4 CONCLUSION

After each wet processing stage, the experimental results revealed that the physical properties of the woven fabric have been changed considerably. Due to fabric shrinkage after pretreatment processes, it was found that woven fabric properties have been affected significantly. The experimental results of this work can be summarized as follows:

- Due to shrinkage after wet processing, woven fabric weight and tensile strength have increased significantly. Whereas, the air permeability and tearing strength decreased considerably.
- Scouring process increased grey woven fabric weight by about 6%, while bleaching one increased scoured fabric weight by 4%.
- The influence of the scoring process on fabric tensile strength is more pronounced compared to the effect of bleaching one.
- The high breaking extension is associated by scoured fabrics followed by bleached and griege woven fabrics respectively.
- The air permeability of woven fabrics was reduced dramatically by introducing scouring and bleaching processes.

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