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Impact of internal notation and hetero bifunctional reactive dyes on color performance, mechanical and dimensional stability of cellulose-based biomaterials

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Abstract: Internal notation factors influence the quality of cellulose-based biomaterials dyed with hetero bifunctional reactive dyes. Different internal notations of materials, such as Single Jersey, Rib and Interlock affect different coloration parameters like dye uptake, color fastness and strength. This research work aims to analyze the influence of various internal notations on color performance with hetero bifunctional reactive dyes. It also intends to identify the varying shades and the manufacturing internal notation factors for achieving consistent color quality and durability across different types of cellulose-based biomaterials. Seven cellulose-based biomaterials with various internal notations (Single jersey, 1×1 Rib, 2×1 Rib, Interlock, French Terry, Single Lacoste, Pique) were analyzed, colored with various dye uptake levels, such as light, medium, and dark. The investigation measured color strength, color parameters (L*, a*, b*, c*, h), surface morphology, color fastness, mechanical strength, shrinkage, and spirality. Standardized testing methods and instruments were employed for quality assessment. It has been observed that internal notation of materials significantly impacts dye absorbency with Interlock appearing brightest (K/S value 11.5). SEM analysis reveals surface morphology differences, affecting dye absorption. Color resistance varies with fabric internal notation while bursting strength differs across fabric types.

Keywords: fabric structure; textile coloration; dyeing performance; colorfastness; quality assessment.

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INTRODUCTION

In recent years, the knitting segment of the textile industry has experienced rapid growth. The demand for weft-knitted garments has significantly increased in both domestic and export markets. Moreover, knit fabrics provide outstanding comfort qualities and have long been preferred as fabrics in many kinds of clothing.[1–4] Since they are produced on different machines with different knit stitches and conditions to create different patterns and fabric types, it is expected they have different qualities.[5] Efforts are being made to enhance the comfort of knitted fabric by altering fibers, yarn parameters (such as twist, bulk, count, and finish), knitting parameters (including courses per inch, wales per inch, loop length, and fabric weight), and post-knitting finishes (such as enzyme and chemical treatments).[6] The Single Jersey (S. Jersey) knitted fabric properties especially the dimensional and physical properties are mainly influenced by the constituent fibers, yarn properties, knitting machine variables, processing and finishing treatments.[7] Fabric quality refers to the various characteristics of finished fabric, which are determined by the properties of the yarn and the fabric's construction. The attributes of knitted fabrics are influenced by multiple factors, including the raw material, yarn structure, fabric internal notation, processing stages, and finishing techniques.[8] The process adopted affects the fabric's properties and its overall performance. The properties that are important for knitted fabric and maintained in the industries from the grey stage to the finished stage are GSM, dimensional stability (shrinkage and spirality), bursting strength, and fastness properties.[9] Tactile (hand) and appearance properties are also very important in all classes of fabrics.

Numerous studies have examined the effects of fibers, dye types, processing parameters and wet processing stages and sequences on knitted cotton fabric physical, dimensional and coloration properties.[10–15] However, a limited number of studies on the influence of fabric internal notations on the physical, dimensional and coloration properties of cotton knit dyed fabrics. The research aims to investigate the impact of various internal notations of cellulose-based materials (knit fabric) on the quality parameters of fabrics dyed with hetero bifunctional reactive dyes were comparing the color strength at a particular wavelength for different knit internal notations including Single Jersey, 1×1 Rib, 2×1 Rib, Interlock, French Terry, Single Lacoste, and Pique, each dyed with different shades. Additionally, the L*, a*, b*, c*, and h values of all fabric internal notations are compared across light, medium, and dark shades. Additionally, SEM analysis was conducted on dyed and undyed fabric internal notations to observe and compare morphology. Subsequently, the color fastness to washing, rubbing (both dry and wet), light exposure, and perspiration of all samples was evaluated. Moreover, the mechanical and dimensional stability features were assessed through various tests such as bursting strength, shrinkage and spirality.

EXPERIMENTAL

Materials and chemicals

Various scoured and bleached cellulose-based biomaterials with different internal notations were collected from Texeurop BD Ltd. Seven types of samples were produced in 30'' dia machine, including plain S. Jersey, French Terry,1×1 Rib, 2×1 Rib, Interlock, S. Lacoste and Pique. These fabrics were made from 100 % cotton yarn with having areal density of 220. The fabric internal notation's knitting parameters are displayed in TABLE I**, which shows** Internal notations of different cellulose-based materials. The chemicals and dye stuff, sourced from Dysin Ltd., were utilized in the coloration process without any further treatment. The reactive dyes included three hetero bifunctional reactive dyes which are Levafix Amber CA (C.I. Reactive Orange 107), Levafix Fast Red CA (C.I. Reactive Red 223) and Levafix Blue CA (C.I. Reactive Blue 19) with vinyl sulphonyl and difluorochloropyrimidyl reactive groups in the molecule. In addition to these dyes, various chemicals played crucial roles in the coloration process. These included electrolyte glauber salt ($Na_2SO_4.10\ H_2O$), alkali soda ash (Na_2CO_3), caustic soda, hydrogen peroxide, wetting agent, leveling agent, anti-creasing agent, acetic acid (100%) and soaping agent.

TABLE I. Knitting parameters of the fabric internal notations.

Fabric type	GSM	Yarn count	M/C dia	M/C gauge	Stitch length
S. Jersey	220	32/1(2ply)	30"	20	3.70/3.60
1×1Rib	220	28/1	30"	18	2.60
2×1 Rib	220	28/1	36"	18	2.70
Interlock	220	24/1	30"	24	1.55
F. Terry	220	28/1	30"	24	2.75/1.35
S. Lacoste	220	22/1	30"	24	2.75
Pique	220	20/1	30"	24	3.05

Coloration process

The impact of coloration on fabric was assessed by applying light, medium, and dark shade recipes using a 30 kg Fongs dyeing machine. Three separate batches were processed for each shade. The light shade recipe included Levafix Blue CA (0.0062%), Levafix Fast Red CA (0.079%), and Levafix Amber CA (0.044%), along with standard auxiliaries such as sequestering (05 g/l) and labelling agents, Glauber's salt, soda ash, and acetic acid at pH 11. Dye concentrations and process parameters were proportionally adjusted for medium and dark shades. The medium shade recipe included Levafix Blue CA (1.04%), Levafix Fast Red CA (1.96%), and Levafix Amber CA (0.24%), along with sequestering agent (05 g/l) and labelling agent (1.0 g/l), Glauber's salt (60 g/l), soda ash (15 g/l), and acetic acid (1 g/l) at pH 11. The dark shade recipe was prepared using Levafix Blue CA (2.40%), Levafix Fast Red CA (1.96%), and Levafix Amber CA (1.36%) with the same auxiliaries at higher concentrations, including Glauber's salt (80 g/l) and soda ash (20 g/l), maintaining the pH at 11. All recipes followed a standard dyeing procedure to assess the effect of dye concentration on fabric shade depth and uniformity. Post-dyeing, the fabrics underwent slitting, stentering, and compacting, followed by quality testing to evaluate coloration performance.

Characterization

The color strength (K/S) values were measured using a spectrophotometer (Datacolor 650, USA) based on the Kubelka-Munk equation: $K/S = (1–R)^2 / 2R$, where R is the reflectance at the maximum absorption wavelength. Measurements were conducted under D65 illumination and a 10° standard observer. Also, the CIELab parameters were measured using same calibrated spectrophotometer under standardized conditions. Measurements were taken with a D65 illuminant and a 10° observer angle. Color fastness to wash is tested according to ISO 105 C10:2006 and ISO 105 C06:2010, where specimens are washed with detergents and assessed for color change and staining.[16,17] Rubbing fastness follows ISO 105 X-12:2001 E, with a test using a crock meter and grey scale evaluation.[18] Shade evaluation was conducted both visually and instrumentally using a spectrophotometer for accurate color comparison. Color fastness to perspiration was assessed according to ISO 105 E04:2008, testing in both alkaline and acidic conditions. Staining was evaluated using the grey scale.[19] The color fastness to light follows ISO 105-B02:2000, exposing fabrics to light and comparing color changes.[20] Bursting strength is measured according to ISO 13938-2:1999, assessing fabric resistance to pressure.[21] All tests were conducted under standardized conditions using calibrated instrumentation to ensure consistency and accuracy. Dimensional stability was evaluated according to ISO 6330 and ISO 5077, assessing fabric shrinkage and deformation post-washing and drying. Spirality or skewness was measured following ISO 13935-2 by examining side seam distortion.[22,23]

RESULTS AND DISCUSSION

Analysis of color strength performance

The K/S values of various fabric types across different shades were analyzed to evaluate color depth and reflectivity. As shown in Fig 1, S. Lacoste exhibited the highest K/S value in the dark shade (12.4), indicating superior color intensity. Both 1×1 Rib and S. Lacoste fabrics demonstrated strong color depth in dark shades, with K/S values of 12.1 and 12.4, respectively. S. Jersey showed a substantial increase from light (0.430) to dark (11.5) shades, highlighting its enhanced dye uptake. Pique and 2×1 Rib fabrics exhibited moderate K/S values, with Pique increasing from 0.446 to 11.4 and 2×1 Rib showing a slight decline in the dark shade (11.25) from a light value of 0.404.

F. Terry and Interlock displayed similar trends, though Interlock reached a slightly higher dark shade value (11.5). Fabric types varied in color saturation, with S. Lacoste demonstrating the most consistent and intense coloration across all shades.

Analysis of lightness, red/greenness, yellow/blueness, chroma and hue

The CIE L*, a*, b*, c*, and h* values in Table II provide a detailed quantitative evaluation of color properties across various fabric types, structures, and shades. Light shades consistently show high L* values (~75–76), indicating greater brightness, while dark shades have low L* values (~24–25), reflecting higher light absorption. This pattern holds across all fabric constructions tested. The a* and b* values reveal tonal shifts: light shades exhibit positive a* and b* (red and yellow hues), medium shades show stable a* with negative b* (green-blue shift), and dark shades approach neutral values, indicating reduced chromaticity. Chroma (c*) values are highest in light shades (17–18), moderate in medium shades (~18), and lowest in dark shades (~1), demonstrating desaturation with decreased lightness. Hue angle (h*) varies from red-yellow hues in light shades (35–37°) to greenish-blue in medium shades (303–305°), with dark shades showing inconsistent values due to low lightness. These results highlight the significant effects of fabric structure and shade depth on color perception, with light and medium shades retaining distinct chromatic features, unlike nearly neutral dark shades.

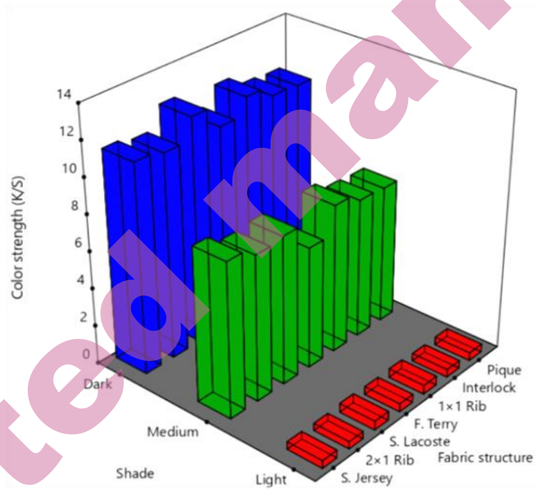

Fig 1. Impact of internal notation and hetero bifunctional reactive dyes on color strength (K/S) of various cellulose based biomaterials.

Surface morphology analysis

Scanning electron microscope (SEM) provides an excellent technique for examination of surface morphology and fiber–dye adhesion, of fabric. Below the Figures in Fig 2 show the SEM photographs of different fabrics before and after coloration, respectively.

TABLE II. Impact of internal notation and hetero bifunctional reactive dyes on L*, a*, b* and c*.

Fabric type	Shade	L*	a*	b*	c*	h
S. Jersey	Light	76.23	13.20	9.44	16.23	35.56
	Medium	30.76	10.80	-15.33	18.75	305.17
	Dark	25.02	0.20	-0.97	0.99	281.91
F. Terry	Light	75.76	13.68	10.24	17.08	36.81
	Medium	33.33	10.52	-15.37	18.62	304.39
	Dark	25.27	0.41	-1.11	1.19	290.32
1×1 Rib	Light	75.18	14.77	10.88	18.35	36.37
	Medium	31.03	10.67	-15.30	18.65	304.88
	Dark	24.18	0.35	-1.05	0.98	288.70
2×1 Rib	Light	76.24	13.86	10.38	17.31	36.83
	Medium	31.58	10.3	-15.37	18.50	303.82
	Dark	24.53	0.34	-0.55	0.65	301.91
Interlock	Light	76.07	14.28	10.74	17.87	36.94
	Medium	31.73	10.63	-15.82	19.06	303.89
	Dark	24.79	0.29	-1.23	1.27	283.23
S. Lacoste	Light	75.05	14.52	10.92	18.17	36.97
	Medium	30.80	10.17	-15.00	18.12	304.16
	Dark	23.79	0.41	-0.69	0.80	300.39
Pique	Light	75.68	13.99	10.75	17.64	37.53
	Medium	31.92	10.58	-15.41	18.69	304.49
	Dark	24.75	0.45	-0.86	0.98	297.62

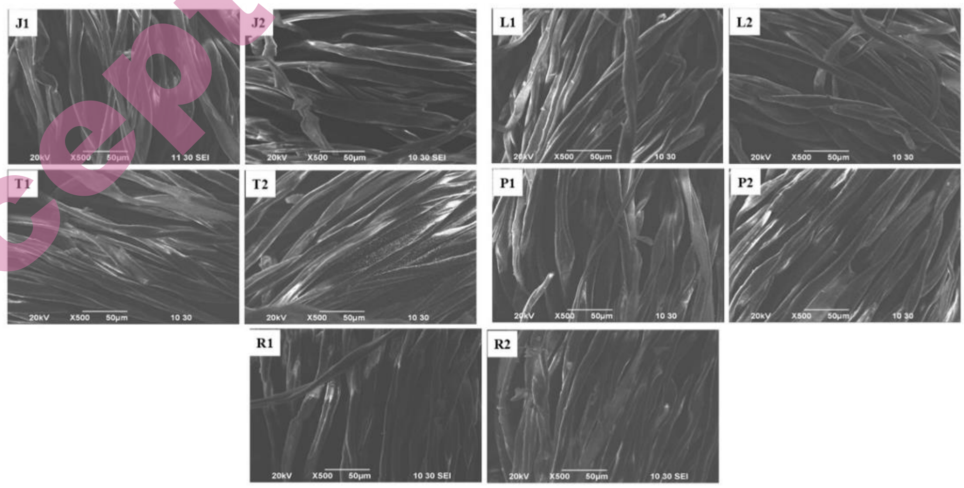

Fig 2. SEM photographs of S. Jersey fabric: (J1) before and (J2) after coloration; Frence Terry fabric: (T1) before and (T2) after coloration; 1×1 Rib fabric: (R1) before, (R2) after coloration; Lacoste fabric: (L1) before, (L2) after coloration; Pique fabric: (P1) before and (P2) after coloration.

Fig 2 (J1) and (J2) illustrate the SEM images of Single Jersey fabric before and after coloration. The post-dyeing SEM analysis indicates a darker appearance, primarily due to the fabric's smooth surface and loosely arranged fibers. The surface exhibits relatively large porosity compared to other fabric structures, which likely facilitates easier and deeper penetration of dye molecules. This increased porosity may contribute to improved dye uniformity and reduced shade unevenness.[24] The Fig 2 (R1) and (R2) show the surface morphology of 1×1 Rib fabric before and after coloration. 1×1 Rib fabric has higher stretchability and elastic recovery than S. Jersey fabric.[25] Examining the image obtained from the scanning electron microscope reveals that the surface is smooth, and there is no indication that there is any evidence of the presence of fibers that are rigid and compact. There is a correlation between the size of the porosity on a surface and the ability of the dye to adhere to that surface. As a consequence of this, the fiber is able to absorb dye molecules, which results in the fiber taking on a darker color.

On the other hand, Fig 2 (L1) and (L2) show the surface morphology of Lacoste fabric before and after coloration. Lacoste fabric shows low shrinkage and high extensibility.[26] The brighter shade observed in the SEM image of the dyed Lacoste fabric is attributed to the cohesiveness and compactness of its fibers. This compact fiber structure, characterized by small and less porous surfaces, restricts the adherence and penetration of dye molecules, resulting in lower dye absorption. Fig 2 (P1) and (P2) illustrate the surface morphology of Pique fabric before and after coloration. Pique fabric exhibits notable resistance to shrinkage and excellent resilience. SEM analysis reveals a characteristic grooved surface morphology with visible macrofibrils oriented along the surface. The rough texture and prominent macrofibril outlines suggest less smooth dye absorption compared to other fabrics. Similarly, Fig 2 (T1) and (T2) show the surface morphology of Terry fabric pre- and post-coloration. The surface displays a mix of smooth and rough areas. The SEM image after dyeing indicates a more vibrant shade, which is attributed to the fabric's compactness. Terry fabric has smaller-sized porosity compared to other fabrics, which limits dye molecule absorption, contributing to its distinctive coloration.[27,28]

Color resistance to aundry

Table III shows that, for the same dye type, color fastness to wash (color change) remains largely consistent across fabric types. Light shades for all fabrics achieved high ratings of 4–5. However, increasing shade depth led to a decrease in wash fastness, with medium shades rated around 4 and dark shades dropping to 3–4. No significant variation in wash fastness was observed due to fabric internal structure, indicating that dye type and shade percentage primarily influence color fastness to washing.

TABLE III Impact of internal notation and hetero bifunctional reactive dyes on color fastness to wash.

Grey scale		Shade	S. Jersey	F. Terry	1×1 Rib	2×1 Rib	Interlock	S. Lacoste	Pique
Color change		Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Dark	4	4-5	4-5	4-5	4-5	4-5	4-5
Color staining	Acetate	Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Dark	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Cotton	Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	3-4	3-4	3-4	3-4	3-4	3-4	3-4
		Dark	3	2-3	4-5	3	2-3	2-3	3
	Nylon	Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Dark	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Polyester	Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Dark	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Acrylic	Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Dark	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Wool	Light	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Medium	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		Dark	4-5	4-5	4-5	4-5	4-5	4-5	4-5

Color fastness to wash results for various fabric internal notations (S. Jersey, F. Terry, 1×1 Rib, 2×1 Rib, Interlock, S. Lacoste, and Pique) across fibers—including acetate, cotton, nylon, polyester, acrylic, and wool—reveal notable trends in color change and staining. All fabrics demonstrated excellent color change resistance, with ratings of 4–5 for light and medium shades. S. Jersey showed a slight decline to a rating of 4 for dark shades, while other fabrics maintained 4–5 ratings. Regarding color staining, synthetic fibers (nylon, polyester, acrylic) and wool consistently achieved high ratings (4–5) across all fabric structures and shade intensities, indicating superior resistance to color transfer and enhanced durability during washing. Cotton fabrics performed well under light and medium staining (ratings 4–5), but showed reduced resistance under dark staining. Specifically, S. Jersey, F. Terry, S. Lacoste, and Pique exhibited lower ratings (2–3) in darker conditions, whereas 1×1 Rib and Interlock maintained higher resistance (4–5).

Color resistance to rubbing and light

Table IV shows that for the same dye type, color fastness to rubbing (color change) and light exposure do not significantly vary across light, medium, and dark shades. Light shade dyeing resulted in excellent dry and wet rubbing fastness ratings (4–5) for all fabric types. For medium shades, dry rubbing ratings remained good (4–4.5), while wet rubbing exhibited variability. Pique fabric showed the lowest wet rubbing rating (2–3), followed by S. Lacoste (3), with 1×1 Rib, 2×1 Rib, and Interlock fabrics rated 3–4. S. Jersey and F. Terry fabrics had a wet rubbing rating of 3. Dark shade dyeing maintained dry rubbing ratings of 4–5 across all samples, but wet rubbing ratings varied similarly to medium shades. Fabrics with rough surfaces, such as Pique and S. Lacoste, demonstrated lower wet rubbing fastness, likely due to surface texture effects during wet rubbing.

TABLE IV Impact of internal notation and hetero bifunctional reactive dyes on color resistance rubbing and light.

Fabric type	Dry rubbing			Wet rubbing			Light		
	Shade								
	Light	Medium	Dark	Light	Medium	Dark	Light	Medium	Dark
S. Jersey	4-5	3-4	4-5	4-5	3	3-4	4-5	4-5	4-5
F. Terry	4-5	4-5	4-5	4-5	3	2-3	4-5	4-5	4-5
1×1 Rib	4-5	3-4	4-5	4-5	3-4	4	4	4	4
2×1 Rib	4-5	4-5	4-5	4-5	3-4	4	4	4	4
Interlock	4-5	4-5	4-5	4-5	3-4	3-4	4-5	4-5	4-5
S. Lacoste	4-5	4-5	4-5	4-5	3	3	4	4	4
Pique	4-5	4	4-5	4-5	2-3	2-3	4	4	4

Table IV evaluates light fastness across various fabric types: S. Jersey (S/J), F. Terry, 1×1 Rib, 2×1 Rib, Interlock, Single Lacoste (S. Lacoste), and Pique. S. Jersey, F. Terry, and Interlock exhibit superior light fastness (4–5), reflecting their comfort, durability, and versatility for casual and activewear. The 1×1 Rib and 2×1 Rib fabrics, rated 4, provide notable elasticity suitable for stretch applications like cuffs and collars. S. Lacoste and Pique, also rated 4, offer breathability and distinctive texture, commonly used in polo and sportswear, though with slightly lower performance. This analysis highlights the specific strengths of each fabric, informing their optimal use in textile manufacturing.

Color resistance to sweating

The present study evaluated the chemical resistance of multiple fabric types—specifically Single Jersey (S. Jersey), French Terry (F. Terry), 1×1 Rib, 2×1 Rib, Interlock, Single Lacoste (S. Lacoste), and Pique—against alkaline and acidic solutions, with results summarized in Table Va and Vb. All fabric samples demonstrated consistently high resistance, receiving uniform grades of 4 to 5 across both acidic and alkaline exposure conditions. This uniformity underscores the intrinsic chemical stability and resilience of the fibers, irrespective of the differing fabric structures and knit notations. The consistently superior resistance ratings suggest that the material properties inherent to these fabrics play a critical role in preserving structural integrity and functional performance when subjected to variable pH environments. Such resilience is particularly advantageous for textile applications where exposure to chemical agents is frequent, indicating these fabrics' robustness and versatility in practical use scenarios. The data further reveals no significant variance in resistance between fabric types, thereby validating their comprehensive applicability across diverse industrial and commercial settings that demand high chemical durability. These findings warrant further investigation into the specific fiber compositions, manufacturing processes, and potential finishing treatments that contribute to this notable chemical stability. Optimizing these factors could lead to enhanced fabric performance and broaden their applicability in environments with stringent chemical exposure requirements.

TABLE Va. Impact of internal notation and hetero bifunctional reactive dyes on color fastness to sweating (alkaline).

Grey scale		Shade	Fastness to perspiration (alkaline)						
			S. Jersey	F. Terry	1×1 Rib	2×1 Rib	Interlock	S. Lacoste	Pique
Color change		L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4	4-5	4-5	4-5	4-5	4-5	4-5
Color staining	Acetate	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Cotton	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	3-4	3-4	3-4	3-4	3-4	3-4	3-4
		D	3	2-3	4-5	3	2-3	2-3	3
	Nylon	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Polyester	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Acrylic	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Wool	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5

L – Light; M – Medium; D – Dark

TABLE Vb. Impact of internal notation and hetero bifunctional reactive dyes on color fastness to sweating (alkaline).

			Fastness to perspiration (acidic)						
Grey scale		Shade	S. Jersey	F. Terry	1×1 Rib	2×1 Rib	Interlock	S. Lacoste	Pique
Color change		L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4	4-5	4-5	4-5	4-5	4-5	4-5
Color staining	Acetate	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Cotton	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	3-4	3-4	3-4	3-4	3-4	3-4	3-4
		D	3	2-3	4-5	3	2-3	2-3	3
	Nylon	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Polyester	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Acrylic	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Wool	L	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		M	4-5	4-5	4-5	4-5	4-5	4-5	4-5
		D	4-5	4-5	4-5	4-5	4-5	4-5	4-5

L – Light; M – Medium; D – Dark

Analysis of mechanical behavior

Fig 3 gives an overview on bursting strength measurement in pressure (kPa) for S. Jersey, F. Terry, 1×1 Rib, 2×1 Rib, Interlock, S. Lacoste and Pique fabric. Fabric structural difference is very much significant in case of bursting strength measurement. For same GSM S. Jersey fabric has the highest bursting strength rating followed by Interlock and Pique. 2×1 Rib and F. Terry is found the lowest rating. For same GSM S. Jersey fabric has the highest bursting strength measurement that is 227.7 kPa. The pressures that needed to burst the Interlock and Pique fabrics are 214.4 kPa and 213.3 kPa. The bursting strength of 1×1 Rib and S. Lacoste are found 205.1 kPa and 195.5 kPa. The F. Terry fabric and 2×1 Rib fabrics show the lowest pressures which are 191.6 kPa and 196.3 kPa.

Analysis of dimensional stability

Shrinkage value also differs from one fabric internal notation to another. From FIGURE 4, S. Jersey fabric the lengthwise shrinkage is found to be -5% and the widthwise shrinkage is found to be -4%, which is acceptable. Because in case of a shrinkage test, under 5% shrinkage is acceptable. For F. Terry fabric, the shrinkage in the length and width directions are found to be -6% and -5%. The shrinkage report of S. Lacoste and Pique fabrics is also found around the same. S. Lacoste and Pique shows lengthwise shrinkage -4% and -5% and widthwise shrinkage is found -5% and -6%. For balanced internal notation like 1×1 Rib the shrinkage percentage is found -4% and -6% (in lengthwise and widthwise direction). But the 2×1 Rib fabric shows the worst result among all the fabric internal notations. It is not possible to control the shrinkage percentage of 2×1 Rib fabric. The shrinkage report for the tested 2×1 Rib fabric is found to be -7% and -8% (lengthwise and widthwise). The report for Interlock fabric is also not so good. It has length shrinkage of -7% and width shrinkage of -6%.

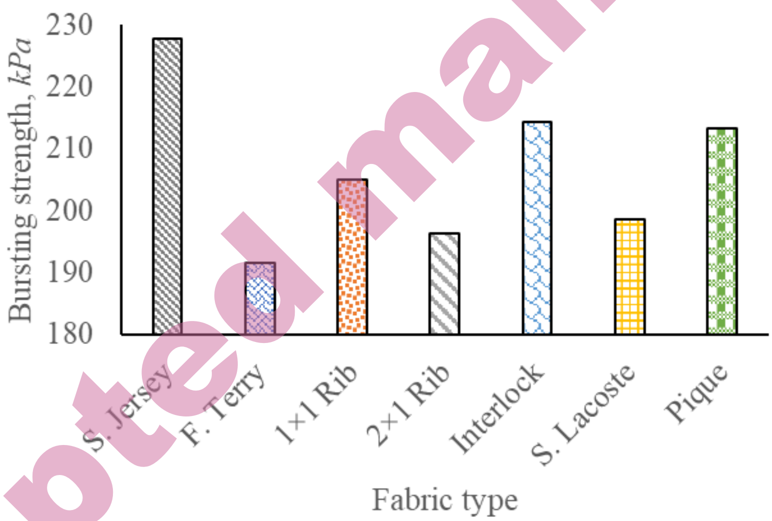

Fig 3. Impact of internal notation on bursting strength.

Fig 4. Impact of internal notation on shrinkage in length and width way.

From Fig 5, the spirality of the S. Jersey fabric of 220 GSM is found very well which is 1%. For S. Jersey derivatives like F. Terry, S. Lacoste and Pique Spirality angles are found to be different. The loop length or Stitch length of F. Terry fabric is larger than that of S. Lacoste and Pique Fabric. Due to the larger stitch length, the spirality of F. Terry fabric is found to be higher than that S. Lacoste and Pique Fabric. Spirality of F. Terry fabric is found 1.54%. The Spirality of S. Lacoste and Pique fabrics is found at 1.5% and 1.78% respectively. Rib and Interlock fabrics are balanced fabric internal notations. So, there are fewer spiral angles. 1×1 Rib and 2×1 Rib fabrics have the same spirality angle which is 1%. Interlock fabric has a spirality of 1.3%.

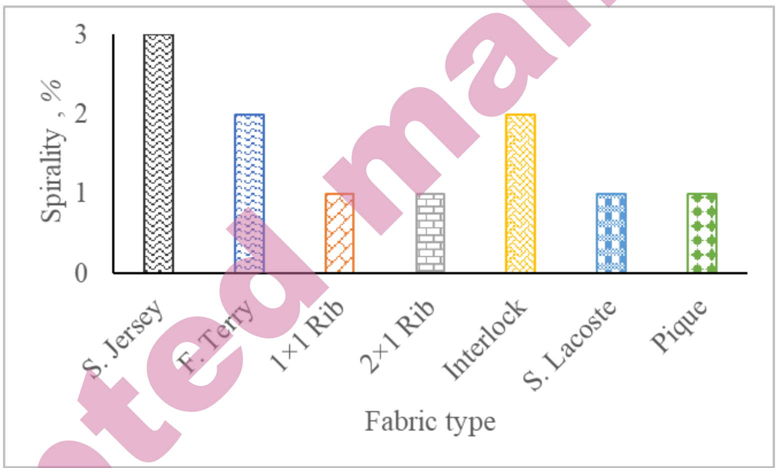

Fig 5. Impact of internal notation on spirality.

CONCLUSION

This study presents a quantitative analysis of quality parameters across various fabric structures, including Plain Jersey, Single Jersey derivatives, Rib, and Interlock. The findings indicate that the quality performance of colored cellulose-based biomaterials is significantly influenced by internal fabric structure, dye type, and shade depth. Despite having the same GSM, variations in dye absorbency were observed due to differences in fabric construction. Visual and spectrophotometric evaluations revealed that Interlock fabric exhibited the highest brightness, followed by 1×1 Rib, while S. Lacoste appeared the dullest. SEM analysis confirmed that S. Lacoste fabric has a grooved surface with prominent microfibrils and a rough texture, contributing to reduced dye absorption. Color fastness to washing (color change) was superior in light shades across all fabric types. However, staining on cotton varied with fabric structure. Dry rubbing fastness was consistent across structures but varied with shade depth, whereas wet rubbing fastness was notably affected by fabric construction. No significant differences were observed in color fastness to light and perspiration. Bursting strength differed significantly across fabric types, attributed to variations in stitch length and loop formation. S. Jersey and Interlock fabrics demonstrated higher bursting strength. Shrinkage and spirality also varied with fabric structure; S. Jersey exhibited the least shrinkage, while S. Lacoste and Pique showed moderate results. Spirality was most favorable in 1×1 and 2×1 Rib fabrics, whereas S. Jersey showed the poorest performance in this regard.

While this study offers valuable insights, certain limitations must be acknowledged. The research did not quantify the actual dye uptake through direct measurement of dye exhaustion or fixation rates. Additionally, statistical analysis, such as standard deviations or confidence intervals, was not incorporated to assess variability across samples. Future studies are encouraged to include detailed dye exhaustion profiles, fixation efficiency, and statistical modeling to deepen understanding of dye–fabric interactions. Expanding the study to include alternative fiber types and environmentally friendly dyeing methods would also support broader applicability and sustainability assessment.

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И З В О Д

УТИЦАЈ ИНТЕРНЕ НОТАЦИЈЕ И ХЕТЕРО БИФУНКЦИОНАЛНИХ РЕАКТИВНИХ БОЈА НА ПЕРФОРМАНСЕ БОЈА, МЕХАНИЧКУ И ДИМЕНЗИОНАЛНУ СТАБИЛНОСТ БИОМАТЕРИЈАЛА НА БАЗИ ЦЕЛУЛОЗЕ

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Фактори унутрашње нотације утичу на квалитет биоматеријала на бази целулозе обојених хетеро бифункционалним реактивним бојама. Различите унутрашње ознаке материјала, као што су Single Jersey, Rib и Interlock утичу на различите параметре обојености као што су прихватање боје, постојаност боје и чврстоћа. Овај истраживачки рад има за циљ да анализира утицај различитих унутрашњих нотација на перформансе боја са хетеро бифункционалним реактивним бојама. Такође намерава да идентификује различите нијансе и факторе унутрашње нотације за постизање конзистентног квалитета боја и трајности у различитим врстама биоматеријала на бази целулозе. Анализирано је седам биоматеријала на бази целулозе са различитим унутрашњим нотацијама (Single Jersey, 1 ×

1 Rib, 2 × 1 Rib, Interlock, French Terry, Single Lacoste, Pique), обојених различитим нивоима уноса боје, као што су светло, средње и тамно. Истрага мери јачину боје, параметре боје (L *, a *, b *, c *, h), површинску морфологију, постојаност боје, механичку чврстоћу, скупљање и спиралност. Стандардизоване методе тестирања и инструменти су коришћени за процену квалитета. Примећено је да унутрашња нотација материјала значајно утиче на упијање боје где је Interlock најсветлији (K / S вредност 11.5). СЕМ анализа је показала површинске разлике у морфологији, што утиче на апсорпцију боје. Отпорност боја варира у зависности од унутрашње нотације тканине, док се снага пуцања разликује у зависности од врсте тканина.

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