ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1716

Performance Assessment of Cotton Single Jersey Knitted Fabrics with Different GSM After Reactive Dyeing

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Publication Date: 2026/06/02

Abstract: Cotton knitted fabrics are widely used in apparel applications due to their comfort, softness, and flexibility. Among the structural parameters of knitted fabrics, fabric GSM plays an important role in determining product performance after wet processing. In this study, the influence of fabric GSM on the fastness and dimensional properties of reactive-dyed 100% cotton single jersey knitted fabric was investigated.

Cotton single jersey knitted fabrics with different GSM values (160, 180, 200, and 220) were subjected to combined scouring and bleaching followed by reactive dyeing under identical laboratory conditions. The dyed fabric samples were evaluated for color fastness to washing, color fastness to rubbing, shrinkage behaviour, and spirality performance according to standard textile testing methods.

The experimental results showed that all reactive-dyed cotton knitted fabric samples exhibited good to excellent washing and rubbing fastness, indicating that variation in fabric GSM had minimal effect on fastness performance. However, dimensional properties showed noticeable variation among the investigated samples. The 200 GSM fabric exhibited the highest lengthwise shrinkage (−4.2%) and spirality (2.2%), while the 160 GSM and 180 GSM samples showed comparatively higher widthwise shrinkage.

The findings suggest that fabric GSM has limited influence on color fastness properties but significantly affects dimensional stability characteristics of reactive-dyed cotton knitted fabric. This study may provide useful guidance for fabric selection and quality control in cotton knitted textile manufacturing.

Keywords: *Cotton Knitted Fabric, Fabric GSM, Reactive Dyeing, Color Fastness, Shrinkage, Spirality.*

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How to Cite: Arifa Fatema; Rahman Md Mahbubur; Hossen Md Mahabub; Md. Mizanur Rahoman; Apu Talukdar; Ahamed Md Tanjil; Pappu Sarker; Md. Shuvo Mia; Abu Raihan; Md. Rezaul Karim (2026) Performance Assessment of Cotton Single Jersey Knitted Fabrics with Different GSM After Reactive Dyeing. *International Journal of Innovative Science and Research Technology*, 11(5), 2837-2845. https://doi.org/10.38124/ijisrt/26may1716

I. INTRODUCTION

Reactive Cotton knitted fabrics are widely used in apparel applications because of their softness, breathability, comfort, and flexibility, making them suitable for casual wear, sportswear, innerwear, and children's garments [1]. Reactive dyes are widely used for cotton dyeing due to their strong affinity for cellulosic fibers and their ability to achieve satisfactory fastness [2]. The performance of reactive dyed cotton knitted fabrics is commonly evaluated through parameters such as color strength, washing fastness, rubbing fastness, perspiration fastness, and other physical performance characteristics, as these properties determine the durability and serviceability of the finished textile during end use and repeated maintenance processes [3-6].

Wet processing treatments, including pretreatment, dyeing, and finishing, significantly influence the physical and performance characteristics of cotton knitted fabrics [7]. Mechanical and post-processing treatments can substantially alter dimensional stability, shrinkage behavior, and fabric mass by inducing structural relaxation and redistributing internal stresses within the knitted structure [8, 9]. Since knitted fabrics possess highly flexible, deformable loop structures, their dimensional behavior after wet processing remains an important quality parameter in apparel manufacturing [10].

Previous experimental studies on knitted cotton fabrics have shown that wet-finishing treatments can significantly affect dimensional properties, such as shrinkage and spirality [11]. Spirality behavior is also influenced by fabric construction, with looser knitted structures exhibiting greater dimensional distortion than more compact constructions [12]. Furthermore, the performance characteristics of reactive-dyed single-jersey cotton knitted fabrics are strongly influenced by structural parameters such as yarn count and post-treatment conditions [13].

Although previous studies have investigated the effects of wet processing, finishing treatments, and structural parameters on the performance of cotton knitted fabrics, limited attention has been given to the specific influence of fabric GSM on the fastness and dimensional properties of reactive-dyed 100% cotton single jersey knitted fabrics under identical processing conditions. Since fabric GSM is an important structural parameter affecting fabric compactness, loop geometry, and dimensional response, understanding its influence is essential for fabric engineering and quality control. Therefore, the present study aims to investigate the effect of different fabric GSM values on the washing fastness, rubbing fastness, shrinkage behavior, and spirality performance of reactive-dyed cotton single jersey knitted fabrics.

Therefore, evaluating the effect of structural variation on the color fastness and dimensional stability of reactive-dyed cotton knitted fabrics remains important for ensuring acceptable fabric quality and performance in practical apparel applications.

II. EXPERIMENTS

A. Materials

The materials used for fabric pretreatment, reactive dyeing, and subsequent performance evaluation included cotton knitted fabric, reactive dyes, and textile auxiliary chemicals. Details of the materials employed in this study are presented in Table 1.

Table 1. Materials Used in the Study.

Material Category	Material Name	Commercial Name / Specification	Function
Fabric	Cotton single jersey knitted fabric	100% cotton; 160, 180, 200, and 220 GSM	Substrate for dyeing
Reactive dye	Reactive Red	Drimaren Ultimate Crimson HD	Dyeing
Reactive dye	Reactive Blue	Drimaren Ultimate Blue HD	Dyeing
Chemical	Glauber salt	Industrial grade	Electrolyte for reactive dyeing
Chemical	Soda ash	Na_2CO_3	Alkali for dye fixation
Chemical	Sodium hydroxide	NaOH	Scouring agent
Chemical	Hydrogen peroxide	H_2O_2	Bleaching agent
Chemical	Wetting agent	Kieralon CDP	Improves wetting
Chemical	Sequestering agent	Lufibrol 2UD	Metal ion control
Chemical	Leveling agent	Dikol SN Liquid	Uniform dye distribution
Chemical	Anti-creasing agent	Laboratory grade	Prevents crease formation
Chemical	Stabilizer	Laboratory grade	Stabilizes bleaching process
Chemical	Acetic acid	Invatex	Neutralization

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B. Equipment

The laboratory equipment used for fabric pretreatment, dyeing, drying, and performance evaluation of the cotton knitted fabric samples are summarized in Table 2.

Table 2 Equipment Used in the Study.

Equipment Category	Equipment Name	Function
Dyeing Equipment	Sample dyeing machine	Fabric pretreatment and reactive dyeing
Drying Equipment	Sample dryer	Drying treated and dyed samples
Measuring Equipment	Electronic balance	Accurate weighing
Testing Equipment	SDL Atlas Rotawash machine	Washing fastness testing
Testing Equipment	James H. Heal Crockmaster	Dry and wet rubbing fastness testing
Testing Equipment	Grey scale	Fastness rating assessment
Testing Equipment	Color matching cabinet	Visual color evaluation
Testing Equipment	Shrinkage measuring template	Dimensional stability measurement
Testing Equipment	Tumble dryer	Sample drying during shrinkage and spirality testing

C. Fabric Pretreatment

Before dyeing, the 100% cotton single jersey knitted fabric samples with different GSM values (160, 180, 200, and 220) were subjected to combined scouring and bleaching to remove natural impurities, waxes, oils, and other non-cellulosic substances, thereby improving fabric absorbency and promoting uniform dye uptake during reactive dyeing.

The pretreatment was carried out under controlled laboratory conditions using a sample dyeing machine. The pretreatment recipe and operating conditions used in this study are presented in Table 3.

Table 3 Recipe for Combined Scouring and Bleaching of Cotton Knitted Fabric.

Chemical / Parameter	Amount
Sodium hydroxide (NaOH)	5 g/L
Hydrogen peroxide (H_2O_2)	5 g/L
Wetting agent	1.5 g/L
Sequestering agent	1.5 g/L
Stabilizer	1.5 g/L
Material-to-liquor ratio	1:10
Temperature	95 °C
Time	60 min

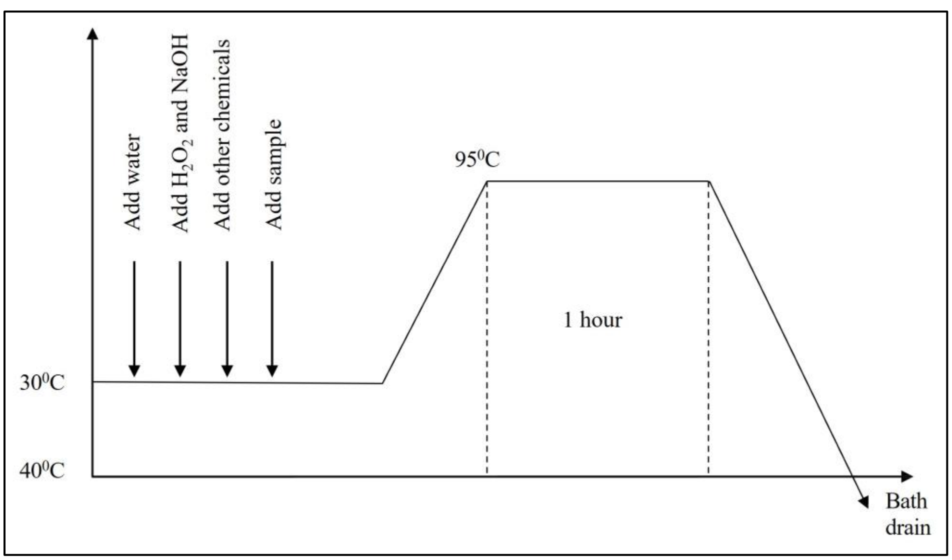

Fig 1 Temperature Profile for Combined Scouring and Bleaching of Cotton Knitted Fabric.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1716

The required amount of water, chemicals, and fabric samples was introduced into the sample dyeing machine, and the combined scouring and bleaching process was carried out according to the temperature profile shown in Fig.1. The treatment was conducted at 95 °C for 60 minutes under controlled alkaline conditions. After completion of pretreatment, the fabric samples were subjected to hot washing, rinsing, and final drying under laboratory conditions before reactive dyeing.

D. Reactive Dyeing Procedure

Following pretreatment, the 100% cotton single jersey knitted fabric samples with different GSM values (160, 180, 200, and 220) were dyed with reactive dyes under controlled laboratory conditions using the same dyeing recipe and processing parameters to evaluate the influence of fabric GSM on fastness and dimensional properties.

The reactive dyeing recipe used in this study is presented in Table 4, and the corresponding process temperature profile is shown in Fig.2.

Table 4 Reactive Dyeing Recipe for Cotton Knitted Fabric.

Component	Amount
Reactive Red	0.027%
Reactive Blue	0.0011%
Glauber salt	10 g/L
Soda ash	5 g/L
Leveling agent	0.03 g/L
Anti-creasing agent	0.5 g/L
Sequestering agent	0.2 g/L
Temperature	60 °C
Time	60 min
Material-to-liquor ratio	1:10
Sample weight	10 g

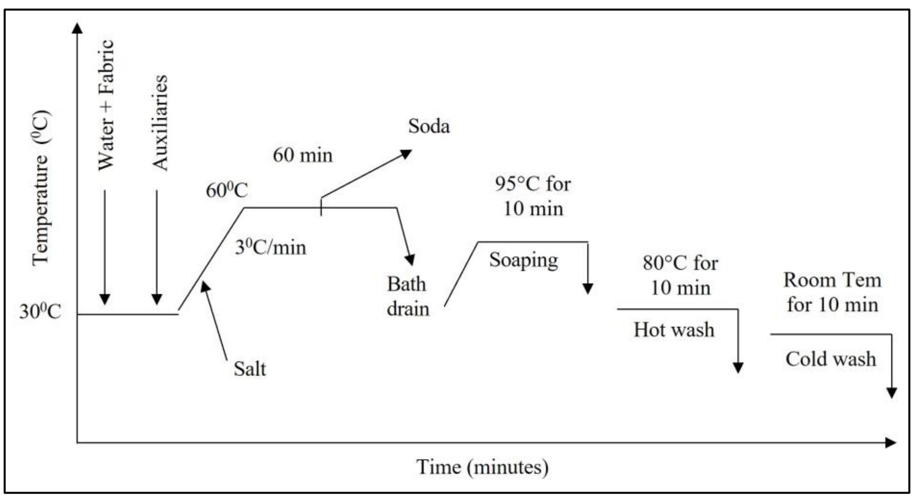

Fig 2 Process Temperature Profile for Reactive Dyeing of Cotton Knitted Fabric.

The required amount of water, reactive dyes, auxiliary chemicals, and fabric samples were introduced into the sample dyeing machine. The dyeing process was initiated under controlled conditions, and the temperature was gradually raised to 60 °C. After the initial dyeing stage, soda ash was added to establish alkaline conditions and promote fixation of the reactive dyes onto the cotton fiber.

Upon completion of the dyeing cycle, the dyed fabric samples were subjected to soaping, followed by hot washing, cold washing, and final drying under laboratory conditions before testing.

E. Testing Methods

- ➤ *Color Fastness to Washing*

Color fastness to washing of the reactive-dyed cotton knitted fabric samples was evaluated according to BS EN ISO 105-C06:2010 (B2S) using an SDL Atlas Rotawash machine. Dyed fabric specimens measuring 10 cm × 4 cm were stitched with adjacent multifiber fabric and conditioned before testing.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1716

The washing solution consisted of 4 g/L ECE detergent and 1 g/L sodium perborate prepared in distilled water. For each test, the required amount of washing solution, along with stainless steel balls, was placed in the test container to simulate the washing action. The specimens were tested at 50 °C for 30 minutes, then rinsed with water and dried under laboratory conditions. The washed specimens were evaluated for color change and staining using the standard grey scale rating system.

➢ *Color Fastness to Rubbing*

Color fastness to rubbing (dry and wet) of the reactive-dyed cotton knitted fabric samples was evaluated according to BS EN ISO 105-X12:2001 using a James H. Heal Crockmaster rubbing fastness tester. Dyed fabric specimens measuring 15 cm × 5 cm were tested against a standard white cotton rubbing cloth measuring 5 cm × 5 cm.

The rubbing test was carried out using a 16 mm diameter rubbing finger with a stroke length of 104 ± 3 mm under an applied downward force of 9 N. Each specimen was subjected to 10 rubbing cycles under both dry and wet conditions. For wet rubbing assessment, the rubbing cloth was wetted with distilled water before testing. After completion of the test, the degree of color staining on the rubbing cloth was evaluated using the standard grey-scale for staining.

➢ *Shrinkage Test*

The dimensional stability of the reactive-dyed cotton knitted fabric samples was evaluated using shrinkage testing in accordance with ISO 6330. Fabric specimens were marked using a standard shrinkage-measuring template before washing to determine their original dimensions in both the lengthwise and widthwise directions.

The marked specimens were washed under controlled conditions, then dried and conditioned in the laboratory. After drying, the dimensional changes in both directions were measured, and the shrinkage percentage was calculated from the difference between the initial and final dimensionss.

➢ *Spirality Test*

The spirality behavior of reactive-dyed cotton knitted fabric samples was evaluated in accordance with ISO 16322. Fabric specimens were prepared and washed, then tumble-dried under controlled conditions. After conditioning, the displacement of the wale direction from its original perpendicular alignment was measured.

The spirality percentage was calculated from the displacement of the wale direction relative to the measured fabric dimensions, and the results were used to assess the effect of fabric GSM on spirality behavior.

III. RESULTS AND DISCUSSIONS

A. Color Fastness to Washing

The color fastness to washing performance of the reactive-dyed cotton single jersey knitted fabric samples with different GSM values was evaluated in terms of color change and color staining, and the results are presented in Table 5 and Fig.3.

Table 5 Color Fastness to Washing of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

GSM	Color Change	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
160	4–5	4–5	4–5	4	4	4–5	4
180	4–5	4–5	4–5	4	4–5	4–5	4
200	4	4–5	4–5	4–5	4–5	4–5	4
220	4	4–5	4–5	4	4–5	4–5	4

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1716

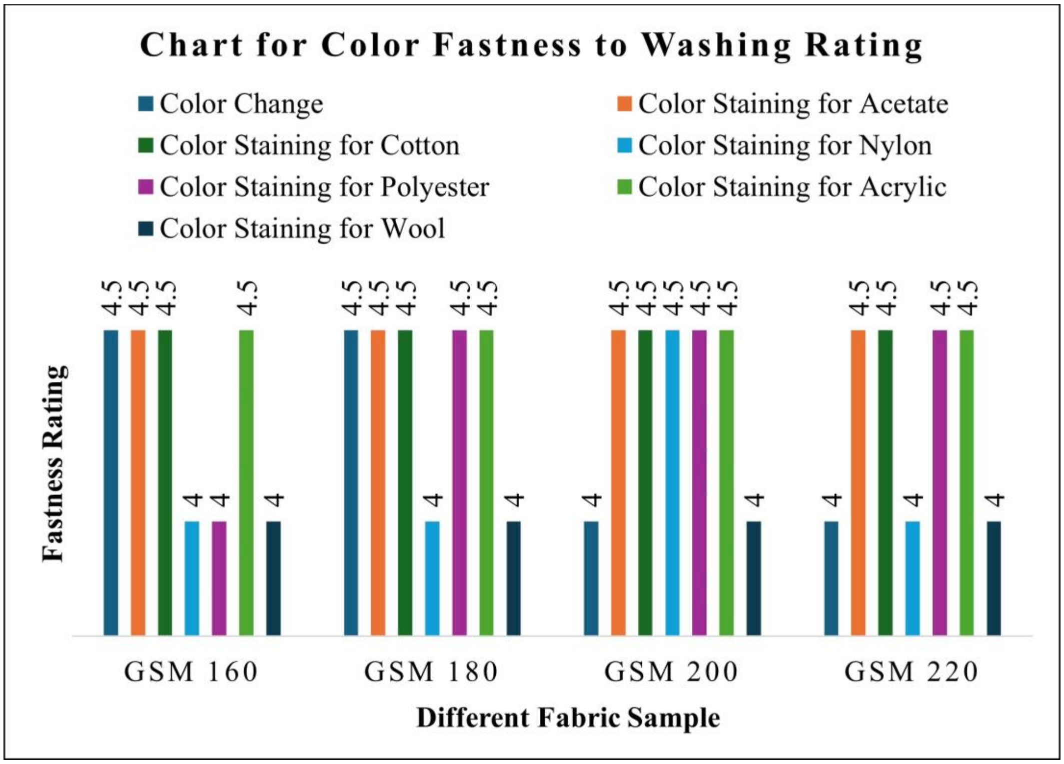

Fig 3 Color Fastness to Washing Performance of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

The washing fastness results indicate that all dyed cotton knitted fabric samples exhibited satisfactory resistance to color change, with ratings ranging from 4 to 4–5 across all investigated GSM values.

The 160 GSM and 180 GSM fabric samples showed color change ratings of 4–5, whereas the 200 GSM and 220 GSM samples exhibited a rating of 4, indicating only slight variation in washing durability.

In terms of color staining, the dyed fabric samples demonstrated satisfactory performance against all adjacent multifiber components. The staining ratings for acetate, cotton, and acrylic fabrics remained at 4–5, while nylon and polyester showed ratings of 4–5. The adjacent wool fabric consistently received a rating of 4 across all GSM conditions.

Overall, the findings indicate that variation in fabric GSM had minimal influence on the washing fastness performance of the reactive-dyed cotton knitted fabrics.

B. Color Fastness to Rubbing

The color fastness to rubbing performance of the reactive-dyed cotton single jersey knitted fabric samples with different GSM values was evaluated under both dry and wet rubbing conditions, and the results are presented in Table 6 and Fig.4.

Table 6 Color Fastness to Rubbing of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

Fabric GSM	Dry Rubbing Rating	Wet Rubbing Rating
160	4–5	4
180	4–5	4
200	4–5	4
220	4–5	4

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1716

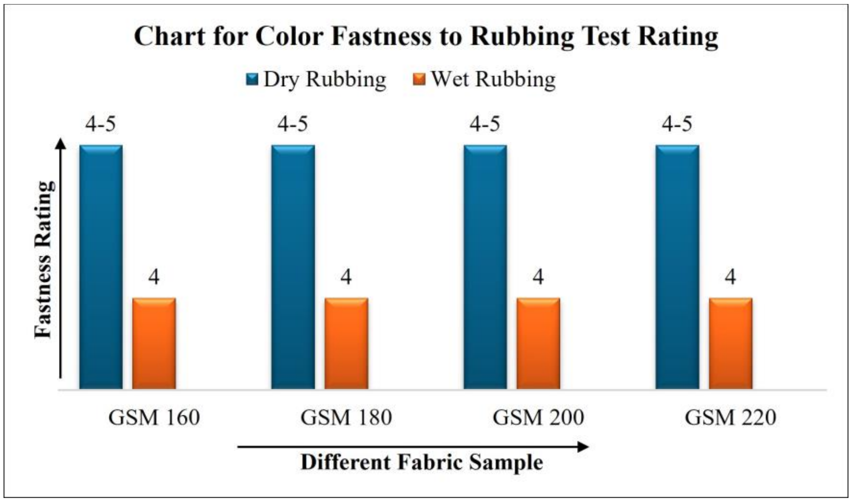

Fig 4 Color Fastness to Rubbing Performance of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

The results indicate that all dyed cotton knitted fabric samples exhibited satisfactory rubbing fastness performance under both dry and wet conditions.

Under dry rubbing conditions, all investigated fabric samples showed a consistent rating of 4–5, indicating minimal variation in color transfer behavior across fabric GSMs.

Under wet rubbing conditions, all samples received a rating of 4, slightly lower than their dry rubbing performance. This reduction may be attributed to the increased mobility of loosely bound dye molecules in the presence of moisture, which can facilitate dye transfer during rubbing action.

However, no significant variation was observed among the investigated GSM samples under either dry or wet rubbing conditions, suggesting that fabric GSM had minimal influence on the rubbing fastness performance of the reactive-dyed cotton knitted fabrics.

C. Shrinkage Analysis

The shrinkage behavior of reactive-dyed cotton single jersey knitted fabric samples with different GSM values was evaluated in both the lengthwise and widthwise directions, and the results are presented in Table 7. A comparative graphical representation of shrinkage and spirality behavior is shown in Fig.5.

Table 7 Shrinkage Behaviour of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

Fabric GSM	Lengthwise Shrinkage (%)	Widthwise Shrinkage (%)
160	-1.1	-5.7
180	-2.2	-5.8
200	-4.2	-2.2
220	-1.4	-2.8

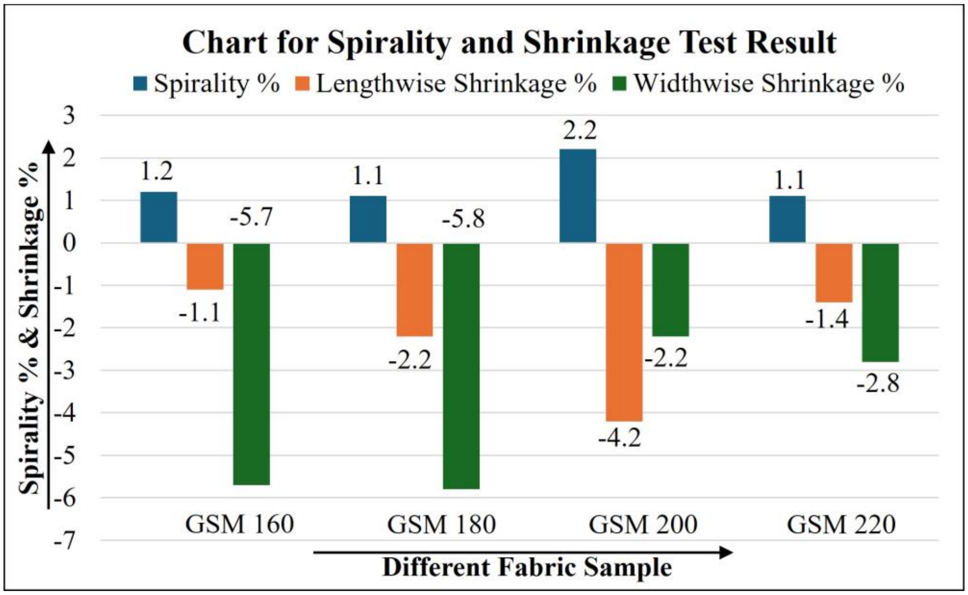

Fig 5 Shrinkage Behaviour of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

The results indicate that fabric GSM had a noticeable influence on the dimensional stability of the dyed cotton knitted fabrics. Variations in both lengthwise and widthwise shrinkage were observed among the investigated GSM samples.

In the lengthwise direction, the 200 GSM fabric exhibited the highest shrinkage value of −4.2%, indicating comparatively lower dimensional stability under washing conditions. The 180 GSM sample showed moderate shrinkage (−2.2%), whereas the 160 GSM and 220 GSM fabrics demonstrated relatively lower shrinkage values of −1.1% and −1.4%, respectively.

In the widthwise direction, the 160 GSM and 180 GSM fabrics exhibited comparatively higher shrinkage of −5.7% and −5.8%, respectively, whereas the 200 GSM and 220 GSM samples showed improved dimensional stability with lower shrinkage of −2.2% and −2.8%, respectively.

This variation in shrinkage behavior may be attributed to differences in fabric structural characteristics associated with GSM, including loop density, fabric compactness, and yarn arrangement, which influence the relaxation and dimensional recovery behavior of knitted fabrics after wet processing.

Overall, the findings suggest that GSM of the fabric significantly affects the shrinkage performance of reactive-dyed cotton knitted fabrics, particularly in the widthwise direction.

D. Spirality Analysis

The spirality behaviour of the reactive-dyed cotton single jersey knitted fabric samples with different GSM values was evaluated, and the results are presented in Table 8. The comparative graphical representation is shown in Fig.5.

Table 8 Spirality Behaviour of Reactive-Dyed Cotton Knitted Fabric with Different GSM.

Fabric GSM	**Spirality (%)**
160	1.2
180	1.1
200	2.2
220	1.1

The results indicate that fabric GSM influenced the spirality behavior of the dyed cotton knitted fabric samples to some extent. Among the investigated samples, the 200 GSM fabric exhibited the highest spirality value of 2.2%, indicating greater distortion of the wale alignment after wet processing.

In contrast, the 180 GSM and 220 GSM fabric samples showed the lowest spirality value of 1.1%, while the 160 GSM sample exhibited a slightly higher value of 1.2%.

The variation in spirality behavior may be attributed to differences in fabric structure, loop configuration, and yarn relaxation characteristics associated with different fabric GSM values. Since spirality in knitted fabrics is closely related to loop geometry and yarn torque, structural variation resulting from changes in fabric compactness can influence the final spirality performance after washing and drying.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may1716

However, the overall spirality values remained relatively low for all samples, indicating acceptable dimensional stability of the reactive-dyed cotton knitted fabrics under the applied processing conditions.

Overall, the findings suggest that fabric GSM has a moderate influence on spirality behavior, with the 200 GSM sample showing comparatively higher spirality than the other investigated fabric samples.

IV. CONCLUSIONS

The present study investigated the influence of fabric GSM on the fastness and dimensional properties of reactive-dyed 100% cotton single jersey knitted fabric. Cotton knitted fabrics with different GSM values (160, 180, 200, and 220) were subjected to identical pretreatment, reactive dyeing, and performance evaluation under controlled laboratory conditions.

The experimental results revealed that fabric GSM had minimal influence on color fastness properties. All dyed fabric samples exhibited good to excellent washing and rubbing fastness, indicating satisfactory dye fixation and acceptable durability across GSM variations.

However, noticeable variation was observed in dimensional properties. The shrinkage results showed significant differences in both lengthwise and widthwise dimensional stability among the investigated samples, indicating that fabric GSM affects relaxation behavior after wet processing. Similarly, variations in spirality behavior were also observed, with the 200 GSM sample showing comparatively higher spirality than the other samples.

Overall, the findings suggest that while fabric GSM has a limited impact on color fastness, it plays a more significant role in determining the dimensional stability of reactive-dyed cotton knitted fabrics. This study may be useful to textile manufacturers in selecting an appropriate fabric GSM to achieve improved dimensional performance in cotton knitted products.

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