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INFLUENCE OF ECO-FRIENDLY SPECIAL FINISHES ON NATURALLY COLOURED COTTON IN GREEN TEXTILES

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ABSTRACT

Eco-friendly textiles are currently in high demand across the industry. Global warming, pollution and other ecological concerns are receiving increasing attention on one hand; on the other, a growing number of consumers are recognizing the need for safe and sustainable fashion. The concept of green textiles encompasses eco-conscious production, sustainable clothing and environmentally responsible fashion—designed to be both safe and secure. Eco-friendly special finishes, including bio-finishes, have emerged as vital enhancements in the textile industry, imparting desirable properties to fabrics while reinforcing the ethos of eco-fashion. In 2021, a study was undertaken to evaluate the influence of specialized eco-finishes on DDCC-1 (Dharwad Desi Coloured Cotton-1) fabric. The fabric underwent bio-desizing to reduce residual sizing agents, followed by bio-polishing to eliminate protruding surface fibers, thereby enhancing smoothness. Subsequently, it was treated with a silicon-based softener to improve its tactile feel and overall comfort. This multi-stage eco-finishing process aimed to elevate both the aesthetic and functional qualities of DDCC-1 in alignment with sustainable textile practices. The control and finished fabrics were evaluated for their mechanical and functional properties, with statistical analysis conducted using the t-test to determine the significance of observed changes. The study revealed that the application of a silicone softener finish notably enhanced the flexibility, drape and pliability of naturally coloured cotton khadi fabric, resulting in improved softness and surface smoothness. Furthermore, tensile strength increased substantially—from 26.00 kgf to 42.88 kgf in the warp direction, and from 15.10 kgf to 25.24 kgf in the weft. These improvements underscore the potential for greater consumer satisfaction through the development of bio-finished, eco-friendly naturally coloured cotton textiles.

Keywords: Eco-friendly clothing, Enzymatic finish, Green textiles, Khadi Fabrics, Naturally Coloured Cotton, Silicon Softener Finish

INTRODUCTION

Textile industries use various chemicals in different processes like scouring, bleaching, dyeing, finishing, etc. The textile finishing & dyeing industry consumes large quantities of water and produces large volumes of waste water from various processes. Waste water from textile processing contains residues and requires appropriate treatment before being released into the environment. Interest in eco-friendly processing in the textile industry has increased in the current scenario because of increased awareness of environmental issues as well as concern for human health.

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The nonprofit Sustainable Technology Education Project (STEP) defines eco-fashions as "clothes that take into account the environment, the health of consumers and the working conditions of people in the fashion industry." Clothes and accessories that meet such criteria are usually made using organic raw materials such as cotton grown without pesticides.As a result, the eco-fashion industry has provided an opportunity to bring back a long-standing fiber, naturally coloured cotton, which has been a part of nature for 5000 years and has produced environmentally friendly clothing. Four species *viz.,Gossypium arboretum, Gossypium herbaceum, Gossypium hirsutum and Gossypium barbadense* were responsible for a variety of lint hues including brown, black, mahogany red, red, khaki, pink, blue, green, filthy white and of course white.

Brown cotton lines from the University of Agricultural Sciences, Dharwad are at the forefront in the All India Coordinated Research Project trials and DDCC-1 was proposed for release in 2021. The Khadi and Village Industries Board of Karnataka had a nearby unit, which wove the cotton and made shirts out of it (Menon, 2020). The dyeing process is omitted when naturally coloured lint is used for the manufacturing of the fabric, reducing the cost of production (Keshamma, 2022). Naturally coloured cotton has become a popular and environmentally sustainable replacement for commercially dyed cotton during this phase (Madhu, 2024).

Bio-finish is mainly applied to the fabric by using enzymes which are naturally occurring proteins capable of catalysing specific chemical reactions. They are required in a small quantity which only catalyses the reactions and are not consumed. Enzymes *viz.,* amylases, pectinases, lipases, proteases, catalases, etc., are used in special finishes like bio-desizing, bio-scouring, bio-polishing, bio-stoning, bio-softening and so on. (Shahid *et al.,* 2016).

Silva *et al.,* 2017 conducted a study on application of an enzymatic pool in bio-scouring of cotton knit fabric and envisaged that a comparison between the enzymatic treatment and the scouring confirmed that bio-scouring can be as effective as the conventional process. It is more environmentally sustainable as it occurs at neutral pH and consumes less water and energy.

The studies by Raafi *et al.,* 2023 and Manasmita *et al.,* 2024, depict that being highly specific biological catalysts, enzymatic scouring is advantageous to conventional chemical scouring in terms of reduced usage of water, chemicals and power as well as milder temperature and pH conditions. By prioritizing eco-friendly finishes, the textile industry can foster a harmonious balance between fashion and environmental responsibility, meeting the growing demand for sustainable and ethically produced textiles.

In response to growing environmental concerns and the rising demand for sustainable textiles, this study explores the potential of eco-friendly, naturally dyed cotton as a pathway to a greener future. Specifically, it focuses on Dharwad Desi Coloured Cotton (DDCC-1), treated with enzymatic special finishes to enhance softness and lustre without compromising ecological integrity. A comparative analysis of mechanical and functional properties between untreated (control) and treated fabrics is undertaken to assess the effectiveness of bio-finishing techniques. The findings aim to support the advancement of naturally coloured cotton as a viable, sustainable alternative in modern textile innovation which is trying to move towards greener future.

MATERIAL AND METHODS

Fabric

DDCC-1 (Dharwad Desi Coloured Cotton-1), *Gossypium arboreum*, the naturally coloured cotton yarn, was procured from Khadi

Fig. 1. White Cotton and DDCC-1 plain woven fabrics

Nekar Sahakar iSangh Niyamita, Uppin-betageri, Dharwad district and was woven with plain weave (Fig 1).

Treatment

The khadi fabric was specially finished with eco-user-friendly enzymes by subjecting them to bio-desizing followed by bio-polishing and finally finished with a silicon softener finish. The commercially used method was followed for finishing the fabric. After final finishing, the treated fabrics were then run in a hydro extractor for 15 mins to remove excess finishing solution and tumble dried below 120°C. (Table 1)

Table 1. Parameters of special finishes

Sl. No.	Parameters	Bio-desizing	Bio-polishing	Silicon Softener
1	MLR(Material Liquor Ratio)	1:10	1:10	1:10
2	Treatment time	20 min	45 min	20 min
3	Treatment temperature	40°C	50°C	-
4	pH	-	4.5-5	4.5-5
5	Acid	-	Acetic acid	Acetic acid
6	Clariant desize	30ml / kg of fabric	-	-
7	Refnol lubricant	25 ml / kg of fabric	25 ml / kg of fabric	-
8	Novo Nordisk enzyme	-	30 ml / kg of fabric	-
9	Resil Silicon	-	-	25 ml / kg of fabric
10	Pidilite Softener	-	-	50 ml / kg of fabric
11	Finishing machine	Drum washer	Drum washer	Drum washer
12	Method incorporated	Hot method	Hot method	Cold method

Assessment of physical properties

Laboratory tests included the assessment of mechanical and functional properties of the naturally coloured cotton fabric. The mechanical properties included yarn count, cloth count, cloth weight, cloth thickness, crease recovery angle, cloth stiffness and shrinkage test, which in turn affected functional properties such as tensile strength, abrasion resistance, drapability and pilling. The tests were conducted by following the standard methods.

RESULTS AND DISCUSSION

Mechanical properties

The treatment has improved the mechanical properties of the khadi fabric by enhancing the yarn fineness with higher density, making the fabric more compact and increasing the fabric weight. This may be because the yarn has become finer after the removal of starch and protruding fibres from the fabric surface. This has made the yarns more compact in the fabric. The bio-polishing and softener treatment also have an impact on the fibre surface, which lowers the intermolecular attraction by penetrating into the fibre system. The weight has increased from 219.44 g/m^2 to 240.88 g/m^2 and the thickness from 0.82 mm to 0.85mm of the treated fabric after treatment; it may be because of the deposition of silicone softener in all the pores of the fabric creating a coating on it and the yarns have become finer on treatment with silicone softener. This is supported by the study conducted by Chowdhury (2018) on effect of special finishes on the functional properties of cotton fabrics where after chemical implementation on both woven and S/J fabrics with various finishing formulations, GSM has increased because chemical has covered up all the pores of the fabric and a chemical coating is created on the fabric. Therefore, the water is not allowed to penetrate into the fabric for water repellent finishes. (Fig. 2, 3, 4 & 5)

Reduction in cloth stiffness from 4.29 cm to 1.54 cm in warp and 2.19 cm to 1.53 cm in weft and increase in the crease recovery angle from 78 to 93 degree in warp and 53.6 to 77 degree in weft of the treated naturally coloured cotton in both warp and weft may be due to removal of size and the effect of the softener must have imparted softness and smoothness to the finished fabric, thus making the fabric more pliable.The exceptional softness of the treated fabric may be attributed to inter-fibre softening and the deposition of hydrophobic hydrocarbons, which form a thin film on the surface. This treatment has also imparted excellent dimensional stability, likely due to the removal of sizing agents applied during warping. The absence of size allows the warp yarns to relax more freely, resulting in a higher percentage of shrinkage during the first wash—thereby stabilizing the fabric for subsequent use. The t-test is found to be significant at 5% in all the mechanical properties. The application of user-friendly and eco-conscious finishes have significantly enhanced the mechanical properties of khadi fabrics—achieved without the use of harmful chemicals. This chemical-free approach not only preserves the integrity of the fabric but also contributes positively to consumer health and well-being, reinforcing the value of sustainable textile innovation. Statistical t-values are also calculated for more accuracy of our experimental results using equation.

Where, d is mean differences between treated and control

s_d is standard deviation of the differences

n is number of paired observations (here n=2 i.e wrap and weft).

These t values proven, *Stiffness*, *Crease Recovery*, *Shrinkage* and *Weight* all have t-values above the typical threshold of ±2, suggesting these properties differ meaningfully from the baseline or control. While *Crease Recovery* shows the strongest positive change,

while *Stiffness* shows the strongest negative change. *Thickness* has a t-value of +1.22, which is below the usual significance threshold. This implies that any observed change in thickness may be due to random variation rather than a true effect.

$$t = \frac{d}{s_d / \sqrt{n}}$$

Functional properties

The elongation percentage has increased from 10.66 % to 13.15% in warp and 7.04 % to 7.22 % in weft on treatment, which may be due to the formation of a thin film of softeners on the fabric surface that lowers the intermolecular attraction within the fibres. This in turn strengthens the fibre and helps to absorb more force, resulting in greater cloth elongation. Finally, the tensile strength of the fabric has also increased from 26.00 kgf to 42.88 kgf in warp and 15.10 kgf to 25.24 kgf in weft, maybe because after treatment, the fabric has become softer and more pliable due to finer yarns but the deposition of silicon softener has added to its strength. However, the drape of the fabric is improved to a large extent from 130.64 % (control) to 61.23 % (treatment), which may be because the treatment has imparted excellent softness and also a reduction in bending length and crease recovery angle positively supports the improvement in the drapability. Thus, the treated samples have shown excellent abrasion resistance and no pilling was observed, which may be because after bio-polishing, the small protruding fibres on the fabric have been removed, resulting in less balling up of fibres.

Pu *et al.*(2015) cited that compared to the traditional softening finishing in aqueous

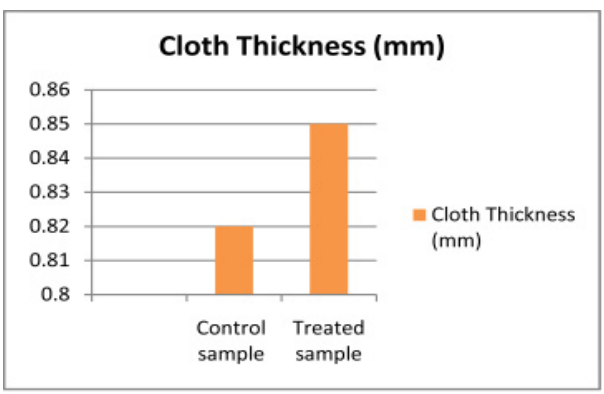

Fig. 2. Cloth Thickness

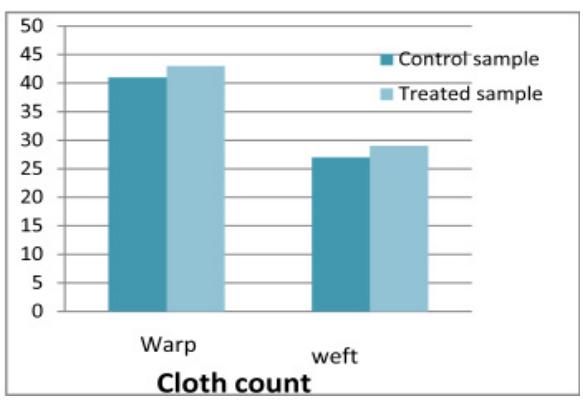

Fig. 3. Cloth Count

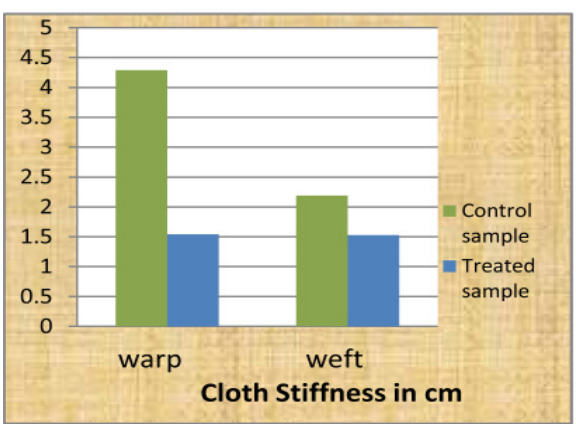

Fig. 4.Cloth Stiffness

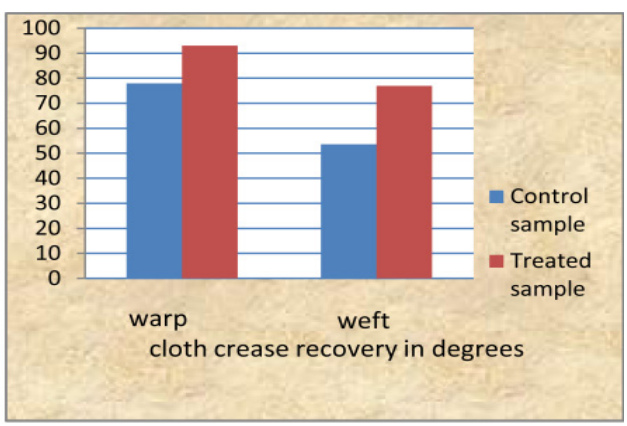

Fig. 5. Cloth Crease Recovery

Table 2. Impact of special finishes on mechanical properties of naturally coloured cotton khadi fabric

Sl. No.	Khadi fabrics	Sample Type	Yarn Count (Ne)		Cloth Count (Numerical expression)		Cloth Thickness (mm)	Cloth Weight (g/mt^2)	Cloth Stiffness (cm)		Cloth Crease recovery (degrees)		Cloth Shrinkage (%)	
			warp	weft	warp	weft			warp	weft	warp	weft	warp	weft
1.	Naturally Coloured Cotton	Control sample	2/6s	2/8s	41	27	0.82	219.44	4.29	2.19	78	53.6	8.44	0.67
		Treated sample	2/8s	2/8s	43	29	0.85	240.88	1.54	1.53	93	77	0.00	0.00
		t-value					**1.22**	**3.42**	**-4.17**		**4.47**		**-2.83**	

bath, the novel softening finishing system can obtain almost the same softening finishing effect and the adsorption rate of silicone softener is about 75 percent.

Varieties with fibre lengths of 25–29 mm and fibre strengths of 20–23 g/tex are required by the textile industry. Depending on the spinning mills' acceptability, a couple of the more recent varieties might be taken into consideration for the purpose. The handloom companies should work with the Khadi Gram Udyog to use coloured cotton types with short fibre (<24 mm) and enhance the production of eco-friendly, naturally coloured cotton fabric.

CONCLUSION

The study revealed that eco-finishing treatments significantly enhanced the flexibility, drape and pliability of naturally coloured cotton khadi fabric resulting in a softer handle, smoother texture, excellent abrasion resistance and complete absence of pilling. Statistical analysis marked by significant *t* values confirmed notable improvements in mechanical properties-particularly through increased yarn fineness and density, which contributed to a more compact structure and elevated fabric weight. These enhancements were achieved using safe and secure eco-friendly finishing methods, entirely free from harmful chemicals that could compromise consumer health or environmental integrity. As a result, consumers benefit from greater satisfaction and value, securing bio-finished, sustainable khadi fabrics that uphold both quality and ecological responsibility. This approach offers a meaningful contribution to green textile development and the reduction of environmental pollution.

REFERENCES

Chowdhury, K.P. 2018.Effect of Special Finishes on the Functional Properties of Cotton Fabrics. Journal of Textile Science and Technology, 4(2): 49-66. https://doi.org:10.4236/jtst.2018.42003

Table 3. Impact of special finishes on functional properties of naturally coloured cotton khadi fabric

Sl. No.	Khadi fabrics	Sample Type	Cloth elongation (%)		Cloth tensile Strength (kgf)		Cloth Abrasion resistance (cycles)	Drape Coefficient (%)	Cloth pilling (Ratings)
			warp	weft	warp	weft			
1.	Naturally Coloured Cotton	Control sample	10.66	7.04	26.00	15.10	Above 10,000	130.64	1
		Treated sample	13.15	7.22	42.88	25.54	Above 10,000	61.23	1

Keshamma, E. 2022. An Overview on Colour Cotton Research – A Review. International Journal of Engineering Technology and Management Sciences, 5(6): 272-278.

Madhu, A. 2024. Naturally Coloured Cotton: A Sustainable Innovation. DOI: 10.5772/intechopen.113290. https://www.intechopen.com/chapters/88495

Manasmita, M., Kumar, S and Mehra, D. 2024. Recent advancements in textile finishing focused on eco-friendly and plasma technology approach. Journal of University of Shangai for Science and Technology, 26(4): 310-321. ISSN: 1007-6735

Menon, M. 2020. Naturally-coloured cotton from India could help reduce the environmental pollution caused by dyes. https://scroll.in/article/975377/naturally-coloured-cotton-from-india-could-help-reduce-the-environmental-pollution-caused-by-dyes.

Pu, D. J., Zhong, Q and Wang, J. P. 2015. A novel softening finishing of cotton fabrics by Silicone Softener/ D5 Dispersion system. Key Engineering Materials, 671: 186-190. https://doi.org/10.4028/www.scientific.net/KEM.671.186

Raafi, M., Arju, S.N., Asaduzzaman, Md., Khan, H. H and Rokonuzzaman, Md. 2023. Eco-friendly scouring of cotton knit fabrics with enzyme and soapnut: An alternative to conventional NaOH and synthetic surfactant based scouring. Science Direct, 9(4). https://doi.org/10.1016/j.heliyon.2023.e15236

Shahid, M., Mohammad, F., Chen, G., Tang, R.C and Xing, T. 2016. Enzymatic processing of natural fibres: white biotechnology for sustainable development. Green Chemistry, 18(8): 2256-2281.https://doi.org/10.1039/C6GC00201C

Silva, L.G. de Melo da, Oliveira, D. de, Souza, A.A. Ulson de, Souza and S.M. GuelliUlson de. 2017. Study and application of an enzymatic pool in bioscouring of cotton knit fabric. The Canadian Journal of Chemical Engineering, 95 (7):1253-1260. https://doi.org/10.1002/cjce.22780

Namrata, M., Turamari, R. I. and Tangod, V. B. 2025. Influence of Eco-Friendly Amazing Finishes on Naturally Colored Cotton in Green Textiles. The Journal of Research ANGRAU, 53(3): 95-101