DYEING OF PREWASHED AND ALKALI PRETREATED COTTON KNITTED FABRICS WITH REACTIVE DYES

DESTALEM MEZGEBO GEBRETSADIK,[*] MIHRET HAILEMARIAM TEKALEGN[*] and NAGENDER SINGH[**]

[*]*Department of Textile Engineering, Faculty of Textile and Fashion Technology, Aksum University, Ethiopia*
[**]*Technological Institute of Textile and Sciences, Bhiwani, Haryana, India*
✉ *Corresponding author: N. Singh, jangra.nagender@gmail.com*

Received February 4, 2026

Knitted cotton fabric pretreatment involves the use of various chemicals and auxiliaries to prepare it for dyeing. Samples of knitted single-jersey cotton fabric of 140 GSM were prewashed with Felosan RGN or alkali pretreated by a combined process, and dyed under the same dyeing parameters; both types of samples were then evaluated. For evaluation, CIELab color difference, K/S value, and color (wash, rubbing, light, and perspiration) fastness were tested. Then, the CIELab color difference was assessed for specific shade percentages, for red, blue, black, and trichromatic combination of primary dyes up to 0.5% (light shade), and yellow up to 1.5% (medium shade), and the results were compared to those obtained for pretreated dyed fabrics. In addition, the prewashed dyed samples were characterized by evaluating various fastness properties. The unavoidable cost analysis revealed the appreciable outcomes of the work.

Keywords: knitted cotton fabric, prewashed, Felosan RGN, combined alkali pretreatment, shade percentage, dyed

INTRODUCTION

Cotton is the most important natural cellulose fiber, and its use continues to increase. It can be used for woven, knitted, and nonwoven fabric productions. Cotton fibers have natural hydrophobic impurities and are slightly yellowish colored.[1-4] Hence, extensive pretreatment processes are required to reduce these natural and additive impurities.[5] The commonly used pretreatment process for knit cotton materials combines alkaline scouring and bleaching. Usually, combined pretreatment processes are carried out at a temperature of 100-120 °C in a very alkaline medium at a pH of 12, with the addition of a large number of auxiliaries. With this combined pretreatment process at high temperatures, large amounts of energy and water are required during processing and after processing. Consequently, the textile industry is considered to be one of the biggest water, energy, and chemical consumers.[6,7] Still, the demand for knitted cotton goods is increasing because they are cheap, and 100% knitted cotton is very comfortable for both underwear and outerwear. As a result, the knit fabric manufacturing, dyeing, and finishing industries are growing very rapidly.

There is an ongoing effort to find ways to increase productivity and profit in the textile industry worldwide, while maintaining an acceptable environmental impact.[4] The traditional knitted cotton preparation for dyeing involves separate scouring and bleaching processes.[8] Later, a combined scouring/bleaching process was developed in alkaline media, which is commonly used for the pretreatment of knitted cotton fabric.[9] Since the combined pretreatment processes have gained advantage over separate scouring and bleaching processes in saving water, energy, and chemicals as well as processing time, new preparation techniques have been developed that lead to minimum water, chemicals, and energy consumption and, as a consequence, reduce manufacturing[10] and effluent load discharged to the environment.[11] To comply with increasingly more rigorous environmental regulations and to save water and energy, biotechnology[12] and several types of enzymes have entered the textile sector.[13] However, the efficiency of pretreatment is lower than that of combined alkaline pretreatment, and enzyme costs are also high. As a result, enzymatic pretreatment is not widely practiced in the textile wet-processing industry. Then, knitted cotton pretreatment still needs advancements in order to progressively lessen water, energy, and chemical consumption to get the advantage of reducing manufacturing cost and achieving environmentally friendly processing and product, with the minimum degradation of cellulose caused by the added chemical complexes.[14-15]

To overcome the current limitations encountered in knitted cotton fabric processing with an combined alkaline pretreatment method, an alternative simple method is proposed in the current research work. According to the Bezema CHT material safety data sheet, Felosan RGN surfactants are used as a universal soaping agent and as a washing, fat-solubilizing, and wet-detaching agent. The effect of washing on the hydrophobicity of knitted cotton fabric using potential detergents is best assessed by the capillary test method.[16] Felosan RGN is a nonionic surfactant that is used as a highly efficient scouring and wetting agent applicable for all types of fiber. It is especially suitable for the pretreatment of all types of textiles, both for continuous and discontinuous bleaching liquor processes.

Therefore, with this understanding, the current work aims to compare prewashed Felosan RGN-dyed cotton knitted fabric with a combined alkali pretreatment and dyeing method under the same dyeing parameters. The comparison considered the economic, environmental, and quality aspects of knitted cotton fabrics dyed by the two processes. The quality aspect comparison includes color strength (K/S value), color difference (CIELab values), and colorfastness to light, washing, perspiration, and rubbing, following the standard ISO testing methods.

EXPERIMENTAL

Materials

100% cotton knitted grey single-jersey fabric (140 GSM, 28 Ne combed yarn) was used for experiments and tests. Reactive dyestuffs (Bezactive Yellow HP-NP, Bezactive Red HP-3B, Bezactive Blue HP-R, and Bezactive Black S-Max) were used. A Felosan RGN (from Bezema CHT manufacturer) chemical was used as a soap or detergent for prewashing of fabric samples before dyeing. Nonionic wetting agents, sequestering agent (EDTA), antifoaming agent, caustic soda (NaOH), hydrogen peroxide (H_2O_2, 30%), peroxide killer (Catalase BF enzyme), stabilizer, acetic acid, globular salt (Na_2SO_4), soda ash/sodium carbonate (Na_2CO_3) were used as combined alkali pretreatment, prewashing chemicals, and dyeing auxiliaries.

Instruments

The following instruments were used to do this experiment: an infra-red laboratory dyeing machine (Ahiba® IR), a washing fastness tester (Laundry-o-meter – Autowash, 311F), a rubbing fastness tester (Crock meter – Mesdan 2540), a light fastness tester (Mesdan s.p.a., Solar Box), a perspiration fastness tester (Perspire-o-meter – Electrical-Heat Thermostatic Culture Box, DH4000B), a spectrophotometer (Gretagmacbeth, Color-Eye 3100), a light box (Solo'(BS) Mesdan Lab), a laboratory oven dryer (OVEN M250-G, Mesdan s.p.a), a soft flow (Thies) dyeing machine, PH-meter, scissors and digital camera.

Experiments employed

Fabric preparation for dyeing

Experimental work was carried out at Bahir-Dar University, the laboratory of the Ethiopian Institute of Textile and Fashion Technology, and the MAA-Garment and Textile Factory PLC in Mekele, Ethiopia. The prewashing was carried out using a soft-flow Theis machine with an automatic control system. A solution containing a wetting agent and detergent (Felosan RG-N, 1.5 g/L) and an anti-crease agent (0.5 g/L) was prepared at a material-to-liquor ratio (MLR) of 1:6. Then, 15 kg of grey knitted single jersey fabric was loaded into the soft-flow Thies machine, taking 5 minutes. The processing temperature rose from room temperature to 100 °C within 25 minutes, and simultaneously, the washing chemicals were dosed at around 400 °C. For greater clarity, see Figure 1. At 100 °C, prewashing was performed for 20 minutes. Then, the temperature was gradually cooled from 100 °C to 70 °C within 10 minutes. The bath was drained and refilled with fresh water within 5 minutes, and maintained at 60 °C. The prewashing treatment was completed within 65 minutes.

For comparison purposes, combined alkaline pretreatment was also carried out, since nowadays these processes are widely used for pretreatment of knitted cotton fabric in textile industries.[17] Due to their economic advantage over conventional (separate scouring and bleaching) processes, they are more efficient than enzymatic pretreatments. The 15 kg weight of 100% cotton fiber knitted grey single jersey fabric, similar to the prewashed treatment used for combined pretreatment in the same machine.

The combined pretreatment process was started by filling the water and loading the fabric for 5 minutes. The processing temperature increased from room temperature to 50 °C, and then, detergent/wetting agent, sequestering agent, anti-creasing agent, antifoam, and stabilizer were added within 5 minutes. Caustic preparation and dosing were carried out at 50 °C for 10 minutes. Then, the temperature was raised to 70 °C and hydrogen peroxide (H_2O_2) dosing was performed within 10 minutes. Again, the temperature rose to 100 °C within 15 minutes and held at 100 °C for 30 minutes. Then, the temperature was cooled to 70 °C within 15 minutes. After that, the bath was drained out and fresh water was filled within 5 minutes. A hot wash was performed for 10 minutes at 80 °C. Again, the processing temperature was reduced to 60-70 °C, and the hot water was drained, and fresh water was added to the machine. Subsequently, neutralization was carried out at 50 °C for 10 minutes, and the bath was drained, and fresh water was added for the last time within 5 minutes of the process time. Peroxide killer was added at 50 °C for 10 minutes. The process is illustrated in Figure 2. For the combined pretreatment process, 165 minutes were used overall.

Table 1
Recipe of combined alkaline pretreatment and prewashing process

Combined alkaline pretreatment		Prewashing processes	
Name of chemicals	Amount (g/L)	Name of chemicals	Amount (g/L)
Detergent	0.5		
Sequestering agent	0.25	Felosan RGN soap	1.5
Antifoam	0.25		
Anti-creasing	0.5	Anti-creasing	0.5
Stabilizer	0.5	---	---
Caustic soda	2	---	---
H_2O_2	2	---	---
Peroxide killer	0.5	---	---
Acetic acid	0.5	Acetic acid	Optional (0.1)

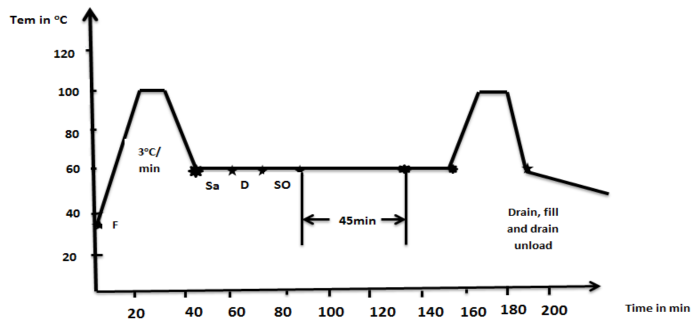

Figure 1: Line diagram for dyeing of prewashed knitted cotton fabric (F = Felosan RGN, Sa = salt, D = dyes, SO = soda ash – represent the stages at which chemicals were added)

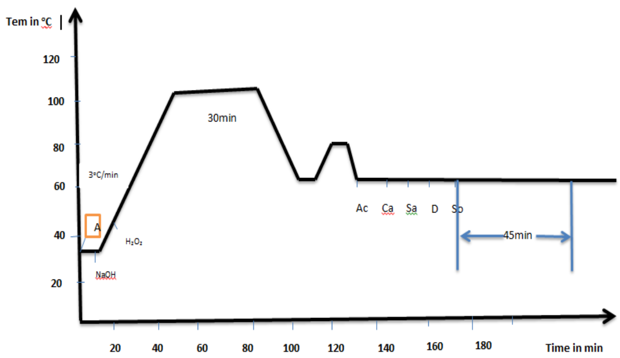

Figure 2: Line diagram for dyeing of conventionally pretreated knitted cotton fabric (A = auxiliary, Ac = acetic acid, Ca = catalase BF, Sa = salt, D =dyes, SO = soda ash – represent the stages where chemicals were added during dyeing)

Dyeing

Dyeing was carried out with the isothermal method using three different shade percentages of the 5 types of reactive dyes, *i.e.*, 0.5%, 1.5%, and 3.5% on the weight of the fabric.[18] The dyes were: Bezactive Yellow HP-NP, Bezactive Red HP-3B, Bezactive Blue HP-R, Bezactive Black S-Max, and Trichromatic recipe (combination of the primary dyes). Knitted cotton fabric treated by both methods (combined and prewashing), with all selected dye types and given shade percentages, was dyed at 60 °C for 45 minutes using a 1:6 material-to-liquor ratio. The line diagrams for the dyeing process of prewashed fabrics are given in Figure 1.

The rest of the dyeing parameters were also the same for knitted cotton fabric prepared by prewashing and combined pretreatment and the dyeing recipes used were the following: shade percentages 0.5, 1.5 and 3.5%

(OWF), sequestering agent 0.25 g/L, globular salt 40, 60 and 80 g/L, soda ash 10, 15 and 20 g/L, acetic acid 0.5, 1 and 2%, and soap 0.5 g/L. The line diagrams for the dyeing process of combined alkali pretreated fabrics are shown in Figure 2. After the treatment or soaping, the process parameters were the same, *i.e.*, 100 °C for 10 minutes.

Tests

After completing the dyeing experiment, the quality parameters of dyed fabric, which was prepared by prewashing and alkali combined pretreatment, were evaluated for color strength (K/S value), color difference (CIE Lab value) with a spectrophotometer (Gretagmacbeth, Color-Eye 3100 and color fastness testing using the standard testing methods. The color fastness tests considered were the following: washing fastness testing using the test method ISO 105-A02 and A03, rubbing color fastness testing using the method ISO 105-A03, color fastness to light using the test method ISO 105-B02, relative to blue wool standards, and color fastness to perspiration using the standard method ISO 105-A02 and A03.

The cost of the pretreatment process using prewashing and the combined pretreatment was calculated in terms of processing time, amount of chemicals used, and energy consumed during processing.

RESULTS AND DISCUSSION

Evaluation of dyed fabric quality parameters

Color strength (K/S values): The color strength of knitted cotton fabric after dyeing, treated by prewashing and combined pretreatment methods, was measured using a spectrophotometer (Color-Eye 3100). The color strength values obtained from the spectrophotometer measurements are shown in Figure 3.

As shown in Figure 3, the color strength (K/S values) obtained for both fabric processing cases is almost equal, despite the significantly reduced use of pretreatment chemicals, energy, and processing time achieved through prewashing. For visual comparison, the color of dyed fabric with all selected types of dyes and their shade percentages are illustrated in Figure 4.

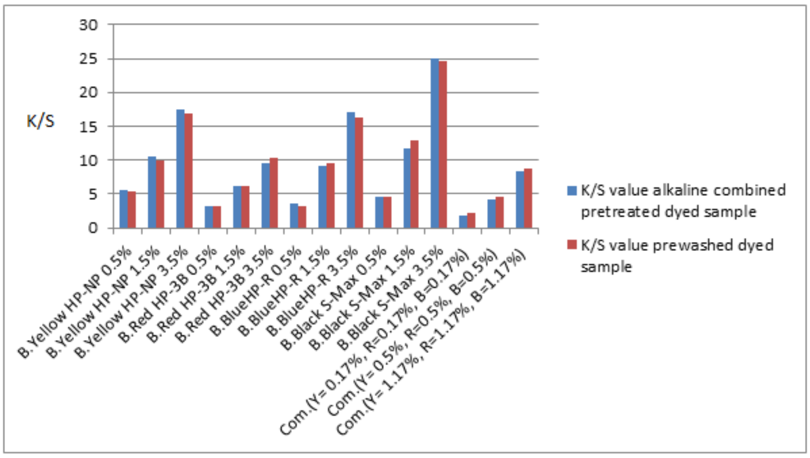

Figure 3: K/S value of dyed trial samples (Com = Combination, Y = yellow, R = red, B = blue)


Alkali Combined Pretreated Fabric
Prewashed fabric
Bezactive Yellow HP-NP = 0.5%
$NaSO_4/NaCO_3$ =40/10 (g/l)
Bezactive Yellow HP-NP = 0.5%
$NaSO_4/NaCO_3$ =40/10 (g/l)
Bezactive Yellow HP-NP = 1.5%
$NaSO_4/NaCO_3$ =60/15 (g/l)
Bezactive Yellow HP-NP = 1.5%
$NaSO_4/NaCO_3$ =60/15 (g/l)
Bezactive Yellow HP-NP = 3.5%
$NaSO_4/NaCO_3$ =80/20 (g/l)
Bezactive Yellow HP-NP = 1.5%
$NaSO_4/NaCO_3$ = 80/20(g/l)
A)
Bezactive Red HP-3B = 0.5%
$NaSO_4/NaCO_3$ =40/10 (g/l)
Bezactive Red HP-3B = 0.5%
$NaSO_4/NaCO_3$ =40/10 (g/l)
Bezactive Red HP-3B = 1.5%
$NaSO_4/NaCO_3$ =60/15(g/l)
Bezactive Red HP-3B = 1.5%
$NaSO_4/NaCO_3$ =60/15 (g/l)
Bezactive Red HP-3B = 3.5%
$NaSO_4/NaCO_3$ =80/20(g/l)
Bezactive Red HP-3B = 3.5%
$NaSO_4/NaCO_3$ =80/20 (g/l)
B)
Bezactive Blue HP-R= 0.5%
$NaSO_4/NaCO_3$ =40/10 (g/l)
Bezactive Blue HP-R = 0.5%
$NaSO_4/NaCO_3$ =40/10 (g/l)
Bezactive Blue HP-R= 1.5%
$NaSO_4/NaCO_3$ =60/15(g/l)
Bezactive Blue HP-R= 1.5%
$NaSO_4/NaCO_3$ =60/15 (g/l)
Bezactive Blue HP-R= 3.5%
$NaSO_4/NaCO_3$ =80/20 (g/l)
Bezactive Blue HP-R= 3.5%
$NaSO_4/NaCO_3$ =80/20 (g/l)
C)

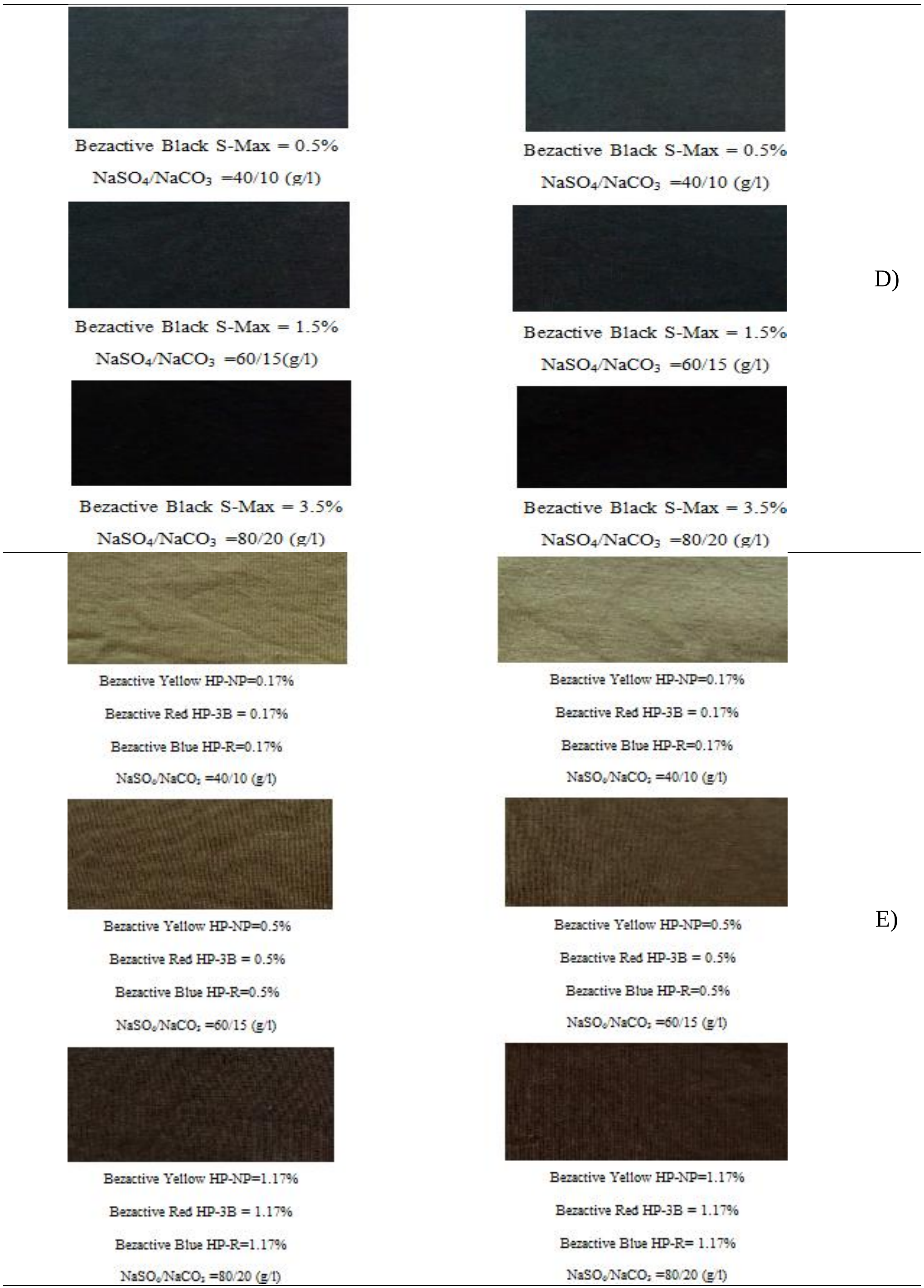

Figure 4: Images of dyed samples (A) Yellow, B) Red, C) Blue, D) Black,
E) Trichromatic combination of primary dyes)

Color difference (CIE lab value): To measure the color difference of the samples, the combined alkaline pretreated dyed fabric was taken as the reference sample, and the prewashed dyed fabric was the trial (developed) sample. The samples were measured in the absorbance mode using a ColorEye 3100 (Gretagmacbeth) spectrophotometer based on a light source of D65 at 10° observer. The color measurement readings are in terms of opponent colors, *i.e.*, red-green (a), yellow-blue (b), and lightness-darkness (L), which were measured with the instrument. Thus, the results of the pretreated and prewashed dyed samples were compared using the "Lab" value parameters given in Table 2.

As shown in Table 1, the prewashed fabric can be dyed with lower shade depths. This can be explained by the possibility of dyeing with 0.5% shade depth of red, blue, and black dyes, and medium shades for yellow, and a specific combination of yellow, red, and blue for fabric prepared by the prewashing method. As the shade depth percentage decreases, the tone of the samples becomes more affected by the natural coloring of the fibers and this is more noticeable in the yellow color. Color/shade matching is only possible up to medium shade for yellow and up to 0.5% for other colors.

Color fastness result: The fastness test was performed similarly for knitted cotton fabric, which was dyed in bulk production on an industrial scale. Here also, the wash, light, rubbing, and perspiration fastness tests were considered. The fastness test results are shown in Table 3.

Table 2
CIELab pass/fail values for different shade % of trial samples within ±2 tolerance limit of color difference

Shade	Shade %	DL	Da	Db	DE	Remark/Comments
Yellow (Bezactive Yellow HP-NP)	0.5	-2.18	0.53	-1.81	2.88	Fail
	1.5	-0.08	-1.09	-0.36	1.15	Pass
	3.5	-0.78	-1.02	-0.72	1.08	Pass
Red (Bezactive Red HP-3B)	0.5	-0.17	0.22	-0.09	0.29	Pass
	1.5	0.30	0.45	-0.04	0.54	Pass
	3.5	-0.87	-0.48	0.51	1.12	Pass
Blue (Bezactive Blue HP-R)	0.5	0.60	-0.19	1.23	1.38	Pass
	1.5	-0.64	-0.02	0.77	1.00	Pass
	3.5	0.25	-0.04	0.55	0.61	Pass
Black (Bezactive Black S-Max)	0.5	-0.16	0.07	0.13	0.22	Pass
	1.5	-1.08	0.01	0.28	1.12	Pass
	3.5	0.09	0.02	-0.02	0.09	Pass
Combination 1	0.5	-1.55	0.36	0.60	1.69	Pass
Combination 2	1.5	-1.56	0.09	0.25	1.58	Pass
Combination 3	3.5	-0.66	-0.96	0.26	1.19	Pass

Note: Combination 1 = 0.17% Bezactive Yellow HP-NP, 0.17% Bezactive Red HP-3B, and 0.17 Bezactive Blue HP-R; Combination 2 = 0.5% Bezactive Yellow HP-NP, 0.5% Bezactive Red HP-3B, and Bezactive Blue HP-R; Combination 3 = 1.17% Bezactive Yellow HP-NP, 1.17% Bezactive Red HP-3B, and 1.17% Bezactive Blue HP-R

Table 3
Color fastness test results of bulk trial samples

		Combined pretreated/dyed fabric							Prewashed dyed fabric						
Shade	Shade	RF		WF		LF	PF		RF		WF		LF	PF	
	%	D	W	S	CF	CF	S	CF	D	W	S	CF	CF	S	CF
B. Yellow HP-NP	0.5	5	4/5	4	4/5	5/6	4/5	4/5	5	4/5	4	4/5	6	4/5	4/5
	1.5	5	4/5	4	4/5	6/7	4	4	5	4/5	4	4/5	6	4	4
	3.5	4/5	4	4	4	7	3/4	3/4	4/5	4	4	4	6/7	¾	3/4
B. Red HP-3B	0.5	5	5	5	4/5	6	4/5	4/5	5	5	5	4/5	6	4/5	4
	1.5	5	4/5	4/5	4/5	6	4/5	4	5	4/5	4/5	4/5	6	4/5	4
	3.5	4/5	4	4	4/5	7	4	4	4/5	4	4	4/5	7	4	4
B. Blue HP-R	0.5	5	5	5	5	5	4/5	4/5	5	5	5	5	4/5	4/5	4/5
	1.5	4/5	4/5	4/5	4/5	5/6	4	4	4/5	4/5	4/5	4/5	5/6	4	4
	3.5	4/5	4/5	4	4	6	3/4	4	4/5	4/5	4	4	6	¾	4
B. Black S-Max	0.5	5	4/5	4	4	6	4	4/5	5	4/5	4	4	6	4	4/5
	1.5	4/5	4	4	4	6	4	4	4/5	4	4	4	6	4	4
	3.5	4/5	3/4	4	4	7	3/4	3/4	4/5	¾	4	4	7	¾	3/4
Combination 1	0.5	5	4/5	4/5	4/5	4/5	4	4/5	5	4/5	4/5	4/5	4/5	4	4/5
Combination 2	1.5	4/5	4/5	4/5	4	4/5	4	4	4/5	4/5	4/5	4	4/5	4	4
Combination 3	3.5	4/5	4	4	4	5/6	4	4	4	4/5	4	4	5	4	4

As shown in Table 3, the fastness results obtained for all considered fastness types are nearly the same for both methods of dyeing, indicating that the prewashing technique of fabric preparation can possibly replace the combined pretreatment fabric preparation method, which is widely used in knitted fabric preparation in industries, giving the advantage of cost savings due to lower consumption of chemicals, energy, and a shorter time of operation.

Cost analysis for prewashing and combined alkali pretreatment processes

The cost analysis was performed considering the soft-flow (Thies) wet processing machine, which has a capacity of loading 1,000 kg of knitted fabric in MAA-Garment and Textile Factory, Mekele, Ethiopia. The recipes (Table 1) considered for cost analyses are:

- Fabric weight: 1,000 kg
- Material to liquor ratio: 1:6
- Total volume of liquor: 6*1,000 = 6,000 liters

Cost savings from pretreatment chemicals

As indicated in Table 4, various pretreatment chemicals (*i.e.*, 9 types) are used in the combined pretreatment process, while only two types of chemicals are used in the prewashing process. Hence, seven types of chemicals can be saved by using the prewashing process. The reduction in chemical types has advantages in reducing fiber degradation and effluent loads on the surrounding environment, as well as reducing process costs.

When the cost of chemicals is considered, prewashing offers a significant advantage by eliminating the need for several pretreatment chemicals. On the other hand, the cost of Felosan RGN per one kilogram is 107.57 Birr or 4.68 € (as per information obtained from MAA-Garment and Textile Factory). Hence, for processing 1,000 kg of knitted cotton fabric, a total of 968.13 Birr (42.15 €) is spent.

Table 4
Required chemicals for the two processes

Combined pretreatment process (existing process)		Prewashing process (proposed process)	
Chemical type used	Amount required as per the recipe (kg)	Chemical type	Amount required as per the recipe (kg)
Detergent (wetting)	3	Felosan RGN	9
Sequestering agent	1.5		
Anti-creasing Agent	3		
Stabilizer	3		
Caustic soda	12		
H_2O_2	12		
Peroxide killer	3		
Antifoam	1.5		
Acetic acid	3	Anti-crease agent	3

Table 5
Total cost of chemicals in combined pretreatment process

Chemicals	Amount (kg)	Price/kg in Euro (€)	Price/kg in Birr	Total cost in Birr
Detergent	3	4.68	107.54	322.64
Sequestering agent	1.5	2.20	50.56	75.83
Antifoam	1.5	3.34	80.09	120.13
Stabilizer	3	0.72	17.26	51.78
NaOH	12	0.57	13.21	158.49
H_2O_2	12	0.44	10.18	122.1
Peroxide killer	3	4.01	92.15	276.45
Acetic acid	3	0.74	17.85	53.55
Total expense costs for one lot		16.7 €		1,180.97 Birr

Thus, the cost of chemicals saved from processing 1000 kg of knitted fabric by the prewashing process rather than the combined pretreatment process can be calculated:

$$\text{Cost savings} = 1{,}180.97 - 968.13 = 212.84 \text{ Birr or } 9.25\ €$$

Cost savings from reduced processing time

As discussed, the pretreatment process for 1,000 kg of fabric required 155 minutes with the combined alkali process and 65 minutes with the prewashing process. This indicates that 90 minutes of processing time is saved with the prewashing pretreatment process. Consequently, the prewashing process offers advantages such as increased production, decreased labor costs, faster product delivery to the customer, and reduced production costs related to electricity, steam, compressed air, and power/energy consumption. Thus, with reduced processing time, the machine's energy cost in terms of electric power consumption decreases. Based on this, it can be calculated as follows:

- 1 kilowatt hour (1 kW) = 1 unit of electricity
- 1 unit of electricity cost = 0.5778 Birr or 0.03 €- approximate (or average) company electric power cost
- Soft flow dyeing machines have 60 kW capacity, and they consume:
    - 60×1= 60 units per hour
    - Cost per unit hour = 60×0.5778 Birr or 60*0.03 €=34.67 Birr/h or 1.8 €/h
- Since the prewashing process saves 90 minutes
    - it saves 90*0.5778 Birr or 90*0.03 € = 52.00 Birr or 2.7 €, *i.e.*, energy cost in processing of 1,000 kg of knitted dyed fabric.

Cost savings from reduced water consumption

Water consumption (required) for processing 1,000 kg of knitted cotton fabric is 22,000 liters for a combined alkali pretreatment process, compared with 13,000 liters for a prewashing process. Therefore, with the prewashing process, 9,000 liters of water are saved in the processing of 1,000 kg of knitted fabric.

- To accumulate and treat 1000 liters of soft water, the company incurs a total cost of around 2.55 Birr or 0.11 €.
- For reduced use of 9,000 liters of water per 1,000 kg of fabric processing by the prewashing process, the reduced cost is calculated as = 9*2.55 Birr or 9*0.11 € = 22.95 Birr or 0.99 €.

Therefore, the total processing cost saving only for the selected cost items is calculated as follows:

$\text{Total cost savings} = \text{Chemical cost} + \text{Water cost} + \text{Energy cost}$

$\text{Total saving in cost} = 212.84 + 52.00 + 22.95$

$\text{Total saving in cost} = 287.79 \text{ Birr or } 12.53\ €$

The cost items calculated here are very limited, and other cost items, which are expected to bring savings with prewashing processes, such as steam energy, compressed air, and effluent treatment costs per 1000 kg fabric processing can be included in cost calculation. If all these are added to the reduced cost of fabric processing with prewashing, the processing cost reduction per 1000 kg of fabric increases further. In general, by applying the prewashing process in fabric treatment, at least 12.53€ will be saved in processing 1,000 kg of knitted fabrics.

CONCLUSION

The prewashing treatment for knitted cotton fabric was compared with commonly used combined alkali pretreatment methods. Considering common dyed fabric quality parameters, including color strength, color difference, and color fastness, promising results were obtained for the application of the prewashing method, which recommend it for replacing the combined alkali pretreatment method. Equivalent quality parameters were obtained for fabric treated by prewashing and combined pretreatment processes, except for the light shade (0.5% shade) of yellow colors, due to the reduced use of pretreatment chemicals, water, and energy, and reduced processing time with the prewashing treatment process, compared to the combined alkali pretreatment process. Further, the effluent load on the environment is significantly reduced by the reduced use of water through the prewashing pretreatment technique. Thus, it can be concluded that dyeing with red, blue, black colors, and primary dye combination shades up to 0.5%, and yellow up to 1.5% (medium) shade, with the prewashing process, has been able to get comparable results to those of combined alkaline pretreatment dyeing process, and can easily make shade matching within these shade percentages. In relation to all this, significant cost savings are achieved with the prewashing pretreatment process. As per a study conducted at the MAA-Garment and Textile Factory, at least 12.53 € will be saved in processing 1000 kg of knitted fabrics using soft-flow machine dyeing.

ACKNOWLEDGEMENT: We would like to thank the Ethiopian Institute of Textile and Fashion Technology, for providing financial support and laboratory equipment for conducting our research. Also, we would like to thank the Alameda and MAA Garment textile factory management committees, who have supported us by providing chemicals, fabrics, and dyes, and for their cooperation in conducting our experimental trials at their companies. Also, we are grateful to all the people who have assisted, helped, and inspired us to complete this task at various stages.

REFERENCES

[1] N. Singh and A. Madhu, *Cellulose Chem. Technol.*, **58**, 851 (2024), https://doi.org/10.35812/CelluloseChemTechnol.2024.58.75

[2] H. Holkar, S. Narayan, J. Sheikh and N. Singh, *Cellulose Chem. Technol.*, **59**, 433 (2025), https://doi.org/10.35812/CelluloseChemTechnol.2025.59.38

[3] S. Khanna, M. Yadav and N. Singh, *Cellulose Chem. Technol.*, **58**, 603 (2024), https://doi.org/10.35812/CelluloseChemTechnol.2024.58.55

[4] S. M. Raafi, S. N. Arju, M. Asaduzzaman, H. H. Khan and M. Rokonuzzaman, *Heliyon*, **9**, (2023), https://doi.org/10.1016/j.heliyon.2023.e15236

[5] M. G. Uddin, *J. Innov. Dev. Strategy*, **4**, 18, (2010), https://ggfjournals.com/assets/uploads/MIN-151_GIAS_18-21.pdf

[6] W. Ma, K. Shen and N. Xiang, *Molecules*, **22**, 2235 (2017), https://doi.org/10.3390/molecules22122235

[7] T. Akther, M. S. Babu and M. R. Islam, in "Sustainable Coloration Techniques in Textiles" edited by S. Maiti, Springer Nature, Singapore, 2025, pp. 181-235, https://doi.org/10.1007/978-981-96-4975-4_7

[8] M. A. Hamzah, F. Liu, L. W. He, Y. J. Cai and P. Zhang, *Adv. Mater. Res.*, **1120**, 193 (2015), https://doi.org/10.4028/www.scientific.net/AMR.1120-1121.193

[9] A. Morshed, A. Y. M. A. Azim, A. A. Mukthy and S. A. Hoque, *Eur. Sci. J.*, **10** (2014)

[10] R. S. Harane and R. V. Adivarekar, *Text. Cloth. Sustain.*, **2**, 2 (2017), https://doi.org/10.1186/s40689-016-0012-7

[11] M. T. Ahmed and S. K. An, *Fibers Polym.*, **19**, 2541 (2018), https://doi.org/10.1007/s12221-018-8255-3

[12] M. M. H. Masum, M. B. Islam and M. R. Anowar, *Discov. Environ.*, **3**, 59 (2025), https://doi.org/10.1007/s44274-025-00245-3

[13] A. M. Grancarić, T. Pušić and A Tarbuk, *J. Nat. Fibers*, **3**, 189 (2006), https://doi.org/10.1300/J395v03n02_12

[14] A. B. Siddiquee, M. Bashar, P. Sarker, T. T Tohfa, M. A. Hossan *et al.*, *Int. J. Eng. Technol.*, **3**, 37 (2014), https://doi.org/10.14419/ijet.v3i1.1055

[15] M. A. Hannan, P. Haque, S. F. Kabir and M. M. Rahman, *Cloth. Text. Res. J.*, **37**, 265 (2019), https://doi.org/10.1177/0887302X19853

[16] M. M. Asaduzzaman, F. Hossain, X. Li and H. Quan, *J. Textile Sci. Eng.*, **6** (2016), https://doi.org/10.4172/2165-8064.1000274

[17] T. A. Chowdhury, *Int. J. Sci. Environ. Technol.*, **3**, 2145 (2014)

[18] U. H. Siddiqua, S. Ali, M. Iqbal and T. Hussain, *J. Mol. Liq.*, **241**, 839 (2017), https://doi.org/10.1016/j.molliq.2017.04.057