



EFFECTS OF SHEATH FIBER CHARACTERISTICS ON CORE-SPUN YARN PERFORMANCE: A COMPARATIVE ANALYSIS

Kozimjon Sotvoldiyev, Xusanxon Bobojanov
Namangan State Technical University, Uzbekistan

Abstract. Core-spun yarns combine continuous filament cores with staple fiber sheaths, offering superior mechanical properties for textile applications. This study investigates how sheath fiber characteristics influence key yarn quality parameters. Three cotton types with varying length and fineness (Cotton A: 20 mm/4.5 Micronaire, Cotton B: 26 mm/3.8 Micronaire, Cotton C: 32 mm/3.2 Micronaire) were used as sheaths on 75-denier polyester cores. Testing revealed that long, fine fibers (Cotton C) achieved the best performance: tensile strength 28.5 cN/tex, hairiness $S_3=3.2$, evenness $CV\%=9.5$, and abrasion resistance 16,800 cycles. Short, coarse fibers (Cotton A) showed inferior results: 22.1 cN/tex, $S_3=5.8$, $CV\%=12.3$, and 11,500 cycles. Long fibers enhance inter-fiber cohesion and anchoring efficiency, while fine fibers improve packing density and surface smoothness. Optimal sheath parameters are length ≥ 32 mm, fineness ≤ 3.2 Micronaire, strength ≥ 28 cN/tex, with high uniformity. These findings provide practical guidance for manufacturers selecting sheath fibers for high-quality core-spun yarn production.

Keywords: Core-spun yarn, sheath fibers, cotton, tensile strength, hairiness, abrasion resistance.

The textile industry continuously seeks innovations that balance strength, comfort, and durability. Core-spun yarns address this need through their unique structure where a synthetic filament core is wrapped with staple fibers. This configuration provides the mechanical strength of synthetics with the aesthetic qualities of natural fibers (Ismailov et al., 2020; Sotvoldiyev et al., 2025). The sheath fibers, as the outer layer, critically determine yarn surface properties, handle, and functional attributes including moisture management and dyeability (Das et al., 2018; Zhang & Wang, 2020). Previous research has examined fiber migration patterns, twist optimization, and material comparisons, yet systematic analysis of sheath fiber length and fineness effects on comprehensive quality parameters remains limited. Understanding these relationships is essential for optimizing yarn production for specific applications. This study aims to analyze the influence of cotton sheath fiber



length and fineness on core-spun yarn tensile strength, hairiness, evenness, and abrasion resistance.

Core filament: 75-denier polyester continuous filament. Sheath fibers: three cotton types with distinct characteristics: Cotton A (short, coarse: 20 mm, 4.5 Micronaire), Cotton B (medium: 26 mm, 3.8 Micronaire), Cotton C (long, fine: 32 mm, 3.2 Micronaire). A sheath-to-core ratio of 95:5 was maintained.

Core-spun yarns were produced on a modified ring spinning frame. Testing methods: Uster Tensorapid for tensile strength (ASTM D2256); Uster Zweigle Hairiness Tester for S3 values; Uster Tester 6 for evenness (CV%); Martindale tester for abrasion resistance (ISO 12947). All measurements conducted on multiple samples with standard deviations calculated.

Table 1. Core-spun yarn properties with different sheath fibers

Property	Cotton A (20 mm, 4.5 Mic)	Cotton B (26 mm, 3.8 Mic)	Cotton C (32 mm, 3.2 Mic)
Tensile Strength (cN/tex)	22.1 ± 0.8	25.3 ± 0.6	28.5 ± 0.7
Elongation (%)	8.2 ± 0.3	7.5 ± 0.2	6.8 ± 0.2
Hairiness (S3)	5.8 ± 0.4	4.2 ± 0.3	3.2 ± 0.2
Evenness (CV%)	12.3 ± 0.5	10.7 ± 0.4	9.5 ± 0.3
Abrasion (cycles)	11,500 ± 500	15,200 ± 600	16,800 ± 700

Long, fine fibers (Cotton C) achieved 29% higher tensile strength (28.5 cN/tex) than short, coarse fibers (22.1 cN/tex). This improvement results from enhanced inter-fiber cohesion through increased contact area and frictional resistance. Longer fibers provide greater fiber overlap, distributing loads effectively and reducing stress concentrations (Das et al., 2018). Fine fibers increase packing density, allowing more fibers per cross-section and better fiber-to-fiber bonding. Well-aligned long fibers bear tensile loads efficiently, minimizing lateral force components. Elongation showed inverse relationship: Cotton C 6.8%, Cotton A 8.2%, reflecting the strength-extensibility trade-off.

Hairiness (S3) improved by 45% with long, fine fibers (3.2 vs. 5.8). Long fibers are effectively anchored through multiple binding points, reducing protruding ends. Fine fibers create smoother surfaces through enhanced packing density, trapping fibers effectively (Özdil & Süpüren, 2017; Militky et al., 2020). Controlled fiber migration in long, fine fibers reduces surface protrusions. Reduced hairiness improves weaving performance, fabric appearance, comfort, and dyeing uniformity.

CV% improved by 23% (9.5 vs. 12.3) with long, fine fibers. Short fibers create irregular mass accumulation due to limited continuous structure formation. Coarse fibers show higher diameter variability. Long fibers provide continuous mass distribution, while fine fibers maintain tighter diameter control and better processing stability. Improved evenness enhances fabric appearance, strength uniformity, dyeing consistency, and processing efficiency.

Abrasion resistance increased by 46% with long, fine fibers (16,800 vs. 11,500 cycles). Long fibers resist pull-out through extensive anchoring, requiring greater force for extraction. Fine fibers create dense, cohesive surfaces preventing abrasion penetration. Reduced friction from smooth surfaces minimizes wear. Inter-fiber cohesion maintains structural integrity, distributing abrasion forces across multiple fibers. These properties make long, fine sheath fibers ideal for high-durability applications including activewear, technical textiles, and automotive fabrics.

Conclusion. This study demonstrates that sheath fiber length and fineness critically determine core-spun yarn quality. Long, fine cotton fibers (32 mm, 3.2 Micronaire) significantly outperform short, coarse fibers across all measured parameters: tensile strength +29%, hairiness -45%, evenness -23%, abrasion resistance +46%. Long fibers enhance inter-fiber cohesion and anchoring efficiency, while fine fibers improve packing density and surface smoothness. Optimal sheath fiber parameters are: length ≥ 32 mm, fineness ≤ 3.2 Micronaire, strength ≥ 28 cN/tex, and high uniformity. These findings provide manufacturers with clear guidance for selecting sheath fibers to achieve high-performance core-spun yarns for premium textile applications.

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