



EFFECT OF AN IMPROVED FINE-IMPURITY
COTTON CLEANER ON HVI FIBER QUALITY
PARAMETERS OF MACHINE-HARVESTED S-6524
COTTON

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ABSTRACT

Machine harvesting increases the need for effective seed-cotton cleaning because leaves, bracts, stems and mineral particles may enter the harvested mass together with open-boll cotton. At the same time, excessive mechanical action during drying, cleaning, ginning and lint cleaning can reduce fiber length uniformity, increase short-fiber content and lower the commercial value of lint. This study evaluates the HVI fiber-quality response of S-6524 cotton after cleaning with an improved fine-impurity cleaner and compares the results with three existing-process tests and the natural-fiber reference. The HVI 900-SA dataset included upper-half mean length (UHML), uniformity index (Unf), short fiber index (SFI), micronaire (Mic), elongation (Elg), strength (Str), reflectance (Rd), yellowness (+b), trash code (Trash), trash particle count (Cnt), and trash area (Area). The improved cleaning variant produced UHML 1.12 in, Unf 79.2%, SFI 7.0%, Mic 3.8, Elg 6.7%, Str 28.3 g/tex, Rd 70.2%, +b 10.6, Trash 4.4, Cnt 10, and Area 0.6%. Compared with the descriptive mean of the three existing-process tests, the improved variant increased Unf by approximately 5.25%, reduced SFI by 4.55%, reduced Cnt by 11.76%, and reduced Area by 18.18%, while UHML, Mic, Elg and Str remained close to the conventional values. The results support the technological principle that fine-impurity removal should be intensified through rational



working-element geometry rather than excessive mechanical loading. The manuscript also defines the additional harvesting and replication metadata required before final international-journal submission.

1. INTRODUCTION

Mechanization of cotton harvesting reduces dependence on manual labor and increases field productivity, but it also changes the composition of the raw material delivered to the gin. A spindle picker selectively removes seed cotton from open bolls and generally introduces less unwanted vegetative material than a non-selective stripper, whereas stripper systems can collect leaves, sticks, immature bolls and other plant fragments together with seed cotton [1]. Therefore, the exact harvesting mechanism is an important experimental factor when machine-harvested cotton is evaluated.

Foreign matter accumulated during machine harvesting must be removed before and during ginning. This requirement creates a technological compromise: cleaning improves the purity and marketability of cotton, yet unnecessary mechanical treatment can damage fibers. Hardin et al. reported that higher fiber moisture at the gin stand better preserves fiber length and strength, while somewhat lower moisture can improve cleaning efficiency; they consequently recommend the minimum drying and lint cleaning needed to achieve the required quality [2]. Research on machine-harvested cotton has likewise shown that repeated lint cleaning can reduce fiber length and substantially increase short-fiber index [3], while seed-cotton cleaning can affect strength depending on leaf adhesiveness and cleanability [4].

S-6524 is a medium-staple *Gossypium hirsutum* L. cultivar widely used as a standard or reference variety in Uzbekistan. Published breeding literature reports that it was developed from the hybridization of 159-F with a semi-wild *G. hirsutum* ssp. *punctatum* source and has been included in the state register since 1988. The reported growing period is approximately 125 days, plant height 100–110 cm, boll mass 5.5–6.5 g, 1000-seed mass 125–135 g, and fiber output 33.5–34.5%. Its fiber is classified as textile type IV, with micronaire 4.3–4.6, UHML 1.12–1.15 in and relative breaking strength around 27.7 g/tex [5]. A 2017 ICAC publication similarly listed S-6524 with micronaire 4.5, staple length 34.1 mm, fiber outturn 33.5–34.5%, and raw-cotton yield 4.0–4.6 t/ha [6].

The suitability of S-6524 for cleaning research is also supported by Uzbekistan-based studies. Recent work on 5DP-130 gin feeder-cleaners used S-6524 in industrial tests and documented the relationship among initial moisture, contamination, cleaning efficiency and the contamination level of cotton delivered to the gin [7]. Dissertation-level research has also used S-6524 to evaluate improved mesh surfaces and peg-drum cleaning systems for fine impurities [8,9].



The purpose of the present study is to evaluate how an improved fine-impurity cleaning process influences the HVI fiber-quality profile of S-6524 cotton and to establish an internationally structured IMRAD manuscript for the machine-harvested treatment. The principal hypothesis is that an improved working-element interaction can lower residual trash indicators while preserving the principal physical and mechanical properties of the fiber.

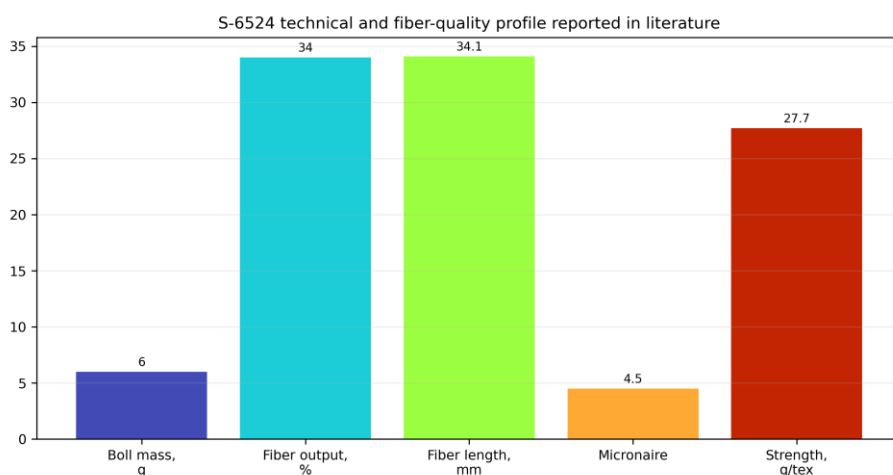


Figure 1. Literature-based technical and fiber-quality profile of the S-6524 cultivar. Range values are represented by central values only for visualization; the original literature ranges are reported in the text.

2. MATERIALS AND METHODS

2.1. Raw material and experimental context. The study focuses on S-6524 cotton and the processing pathway relevant to machine-harvested seed cotton. The available laboratory source identifies the tested fiber as industrial grade III, class “Medium,” and reports HVI 900-SA measurements after the existing cleaning–ginning–fiber-cleaning process, after the new peg-drum cleaning variant, and for natural fiber. The source does not independently record the harvester make/model for every HVI row. Accordingly, the machine-harvested framing of this paper should be finalized by adding the field protocol identifying harvester type, harvest date, initial seed-cotton moisture, foreign-matter content, sample mass and replicate structure.

2.2. Improved fine-impurity cleaner. The technological concept is based on replacing the conventional straight peg interaction with an improved fork-shaped peg working element in the fine-impurity cleaning zone. The design objective is to increase opening and redistribution of seed cotton over the mesh surface, improve the probability of fine-particle separation, and avoid excessive impact loading on the fiber–seed mass. The cleaner is assessed through downstream HVI indicators rather than through cleaning efficiency alone.

2.3. HVI testing. Fiber samples were evaluated using the HVI 900-SA laboratory system. The analyzed parameters were UHML (upper-half mean length), Unf (uniformity index), SFI (short fiber index), Mic (micronaire), Elg (elongation), Str (strength), Rd (reflectance), +b



(yellowness), Trash (trash code), Cnt (number of detected trash particles) and Area (trash area). The supplied source defines Cnt as the number of individual trash particles at least 0.01 in (0.25 mm) in diameter and Area as the total scanned trash-particle area expressed relative to the sample surface.

2.4. Data analysis. All three existing-process columns were retained rather than selecting a single conventional row. Their arithmetic mean was calculated only as a descriptive comparator; the three columns are not called statistical replicates because the source does not explicitly establish that experimental status. Relative change was calculated as $\Delta = (X_{\text{improved}} - X_{\text{existing mean}}) / X_{\text{existing mean}} \times 100\%$. No inferential p-values were generated. A final international submission should use independent replicate-level observations and report mean $\pm$ SD, confidence intervals, ANOVA or an equivalent model as appropriate.

Table 1. Published technical and physical–mechanical characteristics of S-6524

Indicator	Published value / range	Source
Growing period	~125 days	Cotton breeding and seed production
Plant height	100–110 cm	Cotton breeding and seed production
Boll mass	5.5–6.5 g	Cotton breeding and seed production
1000-seed mass	125–135 g	Cotton breeding and seed production
Fiber output	33.5–34.5%	Cotton breeding and seed production / ICAC
Fiber length / UHML	34.1 mm; 1.12–1.15 in	ICAC / breeding literature
Micronaire	4.3–4.6 (4.5 in ICAC table)	Breeding literature / ICAC
Relative breaking strength	~27.7 g/tex	Cotton breeding and seed production



Figure 2. Preparation and visual assessment of cotton/fiber samples in the Research Institute of Fiber Crops laboratory.

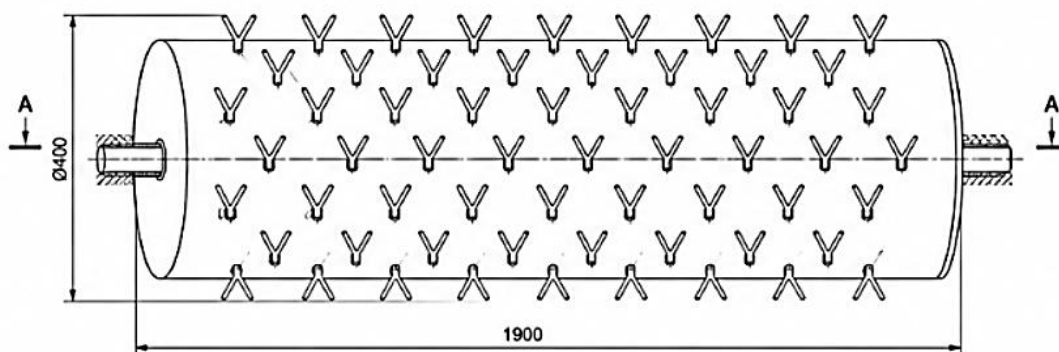


Figure 3. Improved cotton peeling machine from fine impurities of the new design

3. RESULTS

Table 2 presents the complete HVI dataset supplied for S-6524. The natural-fiber reference had UHML 1.15 in, Unf 79.6%, SFI 5.6%, Mic 3.9, Elg 6.9%, Str 29.4 g/tex, Rd 74.4%, +b 8.9, Trash 4.2, Cnt 5 and Area 0.4%. The improved peg-drum treatment yielded UHML 1.12 in, Unf 79.2%, SFI 7.0%, Mic 3.8, Elg 6.7%, Str 28.3 g/tex, Rd 70.2%, +b 10.6, Trash 4.4, Cnt 10 and Area 0.6%.



Table 2. HVI 900-SA quality indicators of S-6524 fiber

HVI parameter	Unit	Existi ng 1	Existi ng 2	Existi ng 3	Existi ng mean	Impro ved cleaner	Natu ral
UHML	in	1.12	1.11	1.12	1.12	1.12	1.15
Unf	%	74.80	74.60	76.40	75.27	79.20	79.60
SFI	%	7.00	7.60	7.40	7.33	7.00	5.60
Mic	—	3.80	3.90	3.80	3.83	3.80	3.90
Elg	%	6.60	6.80	6.60	6.67	6.70	6.90
Str	g/tex	28.20	28.30	27.80	28.10	28.30	29.40
Rd	%	69.20	70.00	70.20	69.80	70.20	74.40
+b	—	10.80	10.60	11.20	10.87	10.60	8.90
Trash	code	4.60	4.60	4.40	4.53	4.40	4.20
Cnt	count	11	12	11	11.33	10	5
Area	%	0.80	0.70	0.70	0.73	0.60	0.40

The descriptive mean of the three existing-process tests was UHML 1.117 in, Unf 75.27%, SFI 7.33%, Mic 3.83, Elg 6.67%, Str 28.10 g/tex, Rd 69.80%, +b 10.87, Trash 4.53, Cnt 11.33 and Area 0.73%. Relative to this mean, the improved cleaner increased Unf by 5.25%, reduced SFI by 4.55%, increased Str by 0.71%, increased Rd by 0.57%, reduced Trash by 2.94%, reduced Cnt by 11.76%, and reduced Area by 18.18%. UHML and Mic changed only slightly.

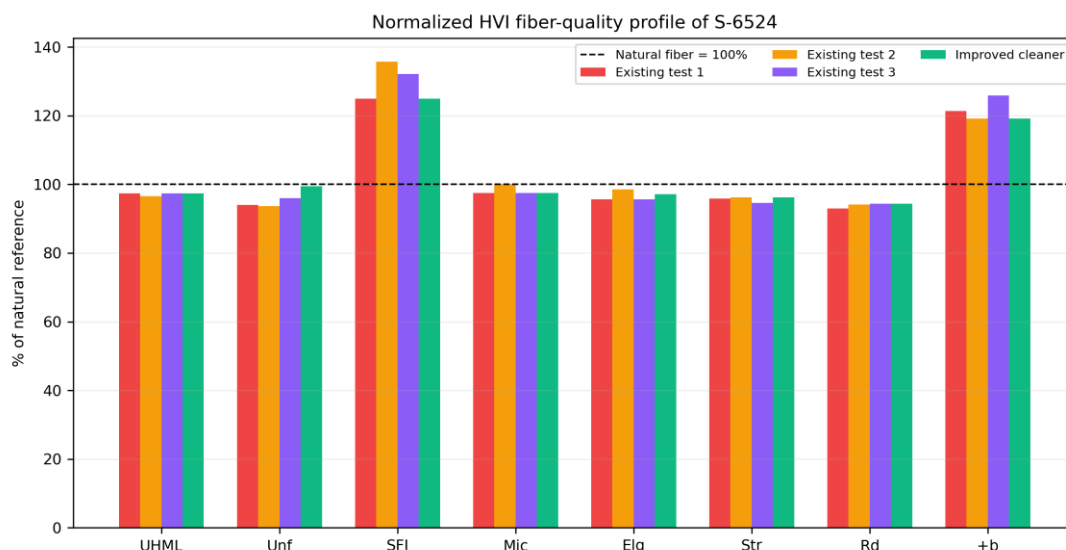


Figure 4. Normalized HVI physical and mechanical quality indicators for S-6524. Each value is expressed relative to the natural-fiber reference (100%).

The figure presents the normalized HVI fiber-quality parameters of S-6524 cotton obtained from three existing cleaning-process tests and the improved cleaning treatment, with the natural fiber properties taken as the 100% reference level. The results indicate that the improved cleaner



provides better preservation of fiber uniformity (Unf) compared with the existing cleaning variants, approaching the natural-fiber reference. The Short Fiber Index (SFI) remains above the natural-fiber level for all processed samples; however, the improved treatment shows a lower SFI than the average tendency observed for the existing cleaning process, indicating reduced formation of short fibers. UHML, micronaire (Mic), elongation (Elg), and strength (Str) remain relatively close among the processing variants, suggesting that the improved cleaning action does not cause substantial deterioration of the principal physical and mechanical properties of the fiber. Reflectance (Rd) also remains comparatively stable. The normalized yellowness (+b) values exceed the natural-fiber reference, indicating that color characteristics are more sensitive to processing and the initial condition of the raw cotton. Overall, the HVI profile suggests that the improved fine-impurity cleaner enhances fiber uniformity and limits short-fiber formation while maintaining the major quality characteristics of S-6524 cotton.

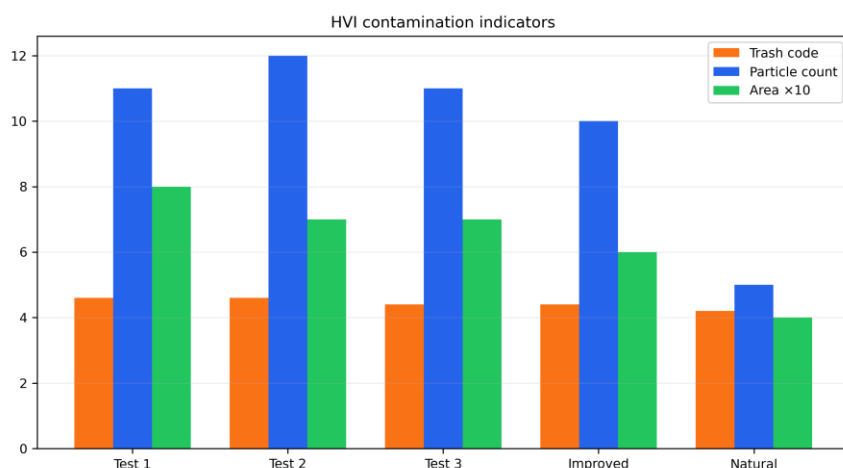


Figure 5. HVI trash indicators for the three existing-process tests, improved cleaner and natural fiber. Area is multiplied by 10 only to improve visual comparability.

The figure compares the HVI contamination indicators of S-6524 cotton fiber obtained from three existing cleaning-process tests, the improved fine-impurity cleaning treatment, and the natural-fiber reference. The results show that the improved cleaner reduced all three contamination indicators compared with the descriptive mean of the existing-process tests. The Trash Code decreased from approximately 4.53 to 4.40, corresponding to a reduction of about 2.9%, while the particle count (Cnt) decreased from 11.33 to 10, representing an improvement of approximately 11.8%. The most pronounced change was observed for Trash Area (Area), which decreased from an average of approximately 0.73% to 0.60%, equivalent to a reduction of about 18.2%. In the figure, the Area values are multiplied by 10 solely for visualization and therefore should not be interpreted as the actual measured percentage values. Although the contamination indicators of the improved treatment remain higher than those of the natural-fiber reference, their consistent reduction relative to the existing cleaning process indicates more effective removal of residual fine impurities. These results suggest that the improved cleaning



system can enhance the cleanliness of S-6524 cotton fiber while avoiding excessive mechanical treatment of the fiber mass.

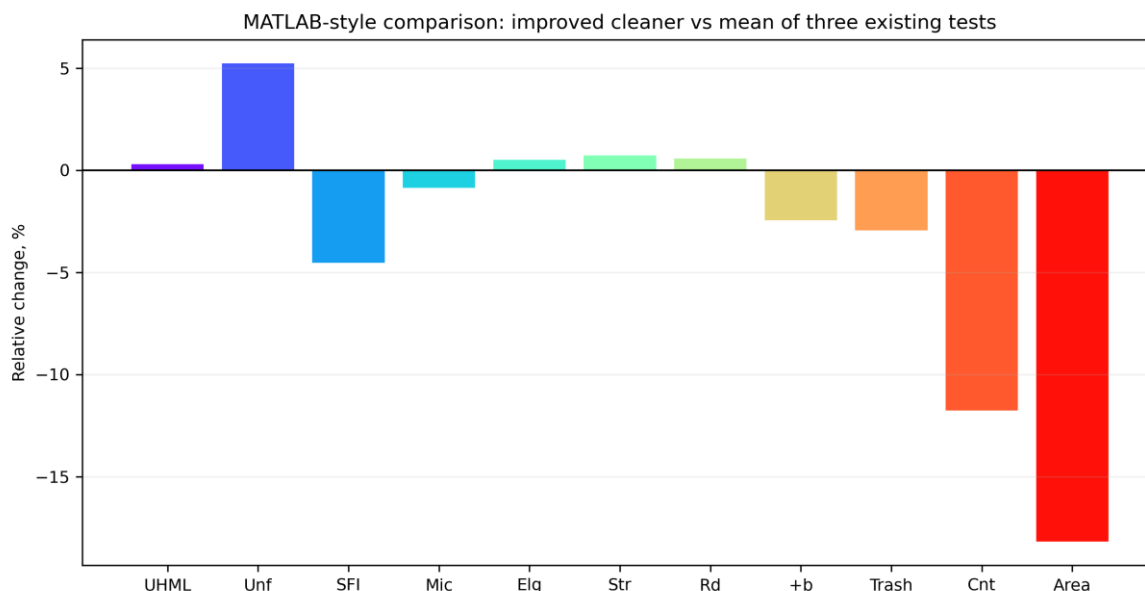


Figure 6. MATLAB-style relative-change analysis of the improved cleaner versus the descriptive mean of the three existing-process tests.

The figure illustrates the relative changes in the principal HVI quality parameters obtained with the improved fine-impurity cleaner compared with the descriptive mean of the three existing cleaning-process tests. The most notable positive change was observed in the Uniformity Index (Unf), which increased by approximately 5.25%, indicating a more uniform fiber-length distribution after the improved cleaning treatment. At the same time, the Short Fiber Index (SFI) decreased by approximately 4.55%, which is technologically favorable because a lower SFI indicates a smaller proportion of short fibers in the tested material.

The principal physical and mechanical properties of the fiber remained comparatively stable. UHML increased only slightly, while micronaire (Mic) showed a minor decrease of less than 1%. Elongation (Elg), fiber strength (Str), and reflectance (Rd) exhibited small positive changes, indicating that the improved cleaning process did not cause substantial deterioration of the main fiber-quality characteristics. The decrease in +b indicates a lower yellowness value relative to the mean of the existing-process tests.

A more pronounced improvement was observed in the contamination-related HVI parameters. The Trash Code decreased by approximately 2.9%, the trash particle count (Cnt) by approximately 11.8%, and the Trash Area (Area) by approximately 18.2%. Since lower Trash, Cnt, Area and SFI values are desirable, their negative relative changes in the diagram represent an improvement rather than deterioration. Overall, the results indicate that the improved fine-impurity cleaner provides more effective removal of residual contaminants while maintaining the principal length, fineness, elongation and strength characteristics of S-6524 cotton fiber.

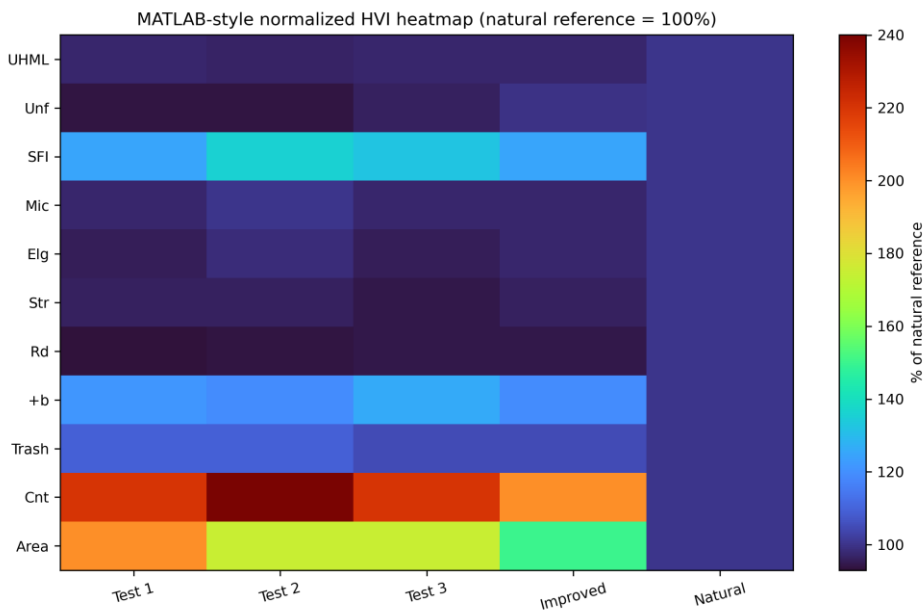


Figure 7. MATLAB-style normalized HVI heatmap. The natural-fiber reference is set to 100% separately for each parameter.

The heatmap provides an integrated comparison of the HVI quality parameters obtained from the three existing cleaning-process tests and the improved fine-impurity cleaning treatment. All parameters are normalized relative to the corresponding natural-fiber value, which is defined as 100%. Consequently, values close to 100% indicate that the measured property remains close to its natural reference, whereas larger deviations indicate a stronger effect of technological processing.

For the principal physical and mechanical fiber properties, including UHML, Unf, Mic, Elg, Str, and Rd, the improved-cleaner column generally remains close to the natural-fiber reference. In particular, the normalized Uniformity Index (Unf) for the improved treatment is closer to 100% than those of the three existing-process tests. This indicates better preservation of fiber-length uniformity. The Short Fiber Index (SFI) remains above the natural reference because the processed samples contain a higher proportion of short fibers than natural fiber; however, the improved treatment shows a lower normalized SFI than the mean tendency of the existing cleaning tests.

The most pronounced contrasts in the heatmap are observed for the contamination-related parameters Cnt and Area. The three existing-process tests show substantially higher normalized values than the natural-fiber reference. After treatment with the improved cleaner, Cnt decreases to approximately 200% of the natural reference, compared with about 220–240% for the existing tests. Similarly, Area decreases to approximately 150% of the natural reference, whereas the existing treatments remain at approximately 175–200%. These changes demonstrate a clear reduction in residual contamination after the improved cleaning treatment.



The Trash Code also moves closer to the natural-fiber reference following improved cleaning. Although the processed fiber does not fully reach the natural contamination level, the simultaneous reduction in Trash, Cnt, and Area, together with the preservation of UHML, Mic, Elg, and Str, indicates that the improved cleaning system achieves additional fine-impurity removal without a pronounced deterioration of the principal fiber properties. Thus, the heatmap provides a comprehensive visual representation of the balance between cleaning efficiency and fiber-quality preservation achieved by the improved fine-impurity cleaner.

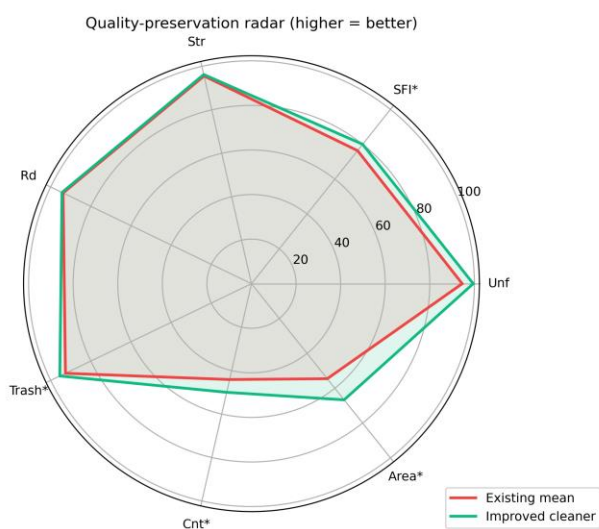


Figure 8. Radar visualization of quality preservation. For SFI, Trash, Cnt and Area the scale is inverted so that higher radial values consistently indicate a more favorable result.

The radar diagram provides an integrated assessment of fiber-quality preservation by comparing the descriptive mean of the three existing cleaning-process tests with the improved fine-impurity cleaning treatment. For easier interpretation, all indicators are expressed on a common normalized scale in which higher values represent a more favorable technological outcome. Therefore, the parameters marked with an asterisk—SFI*, Trash*, Cnt*, and Area*—were inversely normalized because lower values of these indicators correspond to better fiber quality and cleanliness.

The improved cleaner demonstrates a broader quality-preservation profile than the existing process, particularly for Unf, SFI*, Trash*, Cnt*, and Area*. The improvement in Unf indicates better preservation of fiber-length uniformity, while the higher normalized SFI* value reflects a reduction in the proportion of short fibers. At the same time, the Str and Rd profiles remain very close for the two treatments, indicating that the additional cleaning effect was achieved without a substantial reduction in fiber strength or reflectance.

The most pronounced differences are observed for the contamination-related indicators. The improved cleaner shows higher normalized values for Trash*, Cnt*, and especially Area*, corresponding to lower residual contamination in the tested fiber. This agrees with the measured



HVI results, in which the improved treatment reduced the Trash Code from the existing-process mean of approximately 4.53 to 4.40, particle count from 11.33 to 10, and Trash Area from approximately 0.73% to 0.60%.

Overall, the radar profile indicates that the improved fine-impurity cleaning system provides a more favorable balance between contaminant removal and preservation of the principal fiber-quality characteristics. The results are particularly relevant for machine-harvested S-6524 cotton, where effective removal of fine impurities should be achieved without imposing excessive mechanical action on the fiber mass.

4. DISCUSSION

The results show that the strongest response to the improved cleaning treatment occurred in length uniformity and contamination-related indicators rather than in UHML, micronaire or tensile strength. This pattern is technologically plausible because a fine-impurity cleaner is intended primarily to alter the interaction between seed cotton and the cleaning surface, not to change intrinsic fiber fineness.

The Unf increase from the existing-process mean of 75.27% to 79.2%, accompanied by a reduction in SFI from 7.33% to 7.0%, suggests better preservation of the length distribution. This is important for machine-harvested cotton because international studies have demonstrated that excessive mechanical cleaning can reduce fiber length and increase short-fiber content [3]. The present descriptive trend therefore supports further replicated testing of the fork-shaped peg geometry.

The trash response is also relevant. Trash decreased from the existing-process mean of 4.53 to 4.4, Cnt from 11.33 to 10, and Area from 0.73% to 0.60%. The absolute Trash change is modest, but the simultaneous reduction in particle count and area indicates that the improved treatment did not obtain its cleaning effect by sacrificing the principal HVI mechanical properties. This interpretation is consistent with the general recommendation to use only the amount of cleaning required to achieve marketable purity [2].

S-6524-specific processing research strengthens this interpretation. Industrial tests of a 5DP-130 feeder-cleaner on S-6524 reported that cleaning efficiency depended on cotton moisture and initial contamination [7]. Dissertation research in Uzbekistan has used S-6524 to evaluate vibrating mesh surfaces and improved cleaning elements, demonstrating that mesh geometry, spacing and working-element interaction are central factors in fine-impurity separation [8,9].

The machine-harvested context deserves special attention. Published S-6524 work on mechanical harvesting reports relatively high moisture and contamination levels under several harvesting conditions, illustrating why machine-picked material can place greater demands on drying and cleaning [10]. International harvesting literature likewise shows that the quantity and type of foreign matter depend strongly on the harvesting mechanism [1]. Thus, a rigorous continuation of the present study should stratify samples by harvester type and initial foreign-matter composition.



The present manuscript has two deliberate limitations. First, the supplied HVI table does not label its three existing-process columns as independent statistical replicates; consequently, their mean is used only descriptively. Second, the HVI source establishes S-6524 quality after different processing treatments but does not independently document machine-harvesting metadata for every sample. These limitations are stated rather than filled with assumed values. For final submission, the field and laboratory protocols should be appended to the dataset.

From an international-publication perspective, the next experimental stage should use a randomized or blocked comparison with at least three independent lots per treatment. The recorded factors should include harvester type, initial moisture, initial trash content, drying temperature and residence time, cleaner throughput, drum rotational speed, fork opening angle, drum-to-mesh clearance, waste mass, fiber-in-waste percentage, and the full HVI vector. Such a design would permit effect-size estimation and statistical separation of harvesting, drying and cleaning effects.

5. CONCLUSIONS

The S-6524 cultivar combines a reported fiber output of approximately 33.5–34.5%, UHML of 1.12–1.15 in, micronaire of 4.3–4.6 and relative breaking strength around 27.7 g/tex, making it an appropriate reference cultivar for studies of cotton cleaning and fiber-quality preservation, the supplied HVI 900-SA results show that the improved fine-impurity cleaner produced UHML 1.12 in, Unf 79.2%, SFI 7.0%, Mic 3.8, Elg 6.7%, Str 28.3 g/tex, Rd 70.2%, +b 10.6, Trash 4.4, Cnt 10 and Area 0.6%, relative to the descriptive mean of the three existing-process tests, the improved treatment increased Unf by approximately 5.25%, reduced SFI by 4.55%, reduced Trash by 2.94%, reduced Cnt by 11.76%, and reduced Area by 18.18%, while UHML, Mic, Elg and Str remained close to conventional values, these results support continued investigation of the improved working element as a means of intensifying fine-impurity separation without excessive deterioration of the main HVI fiber-quality characteristics.

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