

Modification of Bioscouring Process by Addition of Cellulase Enzyme and Multifunctional Agents with Pectinase

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ABSTRACT

Conventional scouring process confirms better absorbency in common. But the process is harmful for our environment. For this reason, bioscouring (treatment with Pectinase) is introduced which is eco-friendly. But with this process we get average absorbency. It cannot remove all types of natural impurities from cotton. Thus cellulase enzyme was also introduced in attachment of pectinase. The research work concluded that only pectinase enzyme offered less absorbency, where addition of cellulase enzyme affirmed more absorbency. Other parameters like datacolor CMC value, different colour fastness properties were also investigated which inspired a lot in this regard.

Keywords: Absorbency, Bioscouring, CMC Value, Cellulase, Enzyme, Pectinase, Shade.

1. INTRODUCTION

The essence of high as well as required quality material in corporation with environmentally friendly properties is unclouded now-a-days. Thus purpose is served in an eco-friendly way, provided, cost effectivity and quality are ensured. In this consequence, biocatalysts are of utmost importance for different textile cleaning operations. Conventional scouring is thought to be successfully replaced by bioscouring. But unfortunately this is not the fact, rather some modifications are demanded. However enzymatic scouring, that is bioscouring is getting priority in research field for the purposeful service. Little energy consumption and low temperature operation confirms the bioscouring process to be in consideration for the costing issue, as chemical consumption is reduced in a citable amount. Chemical hazards are then eliminated from the list risks.

Cotton reins more than 50% of the kingdom of fibre of the globe. Thus it has a lion share in the total consumption (Lewin and Pearce, 1998). If we take a look in the cross-sectional view of cotton fibre, it is transparent that a thin layer, cuticle is surrounded at the outermost part. This cuticle consists of wax and pectin and thus disallows the fibre to get water into it. In mature fibres, the primary wall is about 0.5-1 μm thick containing almost 50% of cellulose. Devoid of cellulose. The other constituents are pectins, fats, waxes, proteins and natural colorants. The later on secondary wall, which is enriched with 92-95% cellulose, is built of twisting layers with alternating S- and Z-shapes. The layer consists of densely packed elementary fibrils, both microfibrils and macrofibrils. Strong hydrogen bonds hold them together. The lumen forms the centre of the fibres (Buschle-Diller, 2003). Chemical composition of cellulose is simple; it is a linear 1-4-linked polymer of β -D-glucopyranose ring (Lewin and Pearce, 1998). Three free hydroxyl groups in C₂, C₃ & C₆ position in each anhydroglucose unit are available,

and they form strong inter- and intermolecular hydrogen bonds. Each cellulose chain has a non-reducing endgroup at C₄ and a reducing end at C₁. The later exhibits the characteristics of both an alcohol and an aldehyde under appropriate conditions (Nevell, 1995).



Fig 1: Structure of Cotton

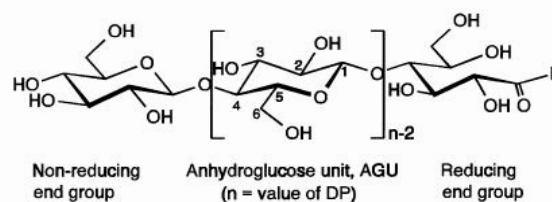


Fig 2: Molecular structure of cellulose

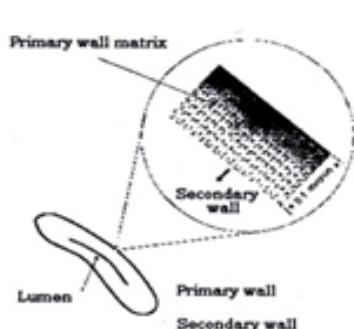


Fig 3: Primary cell wall matrix, illustrating the concentration gradient of noncellulosic material

It is the waxes on the surfaces of cotton fibre in the primary wall, which is basically responsible for the hydrophobic nature of raw cotton. The waxes are comprised of different hydrocarbons, fatty alcohols, fatty acids and their esters. Because of the presence of waxes, the chemical processing of cotton yarns and fabrics is interfered with wetting of the fibres and penetration of reagents (bleaching agent, dyes, etc.). Thus subsequent scouring operation is performed which contributes to the disorientation of the waxy configuration, thus the fibre is honored with hydrophilic properties (Lewin and Pearce, 1998; Trotman, 1968). After scouring is done, the wax content reduces to about 0.15%.

Table 1: Composition of the components identified in cotton fibres and in the cuticle (Lewin and Pearce, 1998; Hardin et al., 2004).

Components	Composition of the whole fibre [% of the dry weight]	Cuticle [%]
Cellulose	88-96	
Protein	1.1-1.9	30.4
Pectin	0.7-1.2	19.6
Wax	0.4-1.0	17.4
Ash	0.7-1.6	6.5
Others (e.g. seed-coat fragment)	0.5-1.0	

With the basic composition recipe, raw cotton is also enriched with some metallic components like potassium, calcium, magnesium, sodium, iron, manganese, copper, zinc etc. These unwanted accessories create severe problems during bleaching and dyeing. Seed-coat fragments are also comprised of potassium, calcium and magnesium compounds in an utterable amount (Csiszár et al., 1987).

Textile industry uses various chemical agents in the different wet process. These chemicals, after their use, cause pollution in the effluents; some of them are corrosive that could damage equipment and the substrate itself. However, by introducing enzymatic process an environment friendly production can be ensured.

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Celluloses, hemicellulases and pectinases (hydrolyses) acting on native cellulosic fibres (cotton, flax, hemp, jute, etc.) became the target enzymes in textile bioprocessing.

Recent results indicate that certain enzymes may be used effectively in the cleaning procedure of cotton. The scientific interest in this process is reflected in the number of papers published during recent years describing biopreparation results obtained, using various enzymes from different sources. But enzymatic biopreparation of cotton represents a fairly new approach and is still mostly in the development stage.

A lot of harsh chemicals are used in traditional scouring process which are very much responsible to increase the amount of BOD, COD and TDS in the effluent water and increase the unwanted pressure on environment. Caustic scouring is responsible for the lion parts of the total effluent of a factory.

It produces -----

54% to the total BOD

49% to the total COD

10-20% of the total pollution load generated during entire textile processing operation.

Risk in chemical handling: The handling of harsh chemicals increase the possibilities of accident and most importantly the longevity of the workers are badly affected by the handling of this harsh chemicals.

1.1 Mechanism involved in Bio-Scouring

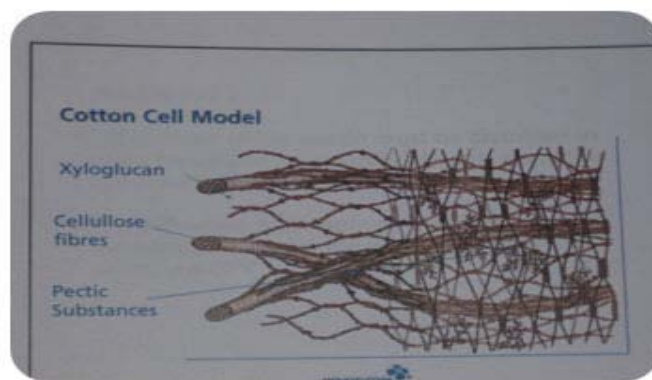


Fig 4: Cotton cell model (Palash and Hannan, 2013)

Step-1: Dismissal of wax is partly initiated here. Wax is the dominator for unwettability. Basically pectin works as a sticking agent for cellulose and wax. During the destruction of pectin, wax seems to become helpless and thus gets easily emulsified. For catalytic action, sequestering agent could help propagating the emulsification by entrapping Ca^{++} of the system.

Step-2: Most of the pectin is extracted and dissolved in this segment of operation. Thus condition of

dyeing, ie absorbency is imparted. The temperature should be at least the melting temp. of wax and higher.

2. RAW MATERIALS AND METHODS

2.1 Raw Materials

10gm single jersey by 100% unscoured fabric for each process.

Sodium Hydroxide NaOH.
Hydrogen per oxide H_2O_2
Pectinase.
Neutral cellulase.
Imarol Blue/Multifunctional agent.

2.2 Machineries

i) M/C Name : Perspiro Meter Phenolic Yellowing Tester & Incubater.
Model : H X 30
Brand : James H. Heal
Method : ISO105 – E04:1994(E)

ii) M/C Name : Grey Scale for Assessing Change in Colour (including half-steps)
Method : ISO105-A02 : 1993 BSEN 20105-A02 : 1995
iii) M/C Name : Grey Scale for Assessing Staining (including half-steps)
Method : ISO105-A03 : 1993 BSEN 20105-A03 : 1995
iv) M/C Name : Light Box
Model : CAC-60
Brand : Verivide
v) M/C Name : Washing & Dry Cleaning (Colour Fastness Tester)
Model : 415/8
Brand : James H. Heal
Method : ISO 105FIO
vi) M/C Name : Infra Red Lab Dyeing Machine
Model : Supermat
Brand : Co-Powe

2.3 Processing Methods

2.3.1 Conventional Scouring/Bleaching

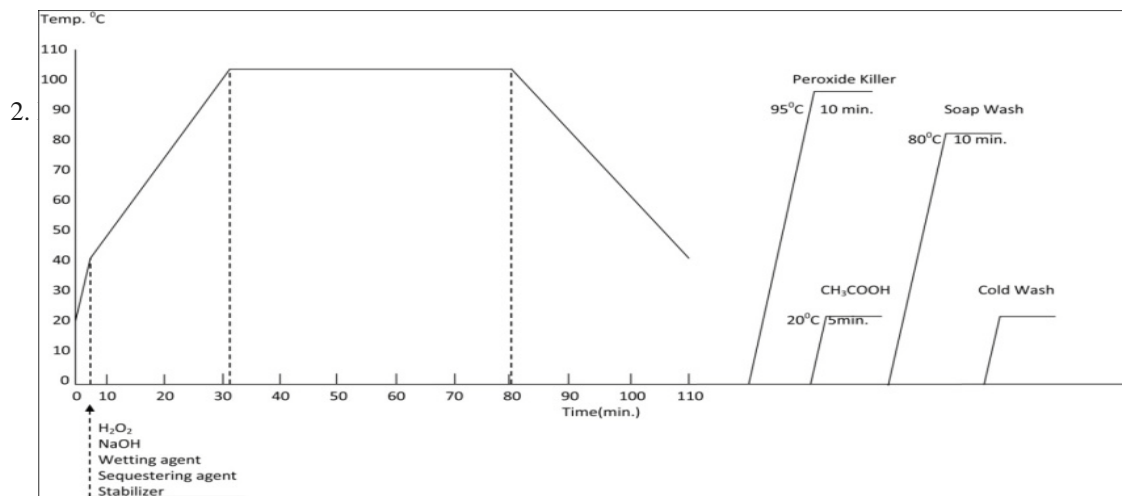


Fig 5: Graphical presentation Conventional Scouring/Bleaching

2.3.2 Bioscouring with Pectinase

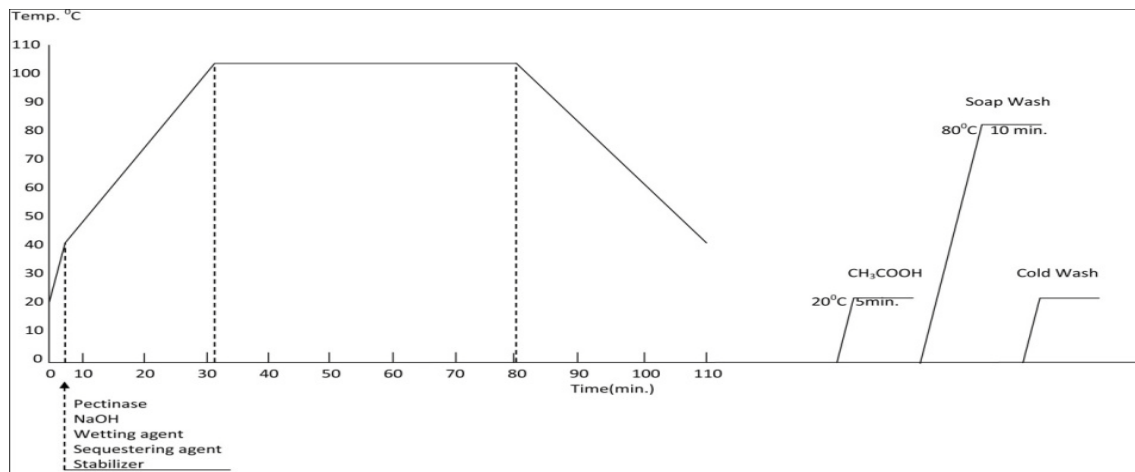


Fig 6: Graphical presentation Bioscouring with Pectinase

2.3.3 Bioscouring with Pectinase + Cellulase

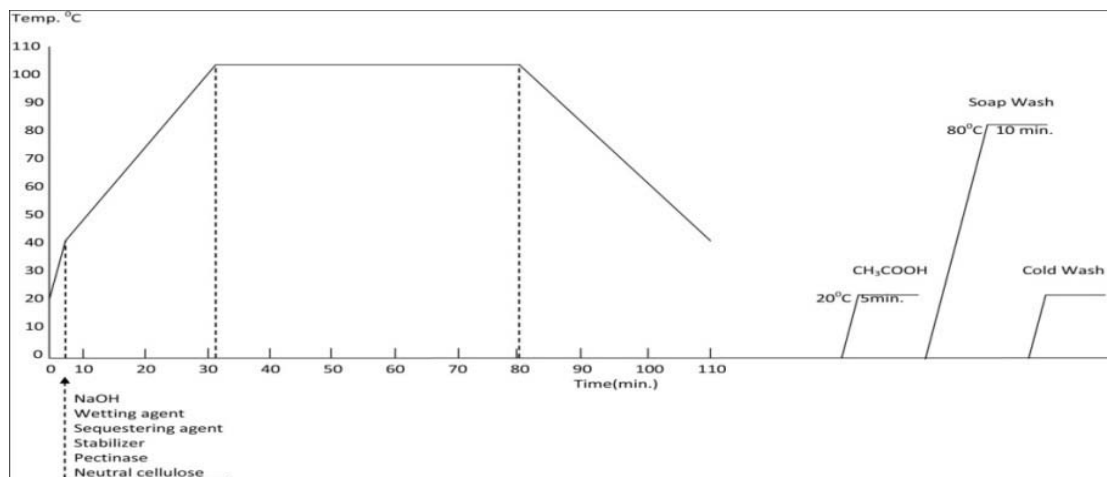


Fig 7: Graphical presentation of Bioscouring with Pectinase + Cellulase

2.3.4 Scouring & Bleaching with Pectinase

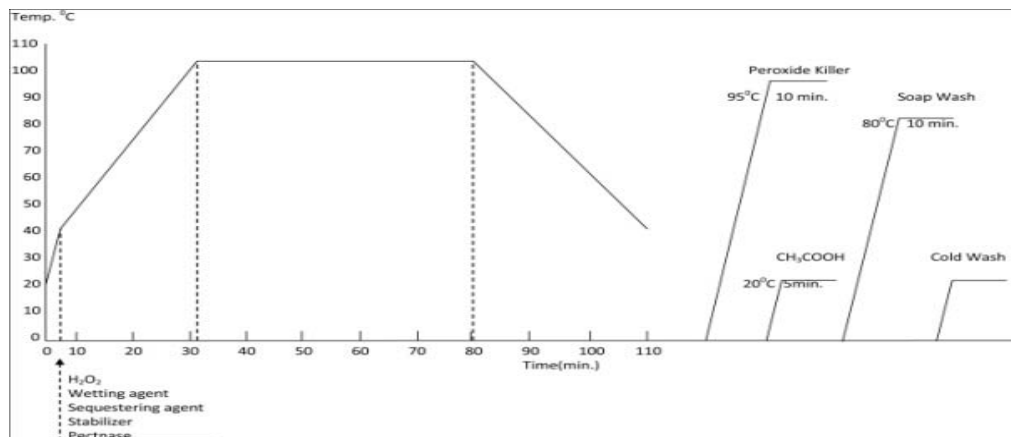


Fig 8: Graphical presentation of scouring and bleaching with Pectinase

2.3.5 Scouring & Bleaching with Pectinase + Neutral Cellulase

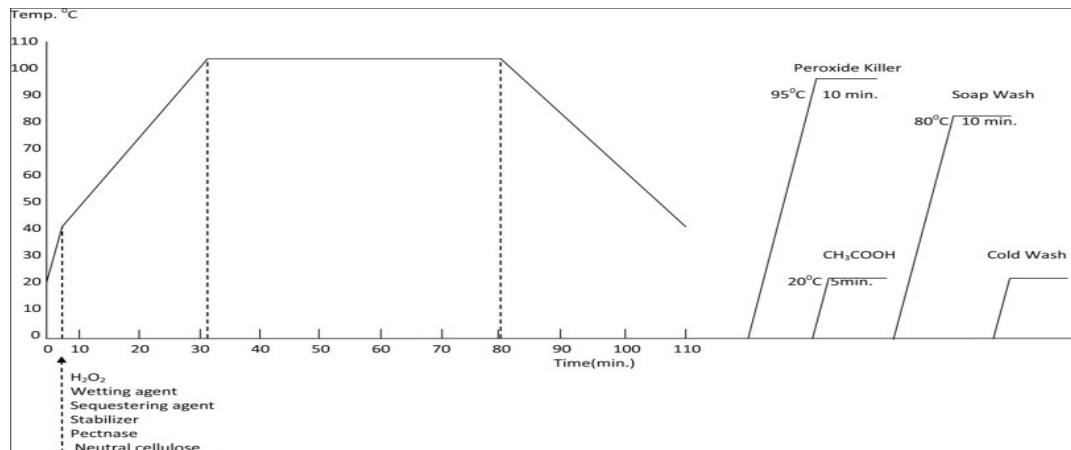


Fig 9: Graphical presentation of scouring and bleaching with Pectinase + Neutral Cellulase

2.4 Testing Methods

2.4.1 Colour Fastness to Rubbing Test

Method : ISO-105F09
 M/C Name : Crockmeter (James H. Heal)
 Model : 670 Hand Driven Crockmeter
 Length of traverse : 100±5 mm
 Testing Procedure

i) Dry Rubbing

Along the warp direction and also along the weft direction, the rubbing performance was engineered, where supplied rubbing cloth and Crock meter was used for the specified test. The sample was turned forth and back 10times in 10 seconds.

ii) Wet Rubbing

Wet out a rubbing cloth with water to have about 100% pick up. Carry out the appropriate test as the procedure for dry rubbing. Allow the tested rubbing cloth to dry at room temperature.

2.4.2 Colour Fastness to Wash Test

Method : ISO105F10
 M/C Name : Washing & dry cleaning
 Brand Name : James H. Heal
 Sample Size - 10 X 4 cm with multifibre

fabric

Recipe:

Anhydrous sodium carbonate - 2 g/l
 Soap - 5 g/l
 M:L - 1:50

Procedure:

Set the bath with substrate at room temperature and run the bath for 5 min. to temperature raising 40°C. Add anhydrous sodium carbonate, soap and run 30 min with 60°C temperature. And dry this sample fabric. Result: Assess by grey scale.

2.4.3 Colour Fastness to Perspiration Test

M/C Name : Perspiro Meter Phenolic Yellowing
 Tester & Incubater.
 Model : H X 30
 Brand : James H. Heal

Recipe for Alkaline solution

L-Histadine Hydrochloride Monohydrate (98%)
 $C_6H_{90}2N_3HC_1$ - 0.5 g/l
 Di-Sodium Hydrogen orthophosphate Dihydrate
 $Na_2HPO_4 \cdot 2H_2O$ - 2.5 g/l
 Sodium Chloride
 NaCl - 5 g/l
 pH : 8
 M:L : 1:50
 Sample size : 10 X 4 cm with multifabric.

After drying, assess the specimens in a colour matching cabinet under D65, artificial daylight. Assess colour staining of all components on the multifibre using the grey scale for assessing staining. Assess the change of shade on the original specimen compared to the tested specimen, using the grey scales for assessing change.

2.4.4 Drop Test

Colored drop was poured on the fabric and the duration to absorb the drop was estimated.

3. RESULTS & DISCUSSIONS

3.1 Drop Test Result for Absorbency

Table 2: Drop test results using different combinations of agents and enzymes

Name of Sample	Time			Avg Value
	1 st	2 nd	3 rd	
Pectinase 5g/l & Imarol	2.3	2.2	1.5	2 sec.

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blue1.2 g/l	0	0		
Pectinase 5 g/l & H ₂ O ₂ 5gl	4.5	4	3.5	4 sec.
Pectinase 5 g/l & N. Cellulase 0.8 g/l	4.30	4.20	3.5	4 sec.
Pectinase 1 g/l & wetting agent 1.5 g/l	3.60	3.50	3.55	3.55 sec.
Pectinase 2 g/l & wetting agent 1.5 g/l	3.40	3.60	3.50	3.5 sec.
Pectinase 3 g/l & cellulase 3 g/l	2.25	2.20	1.55	2 sec.

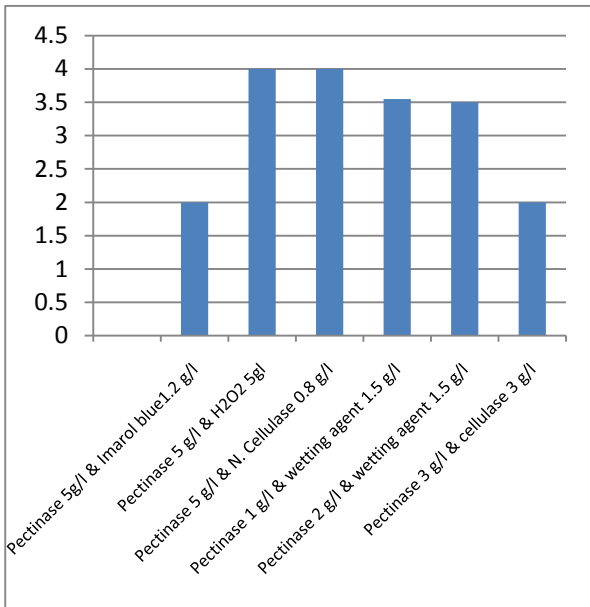


Fig 10: Drop test results using different combinations of agents and enzymes

3.2 Perspiration Fastness Test Results

Table 3: Perspiration fastness test results using different combinations of agents and enzymes

Name of sample	Diacetate	Bleached cotton	Polyamide	Polyester	Acrylic	Wool	in Change color
	Standard 0.3% Shade	5	4/5	5	5	5	5
Standard 0.5% shade	5	4/5	5	5	5	5	4/5
Pectinase 5g/l & Imarol blue1.2 g/l	5	4/5	5	5	5	5	4/5
Pectinase 5 g/l & H ₂ O ₂ 5gl	5	4/5	5	5	5	5	4/5
Pectinase 5 g/l & Neutral cellulase 0.8 gl	5	4/5	5	5	5	5	4/5
Pectinase 1 g/l & wetting agent 1.5 g/l	5	4/5	5	5	5	5	4/5
Pectinase 2 g/l & wetting agent 1.5 g/l	5	4/5	5	5	5	5	4/5
Pectinase 3 g/l & cellulase 3 g/l	5	4/5	5	5	5	5	4

Name of sample	Dry		Wet	
	0.3 % shade	0.5 % shade	0.3 % shade	0.5 % shade
Standard	5	5	4/5	4/5
Pectinase 5g/l & Imarol blue1.2 g/l	5	5	4/5	4/5
Pectinase 5 g/l & H ₂ O ₂ 5gl	5	5	4/5	4/5
Pectinase 5 g/l & N. Cellulase 0.8 g/l	5	5	4/5	4/5
Pectinase 1 g/l & wetting agent 1.5 g/l	5	5	4/5	4/5
Pectinase 2 g/l & wetting agent 1.5 g/l	5	5	4/5	4/5
Pectinase 3 g/l & cellulase 3 g/l	5	5	4/5	4

3.3 Rubbing Fastness Test Results

Table 4: Rubbing fastness test results using different combinations of agents and enzymes

3.3 Washing Fastness Test Results

Table 5: Washing fastness test results using different combinations of agents and enzymes

3.4 Datacolor CMC value results

Name of sample	Diacetate	Bleached cotton	Polyamide	Polyester	Acrylic	Wool	in Change color
Standard 0.3% Shade	5	4/5	5	5	5	5	4/5
Standard 0.5% shade	5	4/5	5	5	5	5	4/5
Pectinase 5g/l & Imarol blue 1.2 g/l	5	4/5	5	5	5	5	4/5
Pectinase 5 g/l & H ₂ O ₂ 5gl	5	4/5	5	5	5	5	4/5
Pectinase 5 g/l & Neutral cellulase 0.8 gl	5	4/5	5	5	5	5	4/5
Pectinase 1 g/l & wetting agent 1.5 g/l	5	4/5	5	5	5	5	4/5
Pectinase 2 g/l & wetting agent 1.5 g/l	5	4/5	5	5	5	5	4/5
Pectinase 3 g/l & cellulase 3 g/l	5	4/5	5	5	5	5	4

Table 6: Datacolor results for CMC Value

Scouring process apply in sample	CMC Value	
	Std. 3% vs trial value	Std. 5% shade vs trial 5 % shade
Pectinase 5g/l & Imarol blue 1.2 g/l	1.39	1.50
Pectinase 5 g/l & H ₂ O ₂ 5gl	1.34	1.61
Pectinase 5 g/l & N. Cellulase 0.8 g/l	1.53	1.47
Pectinase 1 g/l & wetting agent 1.5 g/l	1.69	1.44
Pectinase 2 g/l & wetting agent 1.5 g/l	1.68	1.37
Pectinase 3 g/l & cellulase 3 g/l	1.49	1.60
Pectinase 5g/l	2.30	2.15

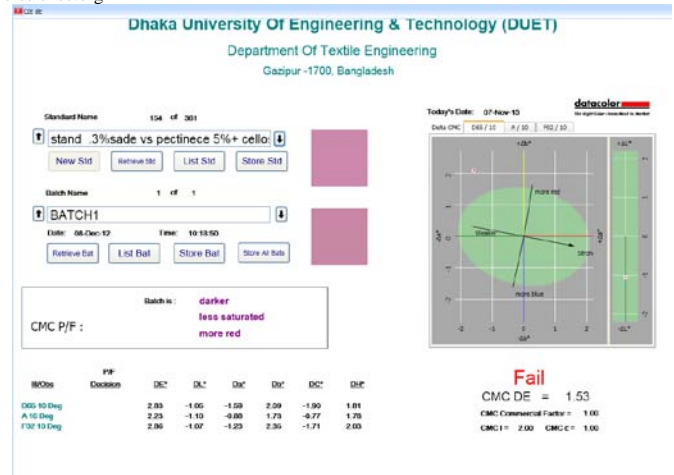


Fig 11: CMC value of pectinase and cellulase treated sample

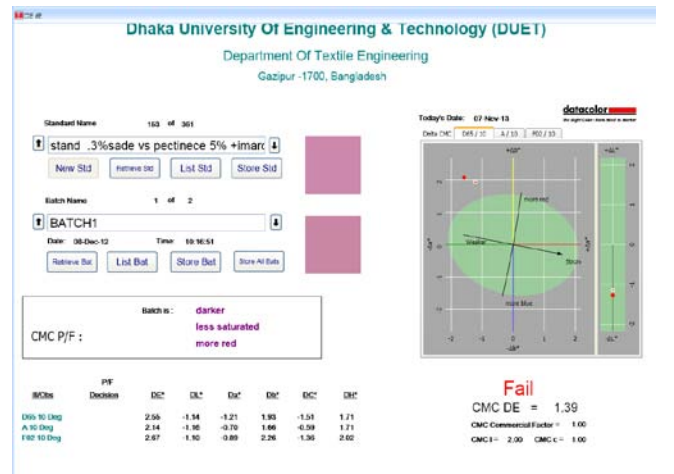


Fig 12: CMC value of pectinase and Imerol blue (multifunctional agent) treated sample

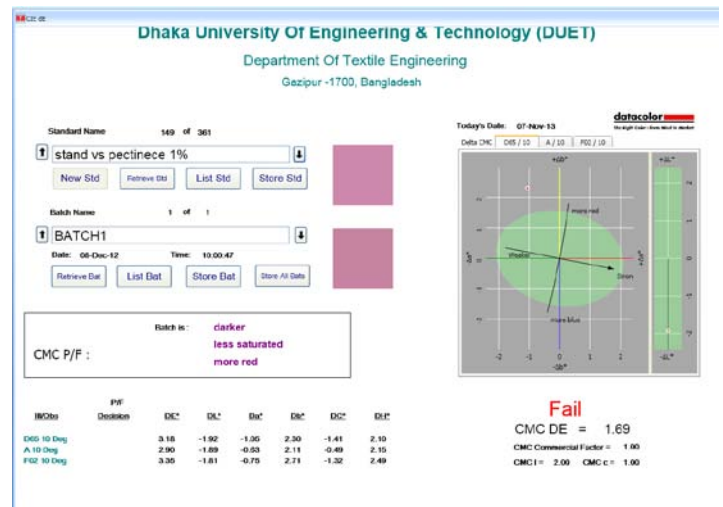


Fig 13: CMC value of only pectinase treated sample

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In almost all the cases only pectinase treated samples provided less values in drop test and CMC values whereas combination with cellulase and other multifunctional agents like Imerol blue focuses on greater values. Moreover, color fastness to wash, rubbing and perspiration test results are also in favor of the combination application.

4. CONCLUSION

This research work concluded that, only pectinase enzyme offered less absorbency, whereas addition of cellulase enzyme confirmed more absorbency, other parameters like datacolor, CMC value, different colour fastness properties referred to better reveals as well.

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