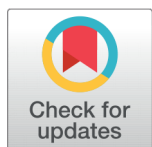


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Effect of chemical dosing amount in conventional cotton fabric pretreatment process

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Abstract

Objectives: The objective of the study is to analysis the effect of chemicals on different physical properties and color fastness of treated cotton samples with standard rating values. **Methodology:** Five single baths are used for the pretreatment process with five different dosages such as 1g/L, 1.5 g/L, 2 g/L, 2.5 g/L, 3 g/L of NaOH and H₂O₂. After that, reactive dyeing was performed for these five samples with a standard recipe. **Findings:** With the gradual increment of NaOH and H₂O₂ dosages, the absorbency and whiteness index of pretreated samples were improved and for that particular reason bursting strength was degraded. On the other hand, for dyed samples, a little variation was observed in color fastness to wash and rubbing but the changes in the color shade of every sample were observable.

Keywords: Bleaching; color fastness; physical properties; scouring; shade variation

1 Introduction

Pretreatment is considered to be the heart of the wet processing of cotton. As an integral part of cotton wet processing, the scouring & bleaching process is usually named as pretreatment. Because of inherited characteristics of comfortability, absorbency, breathability, etc., cotton fabrics are still on the top in the list of people's demands. As it is a natural cellulosic fiber, it contains about 6% impurities of its total ingredients. Cotton fabric pretreatment process not only deals with the removal of protein, pectin, oil, wax, fat, mineral substances, etc. from the fabric but also need to achieve an acceptable absorbance value and whiteness index value with the least deterioration of fabric strength by applying minimum use of chemical & auxiliaries, power, time and water^(1,2).

As an important part of textile processing, usually, pretreatment contains two processes, such as the scouring process & bleaching process. Scouring deals with

the underlying impurities trapped inside fibers. Scouring the fabric is considered to be one of the significant stages in pretreatment, in which the total or partial removal of non-cellulosic composites as well as lubricants of machinery and size chemicals are trapped inside fibres^(3,4). Specifically, after the reaction in the scouring process of cellulosic fibers, weight loss percentage of cotton fabric ranges to 5-10% and for wettability and absorbency properties, an observable improvement is achieved⁽⁵⁾. Besides, bleaching removes the chromophore group of natural coloring elements from the fibers and whitens the fabric according to the given dosages. Following three major functions, such as (a) soaking the cotton fabric with a bleaching agent and other chemicals, (b) increasing the temperature to the optimum level & for a certain period have to retain the temperature, (c) finally completely rinsing, washing and drying the cotton fabric; bleaching process has completed⁽⁶⁾. In some conditions, hydrogen peroxide bleaching sometimes may get combined with the cotton scouring process, where peroxide bleaching is accomplished under alkaline medium⁽⁷⁾. In the bleaching process with hydrogen peroxide which is not obnoxious for the environment, pH is maintained at 10.5–11 and 80–85°C temperature is required with 4 hours of treatment, and also sodium silicate is usually used as a stabilizer in the bath^(8,9).

Reactive dyes, because of their vast range of color, intense brightness of light, and extremely good fastness properties, it becomes much admired in the dyeing of cotton fabrics⁽¹⁰⁾. In exhaust dyeing method, for dye exhaustion, 30–150 g/L of salts (usually sodium chloride or sodium sulfate is used) is needed to be added because of having a slightly negative charge in cotton fibers and reactive dyes show its anionic characteristics in the dyeing bath^(11–13).

Through this project work, some findings have been analyzed to observe how physical properties of single jersey cotton knitted fabric altered when H₂O₂ & NaOH had been dosed at a different percentage. Similarly, after dyeing those cotton knitted samples the dyeing shades of each sample were also varied from each other. All those data & information have been thoroughly deconstructed in this study.

2 Materials and Methods

2.1 Materials

The experiment was done with the following materials.

2.1.1 Fabric

Single jersey 100% cotton knitted fabric and the GSM of the fabric was 160.

2.1.2 Dye-stuffs & Auxiliaries

Table 1. List of used dye-stuffs & auxiliaries.

Reactive Dyes	Auxiliaries	
	Detergent	Leveling agent
Sunfix Yellow EX	Sequestering agent	Glauber's Salt
	Sodium Hydroxide	Soda Ash
Sunfix Red EX	Hydrogen Peroxide	Acetic Acid
Sunfix Blue EX	Stabilizer	Soaping Agent

2.1.3 Machinery

- Laboratory Sample Dyeing Machine (Brand: Mathis; Model: H-T2-000; China)
- Washing Fastness Machine (Brand: James Heal; Model: 1615 20 Gyro-wash; UK)
- Crock meter/Rubbing fastness tester (Brand: James Heal; Model: 680; UK)
- Spectrophotometer (Brand: x-rite; Model: Color Eye 7000A; USA)
- Bursting Strength Tester (Brand: SDL Atlas; Model: M229P; UK)

- Color Assessment Cabinet (Brand: Verivide; Model: CAC-60; UK)

2.2 Methods

2.2.1 Pretreatment

The grey fabric was collected and from which we cut off 5 pieces of fabric for our experiment and the weight of every single piece was 10 grams. Pretreatment chemicals, dyes, auxiliaries, and fabric samples were weighted by using the digital electronic weight balance. For the proper clarification of this experiment 5 samples had been taken into 5 batches (Batch - A, Batch - B, Batch - C, Batch - D & Batch - E) where the liquor ratio (L:R) for all batches were 1:30

Table 2. Pretreatment Recipe of Batch – A

	Water	Chemicals	% or g/L	Time	Temperature
Pretreatment Recipe	300 ml	Detergent	1 g/L	30 min	100°C
		Sequestering agent	1 g/L		
		NaOH	1 g/L		
		H ₂ O ₂	1 g/L		
		Stabilizer	0.25 g/L		
Neutralization	300 ml	Acetic Acid	0.5 g/L	5 min	55°C

Table 3. Pretreatment Recipe of Batch – B

	Water	Chemicals	% or g/L	Time	Temperature
Pretreatment Recipe	300 ml	Detergent	1 g/L	30 min	100°C
		Sequestering agent	1 g/L		
		NaOH	1.5 g/L		
		H ₂ O ₂	1.5 g/L		
		Stabilizer	0.37 g/L		
Neutralization	300 ml	Acetic Acid	0.5 g/L	5 min	55°C

Table 4. Pretreatment Recipe of Batch – C

	Water	Chemicals	% or g/L	Time	Temperature
Pretreatment Recipe	300 ml	Detergent	1 g/L	30 min	100°C
		Sequestering agent	1 g/L		
		NaOH	2 g/L		
		H ₂ O ₂	2 g/L		
		Stabilizer	0.50 g/L		
Neutralization	300 ml	Acetic Acid	0.5 g/L	5 Min	55°C

Table 5. Pretreatment Recipe of Batch – D

	Water	Chemicals	% or g/L	Time	Temperature
Pretreatment Recipe	300 ml	Detergent	1 g/L	30 min	100°C
		Sequestering agent	1 g/L		
		NaOH	2.5 g/L		
		H ₂ O ₂	2.5 g/L		
		Stabilizer	0.62 g/L		
Neutralization	300 ml	Acetic Acid	0.5 g/L	5 Min	55°C

Table 6. Pretreatment Recipe of Batch – E

	Water	Chemicals	% or g/L	Time	Temperature
Pretreatment Recipe	300 ml	Detergent	1 g/L	30 min	100°C
		Sequestering agent	1 g/L		
		NaOH	3 g/L		
		H ₂ O ₂	3 g/L		
		Stabilizer	0.75 g/L		
Neutralization	300 ml	Acetic Acid	0.5 g/L	5 min	55°C

2.2.2 Dyeing

After completing the batch-wise pretreatment, 5 samples (A, B, C, D, & E) were dyed with the same reactive dyeing recipe mentioned in Table 7. For dyeing, the weight of every sample piece was 10 grams and the liquor ratio (L:R) was 1:30. After dyeing, all samples were washed with water then treated with acetic acid followed by soaping as mentioned in Table 7. At last, the samples were squeezed and then dried in the oven dryer machine at 100°C for 5 minutes.

Table 7. Dyeing Recipe for all Samples

	Water	Dyes & Chemicals	% or g/L	Time	Temperature
Dyeing Recipe	300 ml	Leveling Agent	1 g/L	60 min	60°C
		Sunfix Yellow EX	0.5%		
		Sunfix Red EX	0.5%		
		Sunfix Blue EX	1%		
		Glauber's Salt	50 g/L		
		Soda Ash	12 g/L		
After Treatment Recipe	300 ml	Acetic Acid	0.5 g/L	5 min	55°C
	300 ml	Soaping Agent	0.5 g/L	5 min	80°C

2.2.3 Testing

- Bursting Strength Test:** To determine the bursting properties of the samples after the pretreatment process, the method of ISO 13938-2:2019 was used.
- Whiteness Index (WI) Test:** For each sample, the CIE whiteness index was calculated according to the AATCC test method 110-2005. Whiteness index of the scoured and the bleached sample was determined by using x-rite Color Eye 7000A spectrophotometer at 10° observer and D65 illuminant. Each sample was conditioned, folded twice for ensuring perfect opacity.
- Absorbency Test:** This absorbency test method was used to evaluate the ability of vertically aligned fabric specimens to transport liquid along or through them by obeying the AATCC test method 197-2013 & 198-2013. It is also named as the vertical & horizontal wicking test method.
- Color Fastness to Wash & Rubbing:** According to ISO 105 C06 A2S:2010 & ISO 105 X12:2016 methods, the five dyed samples were tested for colorfastness to wash and colorfastness to rubbing respectively.
- Color Co-ordinates Measurement:** Using x-rite Color Eye 7000A spectrophotometer at 10° observer and D65 illuminant, CIE color coordinates of the dyed sample were measured. L* (Lightness and Darkness), a* (Redness and Greenness), b* (Yellowness and Blueness), C* (Chroma) and H* (Hue) determine the color qualities & shade differences.

3 Results and Discussion

3.1 Measurement of Whiteness Index for Pretreated Fabric

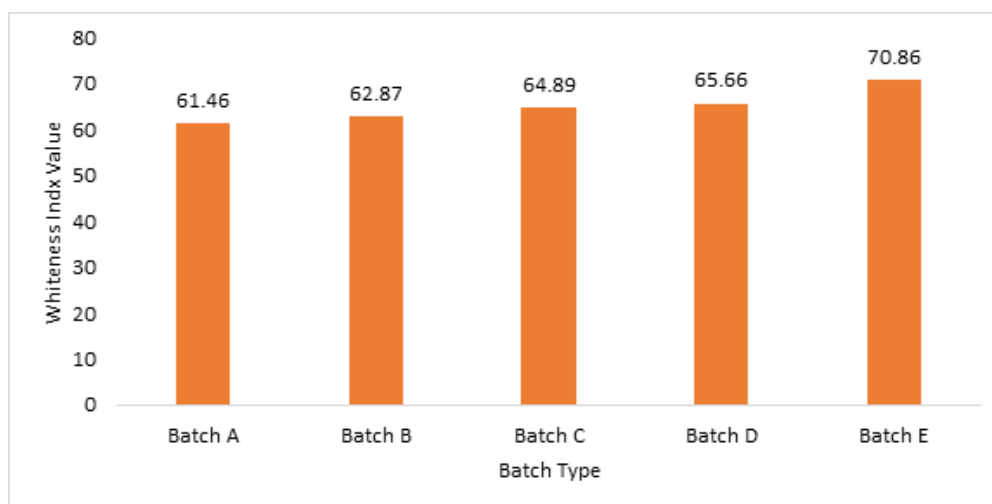


Fig 1. Pretreatment effect on Whiteness Index

Figure 1 shows that whiteness of the fabric is gradually improving when the dosages of NaOH & H₂O₂ are getting increased in the pretreatment bath. Along with increasing H₂O₂ dosages, the discoloration of the samples takes place by breaking the chromophore of natural color which is organic compounds with conjugated double bonds. And samples become whiter successively.

3.2 Measurement of Bursting Strength for Pretreated Fabric

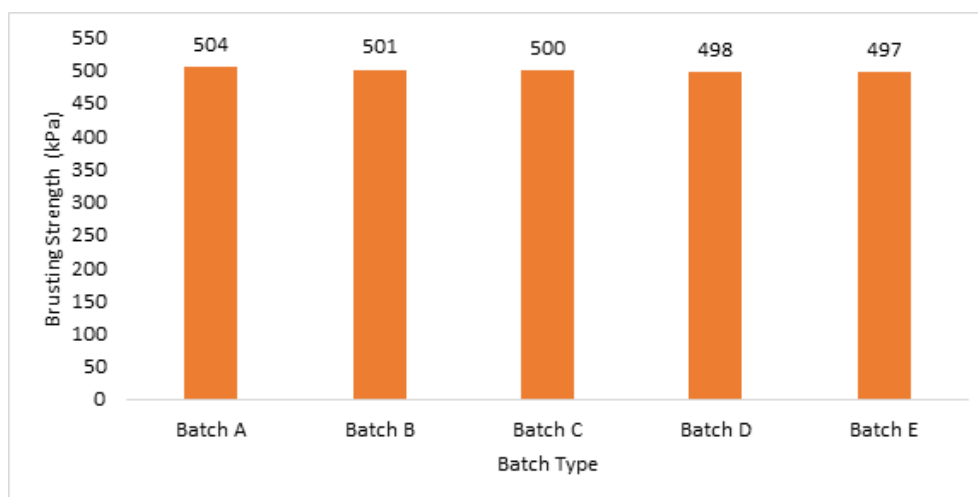


Fig 2. Pre treatment effect on Bursting Strength

On the contrary, the bursting strength of the samples is decreased successively after increasing the NaOH & H₂O₂ dosages. That means due to applying high dosages of NaOH & H₂O₂, deterioration of cotton gets started due to oxidation, and that's why less pneumatic pressure is required to burst out the fabric samples.

3.3 Measurement of Absorbency for Pretreated Fabric

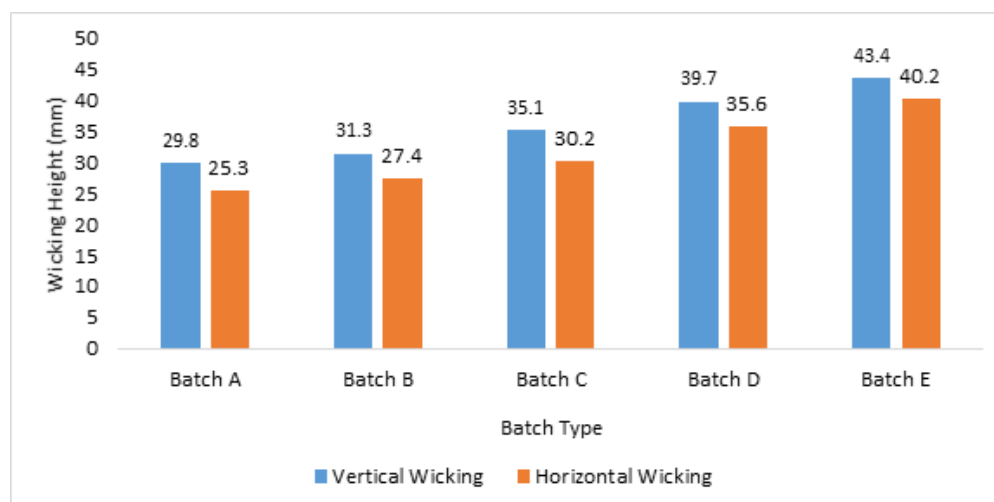


Fig 3. Pre treatment effect on Absorbency

In Figure 3, the vertical & horizontal wicking height of the samples is going upwards in the bar chart by increasing the dosages of NaOH & H₂O₂. Due to successive increasing of NaOH dosages, the samples are started to losing more impurities (oils, wax, gums, soluble impurities and sold dirt) generally found in grey fabric and for that reason; the samples are being better absorbent to water.

3.4 Analysis of Color Fastness to Wash for Dyed Fabric

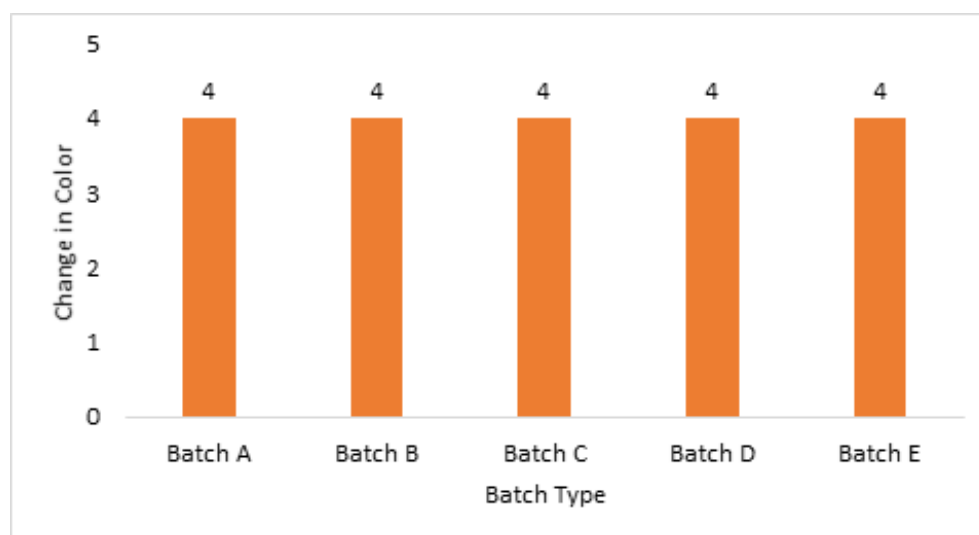


Fig 4. Change in Color due to Washing

Figure 5 shows that there is a stable as well as an acceptable grade of all the samples for change in color due to washing. But in the case of color staining, cotton fibre exhibits poor ratings. Due to undergoing the pretreatment process with more NaOH & H₂O₂ gradually, the dye uptake % is increased than the dye fixation limit of the samples. As a result, color bleeding in the cotton fibre of multifibre fabric has appeared which is in the tolerance limit also.

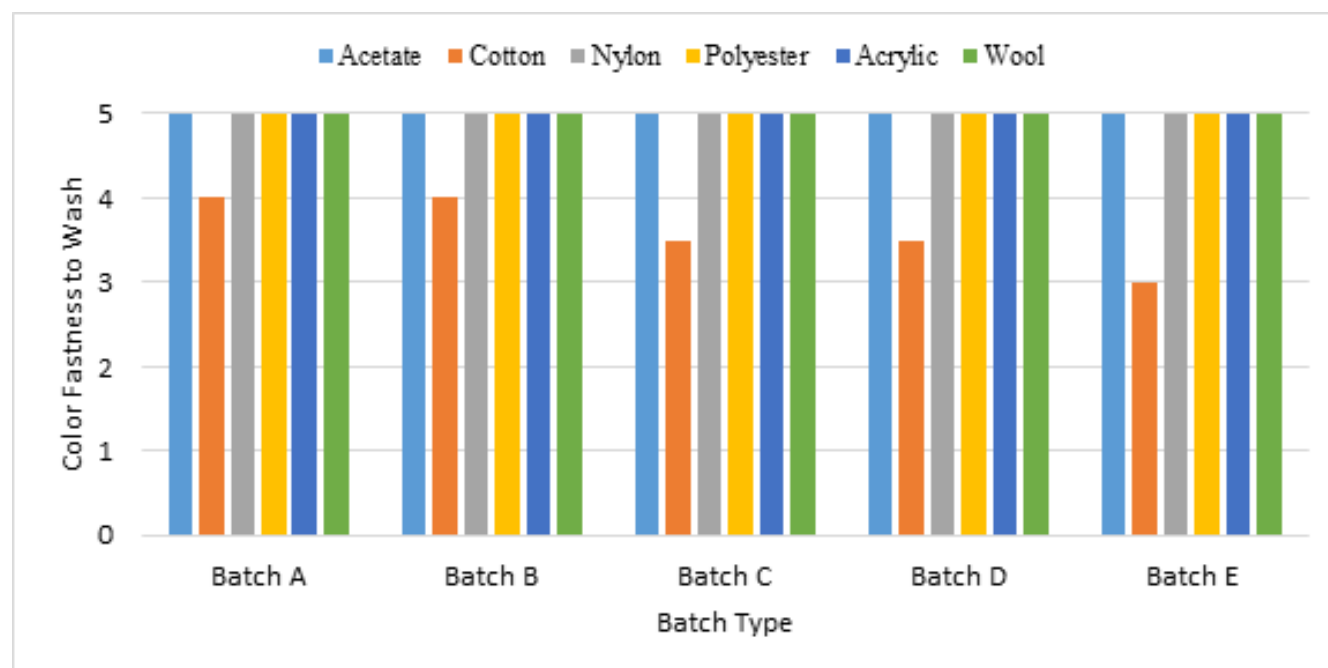


Fig 5. Color Staining due to Washing

3.5 Analysis of Color Fastness to Rubbing for Dyed Fabric

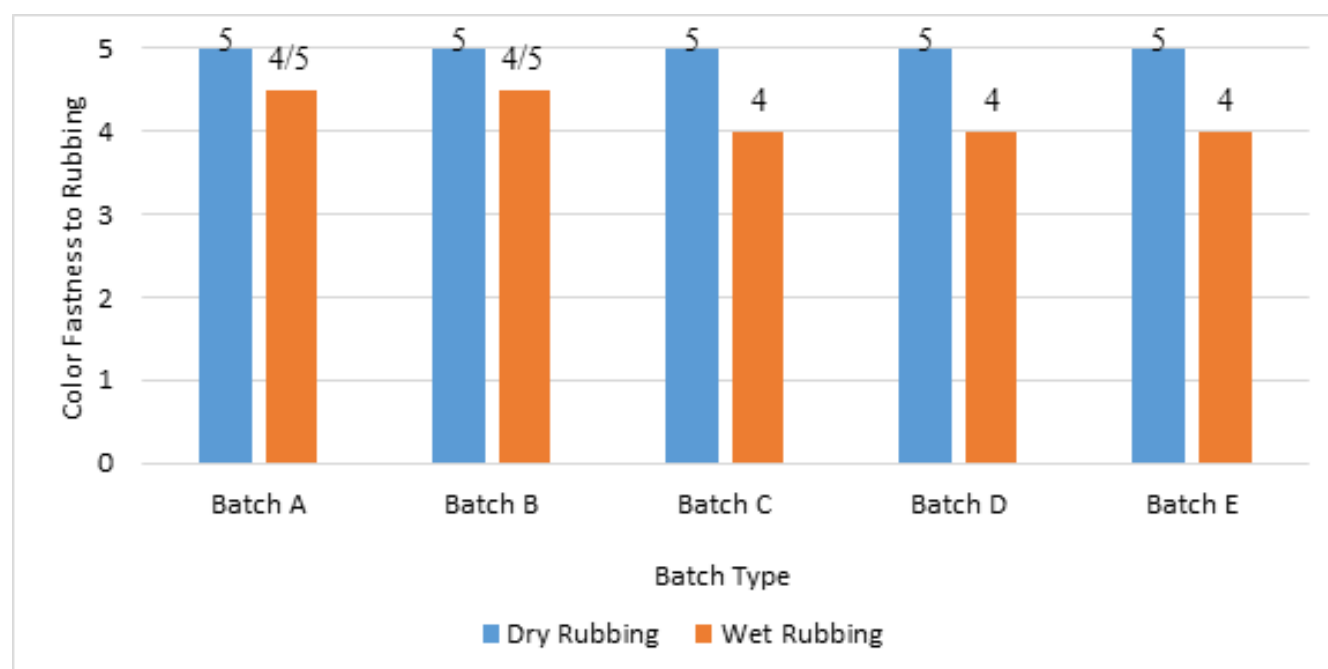


Fig 6. Color Staining due to Rubbing

As the same reason for colorfastness to wash, in Figure 6, there is also a slight decrease in colorfastness due to rubbing. But in comparison with the result of colorfastness to wash, the result of colorfastness to rubbing is better &

more acceptable.

3.6 Measurement of CIE-LAB Color Co-ordinates

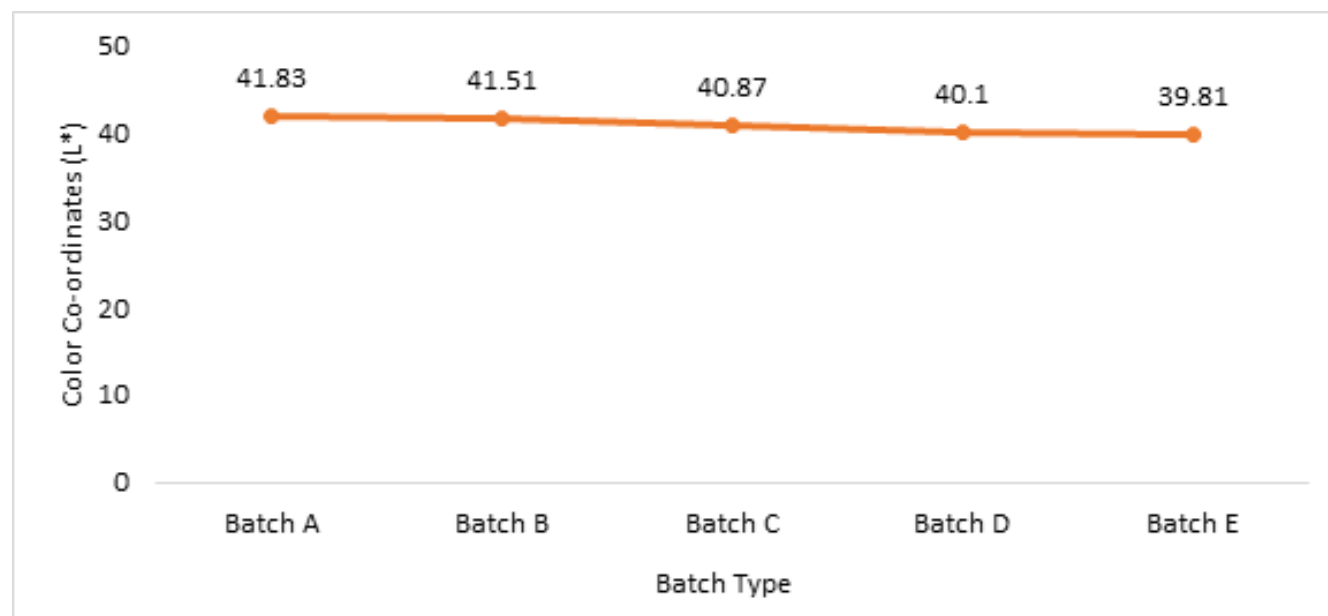


Fig 7. Changes of Color Co-ordinate, Lightness (L^*).

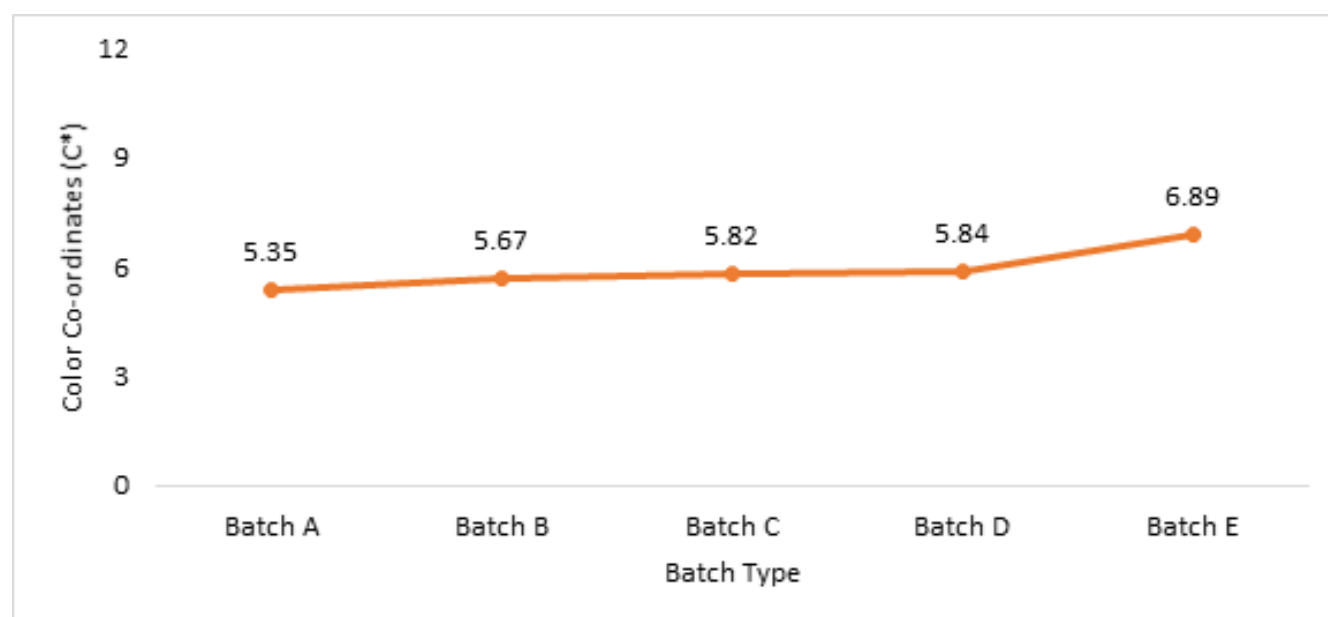


Fig 8. Changes of Color Co-ordinate, Chroma (C^*).

Figures 7, 8 and 9, show that gradually the values of Lightness (L^*) were decreased whereas the Chroma (C^*) and Hue (H^*) were increased with higher dosing of NaOH & H_2O_2 . This has happened because the highly pretreated

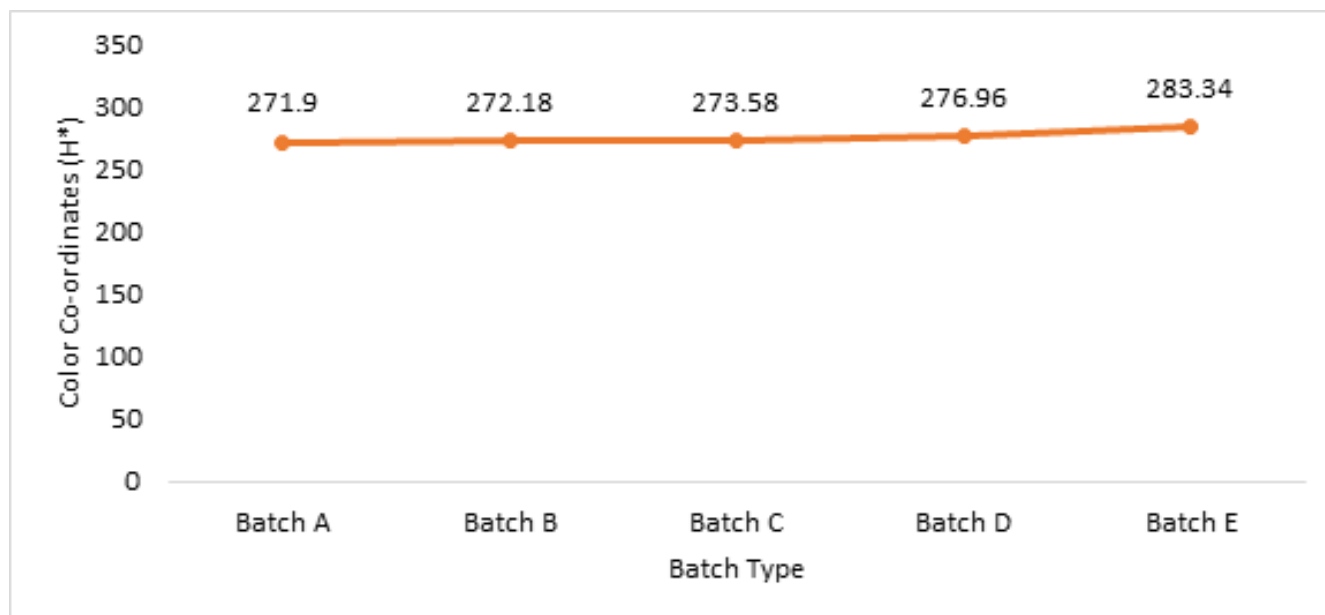


Fig 9. Changes of Color Co-ordinate, Hue (H*).

fabrics favor for the dyes uptake%.

4 Conclusion

From this study, it can be concluded that if the dosages of pretreatment chemicals are getting higher successively, then the absorbency and whiteness index of grey samples are improved and because of that reason bursting strength get decreased gradually. But while for dyeing of these pretreated fabric, color fastness to wash and rubbing showed a downward movement in their performance. As bursting strength, colorfastness to wash and rubbing influences the quality of the finished fabric, then a suitable pretreatment recipe should be maintained.

Conflicts of Interest

Authors have no conflicts of interest.

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