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Comparative analysis of key fiber characteristics in white Pima cotton (*Gossypium barbadense* L.): Native accessions from the Peruvian Amazon

Luis Morales-Aranibar[1] | **Marite Yulisa Nieves Rivera**[2] | **Hebert Hernán Soto Gonzales**[3] | **Carlos Genaro Morales Aranibar**[4] | **Nataniel Linares Gutiérrez**[4] | **Francisco Gamarra Gomez**[4] | **Alan Mario Zuffo**[5] | **Jorge González Aguilera**[6] | **Fabio Steiner**[6]

[1]National Intercultural University of Quillabamba (UNIQ), Cusco, Peru

[2]National Institute of Agrarian Innovation (INIA), Lima, Peru

[3]National University of Moquegua (UNAM), Ilo, Peru

[4]Jorge Basadre Grohmann National University, Tacna, Peru

[5]Department of Agronomy, State University of Maranhão, Balsas, Brazil

[6]Department of Crop Science, State University of Mato Grosso do Sul, Cassilândia, Brazil

Correspondence
Luis Morales-Aranibar, National Intercultural University of Quillabamba (UNIQ), Cusco 08741, Peru.
Email: luis.morales@uniq.edu.pe

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Abstract

The fiber quality of cotton (*Gossypium barbadense* L.) native to the Peruvian Amazon region is one of the most versatile and essential natural fibers in the Peruvian textile industry. There is little information about the fiber quality traits of cotton genotypes native to the Peruvian Amazon region. This study investigated the fiber quality traits of Peruvian Pima cotton accessions native to the Amazon region of the La Convención Province, Cusco, Peru, to determine the lines with the greatest potential for improving fiber quality in cotton genetic breeding programs. A total of 14 cotton accessions with white fiber color, being 12 accessions of *G. barbadense* L. (Pima cotton) and two accessions of *Gossypium* sp. (unknown cotton), were analyzed. The fiber properties determined using the high volume instrument method included seven characteristics. All fiber properties were classified into five quality classes. The data on fiber quality properties were subjected to distribution, correlation, and canonical variable analysis. The results of fiber quality properties showed that the two accessions of *Gossypium* sp. (unknown cotton) can be promising options to be used as high-quality fiber progenies in crop genetic breeding programs or can be cultivated by regional farmers for the purpose of producing cotton with high fiber quality. Future investigations could utilize other methods of fiber quality analysis and compare the fiber quality of these cotton accessions native to the Peruvian Amazon region with other cotton species grown worldwide to improve the understanding of Pima cotton fiber quality and its applicability in different contexts of the textile industries.

Abbreviations: BCI, Better Cotton Initiative; CV, coefficient of variation; FE, fiber elongation; GOTS, Global Organic Textile Standard; GRS, Global Recycle Standard; HVI, high volume instrument; Mc, maturity coefficient; MIC, Micronaire index; SFC, short fiber content; SL, staple length; STR, fiber strength; UHML, upper half mean length; UI, length uniformity index.

1 | INTRODUCTION

Cotton, one of the most important and versatile natural fibers, has played a crucial role in the textile industry for centuries (Zheng et al., 2023). The genus *Gossypium* currently comprises 52 cotton species grown around the world (Campbell et al., 2010; Gallagher et al., 2017; Grover et al., 2015), and each species has distinct fiber quality traits (Y. Wang et al., 2023). Among the seven allotetraploid cotton species (2n = 4× = 52), *Gossypium barbadense* L. is widely known for its excellent fiber quality. This species is a tropical perennial plant native to Peru (Westengen et al., 2005) and has been frequently found within Amazonian native communities of Cusco (Morales-Aranibar et al., 2023). To maintain their ancestral traditions, the native tribes of the Peruvian Amazon use cotton fibers produced in their communities for the artisanal production of clothing and other accessories, and with this, native's communities have contributed to the preservation and conservation in situ of the genetic diversity of the species (Cardoso et al., 2023).

Gossypium barbadense L., commonly known as Sea Island, Pima, Egyptian, long staple cotton (Montes et al., 2023), is characterized by its exceptional fiber quality, with silky, long, strong, and fine fibers (Abdelraheem et al., 2022). Cardoso et al. (2023) reported that modern genotypes of *G. barbadense* L. are derived from Sea Island cotton, which was later improved to produce Egyptian and Pima cotton. Therefore, due to its excellent fiber quality, *G. barbadense* L. represents an attractive option for the introgression of beneficial fiber quality alleles into upland cotton (*Gossypium hirsutum* L.) (Campbell et al., 2018).

In recent studies by Morales-Aranibar et al. (2023), new cotton accessions were identified in the native Amazonian communities of Echarati and Megantoni in the La Convención Province, Cusco, Perú. Collecting and conserving these native or wild populations of cotton is vital to avoid the loss of valuable genes to global germplasm banks (Arriel et al., 2023). However, there is no updated and accurate information on the fiber quality of Pima cotton native to the Peruvian Amazon region. This information is essential for two distinct cotton fiber production sector segments. It allows cotton plant breeders to identify cotton accessions with beneficial fiber quality alleles to be used to improve upland cotton's fiber quality and competitiveness. In addition, it allows local and regional farmers to decide which cotton genotype should be grown to meet the fiber quality traits of local and international markets and achieve higher fiber quality and yield and greater profitability in cotton cultivation.

Currently, the genetic improvement of fiber quality is one of the main challenges for cotton breeders. This is because the genetic diversity of cotton accessions in global germplasm banks is limited. Multiple genes control fiber quality traits with a negative relationship with productive potential, which has often restricted advances in improving the fiber quality of new commercial varieties (Arriel et al., 2023; Hayat & Bardak, 2020; Ijaz et al., 2019; Li et al., 2022; Liu et al., 2020). Furthermore, some studies have reported that commercial upland cotton cultivars are losing some fiber quality characteristics, such as fiber strength (Hinze et al., 2016; Peixoto et al., 2022). In this context, the genetic breeding of fiber quality depends on exploring and efficiently using available plant genetic resources (He et al., 2021). Therefore, studies that seek to evaluate native or wild cotton accessions from the Peruvian Amazon region can contribute to introducing new accessions and genes with high potential for use in cotton breeding programs.

Core Ideas

- There is variability among the cotton accessions collected in the Peruvian Amazon.
- Promising accessions for white cotton fiber quality are identified.
- Crop improvement programs can be favored by using the high-quality fiber cotton accessions.

Cotton fiber quality is determined through several properties, including fiber length, uniformity, strength, elongation, fineness, maturity, trash, and color (Hayat & Bardak, 2020; H. Wang & Memon, 2020). Cotton fiber quality is essential to produce high-quality textile products and meet global market demands (He et al., 2021; Liu et al., 2020; Zhang et al., 2023). However, the textile industry still demands scientific research related to the genetic breeding of cotton with an emphasis on its fiber quality (Ijaz et al., 2019; Li et al., 2022; Nand et al., 2020). A comprehensive and detailed approach to fundamental fiber properties allows the assessment of fiber quality to produce high-quality fiber and then improve fabric quality (H. Wang & Memon, 2020).

The comparative analysis of the quality of Pima cotton fiber is relevant in regions such as Peru, which use this species of cotton as the primary source of natural fiber for the textile industry and local communities. Identifying cotton genotypes with high fiber quality can significantly contribute to the final quality of textile products and the profitability of local farmers (Serquen-Lopez & Iglesias-Osores, 2019). Furthermore, an accurate characterization of fundamental fiber quality properties can provide valuable information to cotton processors and textile manufacturers, helping in decision-making on the optimal use of different fiber types (H. Wang & Memon, 2020).

This study investigated the fiber quality traits of 12 *G. barbadense* L., and two *Gossypium* sp. accessions native to the

Amazon region of the La Convención Province, Cusco, Peru, to determine the lines with the greatest potential for improving fiber quality in cotton genetic breeding programs. The results of this study are of great importance to the international scientific community, regional farmers, and the textile industry since the genetic material collected can be a source of highly useful and usable genes for the selection of progenies with high-quality fiber production.

2 | MATERIALS AND METHODS

2.1 | Plant material sampling location and method

The collection was carried out in areas of native forest in the Amazonian indigenous communities of Chacopishiato, Poyentimari, and Koribeni located in the district of Echarati, La Convención, Cusco, Peru (12˚46′03″ S and 72˚34′54″ W, and altitude 980 m above sea level [a.s.l.]) and in the native communities of Miaría, Kirigueti, Timpía, Sensa, Ticumpinía, and Camisea located in the district of Megantoni, La Convención, Cusco, Peru (12˚46′03″ S and 72˚34′54″ W, and altitude 360 m a.s.l.).

Cotton genetic materials were collected during the months of April and December 2021. A total of 12 samples of *G. barbadense* L. (Pima cotton) and two samples of *Gossypium* sp. (unknown cotton [cotton characterized only in terms of genus, without classification at the species level to date]) with white fiber color were collected in native Amazonian communities in the districts of Echarate and Megantoni. Authorizations were requested from native Amazonian communities to collect cotton genetic materials. The sampling of cotton accessions was carried out using the non-probability subjective sample selection method (i.e., non-random) (Otzen & Manterola, 2017). In the native Amazonian communities, samples of cotton fibers (*G. barbadense* L.) were collected in Timpía (A3), Chacopishiato (A4), Sensa (A5), Kirigueti (A6), Ticumpinía (A7), Sensa (A8), Chacopishiato (A9), Kirigueti (A10), Miaría (A11), Camisea (A12), Kirigueti (A13), and Koriben (A14). In addition to these *G. barbadense* accessions, fiber samples from a variant of *Gossypium* sp. not yet identified were also collected in cultivated areas in the communities of Koribeni (A1) and Poyentimari (A2). These samples were collected because these two cotton accessions have a set of phenotypic parameters preliminarily associated with superior fiber quality characteristics. All samples were collected following the procedures described by Morales-Aranibar et al. (2023). The selection of these 14 cotton accessions native to the Amazon region of Peru from the 147 samples collected by Morales-Aranibar et al. (2023) was carried out based on the separation of accessions that had white fibers.

2.2 | Measurement of cotton fiber qualitative and quantitative properties

The 14 white fiber cotton accessions selected for this study were collected by Morales-Aranibar et al. (2023). Fiber quality analyses of all cotton fiber samples were performed using the Uster high volume instrument (HVI) M-1000 equipment under controlled conditions (20˚C and 65% relative humidity) in the Textile Laboratory FILASUR S.A. accredited by the Global Organic Textile Standard (GOTS), Global Recycle Standard (GRS), Better Cotton Initiative (BCI), world's finest cottons (SUPIMA is a brand and association promoting high-quality cotton especially Pima cotton), Peruvian Pima (the world's softest cotton). A 50 g sample of fibers from each of the cotton accessions was used. The fiber properties determined using HVI included staple length (SL, mm), length uniformity index (UI, %), short fiber content (SFC, %), Micronaire index (MIC, unit), fiber strength (STR, g tex^{-1}), fiber elongation (FE, %), and maturity coefficient (Mc, unit).

Staple length (mm) was measured as the upper half mean length (UHML). The uniformity index (%) is the ratio of the fiber mean length divided by the UHML. Short fiber content (%) is the percentage of fibers with a length of less than 12.7 mm. Micronaire index (unit) is a measure of fiber diameter and an indicator of the air permeability of compressed cotton fibers. It is often used to indicate fiber fineness (outer diameter) and maturity (thickness). Fiber strength (g tex^{-1}) represents the maximum tension the fiber is able to sustain before breaking. Elongation at fiber break (%) is the amount of stretch a fiber can take before it breaks. The Mc is the degree of wall thickening and is calculated by the following equation:

$$\text{Mc} = [M + (0.6 \times H) + (0.4 \times I)]/100, \tag{1}$$

where M is the percentage of matured fibers, H is the percentage of half matured fibers, and I is the percentage of the immature fibers.

All fiber quantitative properties of the 14 white fiber cotton accessions were classified into five class ranges based on each fiber trait's average value, as Hayat and Bardak (2020) used. The descriptive designation of each fiber property class is shown in Table 1.

From the numerical data obtained in the quantitative classification process (Table 1), a qualitative classification of fibers was established following that described by the GOTS, GRS, BCI, and world's finest cottons (SUPIMA).

2.3 | Statistic analysis

To compare the relationship between fiber quality traits, two groups were formed considering the cotton species: the first group was formed by the two accessions of unknown cotton

TABLE 1 Classification of fiber quantitative properties of 14 white fiber cotton accessions native to Amazonian communities in the La Convención Province, Cusco, Perú.

Fiber properties[a]	Descriptive designation	Value range
Staple length (mm)	Short	≤21
	Medium	22–25
	Medium long	26–28
	Long	29–34
	Extra long	≥35
Length uniformity index (%)	Very low	<77
	Low	77–79
	Intermediate	80–82
	High	83–85
	Very high	>85
Short fiber content (%)	Very low	<6
	Low	6–9
	Average	10–13
	High	14–17
	Very high	>17
Micronaire index (unit)	Very fine	<3.0
	Fine	3–3.9
	Medium	4–4.9
	Slightly coarse	5–5.9
	Coarse	≥6.0
Fiber strength (g tex^{-1})	Weak	≤23
	Intermediate	24–25
	Average	26–28
	Strong	29–30
	Very strong	≥31
Fiber elongation (%)	Very low	<5.0
	Low	5.0–5.8
	Average	5.9–6.7
	High	6.8–7.6
	Very high	≥7.7
Maturity coefficient (unit)	Very immature	<0.60
	Immature	0.60–0.70
	Average maturity	0.71–0.80
	Good maturity	0.81–0.90
	Very good maturity	>0.90

[a]*Source*: Adapted from Hayat and Bardak (2020).

(*Gossypium* sp.) and the second group was formed by the 12 accessions of Pima cotton (*G. barbadense*). One-way analysis of variance (*F* test; $p < 0.05$) was applied to fiber quality traits considering unbalanced data treatments (cotton species).

A scatter diagram based on the analysis of Pearson correlation coefficients between all fiber quality traits was constructed. Multivariate analysis using the canonical variables method was performed to verify the overall variability between the two cotton groups and verify the clustering tendency of fiber quality traits with the two cotton groups (unknown cotton or *G. barbadense*). The graphs were created using the software Rbio (Federal University of Viçosa—UFV, Viçosa, MG, BRA), SigmaPlot 10.0 (Systat Software, Inc.), and R version 4.3.1 (R Core Team) with the "GGally" package to generate the correlation graph.

3 | RESULTS

3.1 | Classification of fiber quality properties

The fiber quality properties of the 14 white fiber cotton accessions were classified into five quality class intervals, and the results are shown in Table 2. The fiber properties with the greatest variability among the 14 cotton accessions were the length UI and SFC with four quality classes, followed by SL and STR with three quality classes (Table 2). For the UI, only the unknown cotton accession (*Gossypium* sp.) collected in the native community of Koribeni was classified in the very high class (>85%) with the highest uniformity value, which demonstrates the superiority of this cotton accession in comparison to other white fiber cotton accessions.

For the SFC, 50% of the white fiber cotton accessions, being the two accessions of unknown cotton (*Gossypium* sp.) and five accessions of Pima cotton (*G. barbadense* L.), were classified in the very low class (<6%) of the short fiber index (Table 2). For fiber strength, 71% of the white fiber cotton accessions, the two unknown cotton accessions (*Gossypium* sp.), and eight Pima cotton accessions (*G. barbadense* L.) were classified in the very strong fiber class. Among all fiber quality traits, fiber elongation and maturity coefficient were the fiber properties with the least variability, with the 14 white fiber cotton accessions being classified into only one quality class (Table 2).

In general, the fiber quality properties of the 14 white fiber cotton accessions were used to identify cotton accessions with ideal fiber quality standards for the textile industry. This allowed the identification of three cotton accessions collected in the native communities of Koribeni (*Gossypium* sp.), Poyentimari (*Gossypium* sp.), and Timpía (*G. barbadense*) with high-quality standards and fiber properties highly valued in the textile industry. These cotton accessions have long fiber lengths (>28 mm), very high strength (>28 g tex^{-1}), very low short fiber content (<10%), very high elongation (>7.7%), and good maturity (>0.86) (Table 2). In particular, the unknown cotton accession (*Gossypium* sp.) collected from the Koribeni community stood out for having very high length uniformity (>85%) (Table 2). These fiber properties position these three cotton accessions as promising options for use in genetic improvement programs aimed at improving some key

TABLE 2 Qualitative characterization of fiber quality properties of 14 white fiber cotton accessions native to Amazonian indigenous communities in the La Convención Province, Cusco, Peru.

			Cotton fiber quality properties						
Access	Cotton species	Collection site[a]	SL	UI	SFC	MIC	STR	FE	Mc
A1	*Gossypium* sp.	Koribeni	Long	Very high	Very low	Coarse	Very strong	Very high	Good maturity
A2	*Gossypium* sp.	Poyentimari	Long	Intermediate	Very low	Coarse	Very strong	Very high	Good maturity
A3	*G. barbadense*	Timpía	Long	Intermediate	Very low	Coarse	Very strong	Very high	Good maturity
A4	*G. barbadense*	Chacopishiato	Medium long	Intermediate	Low	Medium	Strong	Very high	Good maturity
A5	*G. barbadense*	Sensa	Medium long	Low	Very low	Coarse	Very strong	Very high	Good maturity
A6	*G. barbadense*	Kirigueti	Medium long	Intermediate	Low	Coarse	Very strong	Very high	Good maturity
A7	*G. barbadense*	Ticumpinía	Medium long	Intermediate	Very low	Coarse	Very strong	Very high	Good maturity
A8	*G. barbadense*	Sensa	Medium long	Intermediate	Average	Coarse	Very strong	Very high	Good maturity
A9	*G. barbadense*	Chacopishiato	Medium	Intermediate	Very low	Coarse	Very strong	Very high	Good maturity
A10	*G. barbadense*	Kirigueti	Medium	Low	Average	Coarse	Strong	Very high	Good maturity
A11	*G. barbadense*	Miaría	Medium	Very low	Very low	Coarse	Very strong	Very high	Good maturity
A12	*G. barbadense*	Camisea	Medium	Low	Average	Medium	Average	Very high	Good maturity
A13	*G. barbadense*	Kirigueti	Medium	Very low	Average	Coarse	Very strong	Very high	Good maturity
A14	*G. barbadense*	Koribeni	Medium	Low	High	Coarse	Strong	Very high	Good maturity
Number of classes (groups)			3	4	4	2	3	1	1

Abbreviations: FE, fiber elongation; Mc, maturity coefficient; MIC, Micronaire index; SFC, short fiber content; SL, staple length; STR, fiber strength; UI, length uniformity index.

[a]Name of the native community of the Peruvian Amazon.

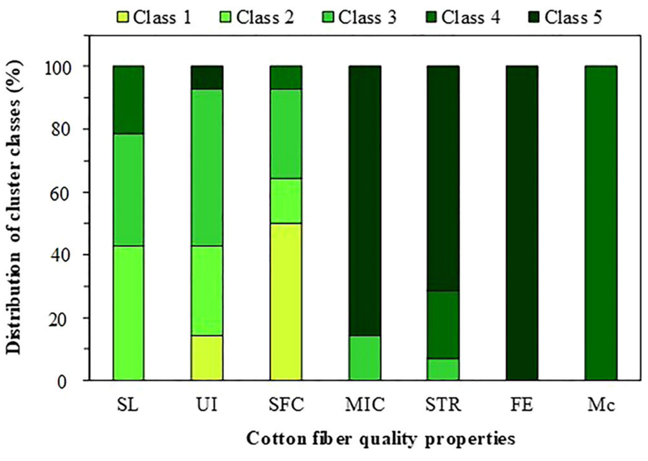

FIGURE 1 Distribution of the grouping classes of the seven fiber quality traits of the 14 white fiber cotton accessions native to Amazonian indigenous communities in the La Convención Province, Cusco, Peru. Classes 1–5 represent the lowest value class to the highest value class for each fiber property. FE, fiber elongation; Mc, maturity coefficient; MIC, Micronaire index; SFC, short fiber content; SL, staple length; STR, fiber strength; UI, length uniformity index.

fiber quality traits such as fiber length, strength, elongation, and uniformity.

The percentage distribution of the grouping classes of fiber quality properties of white fiber cotton accessions native to the Peruvian Amazon region is shown in Figure 1. For the SL, 79% of cotton accessions have medium (class 2) or medium-long (class 3) fiber length. For the UI, 50% of cotton accessions have intermediate fiber length uniformity (class 3). For SFC, 50% of cotton accessions have a very low short fiber content (class 1). For the MIC, 85% of cotton accessions have coarse diameter fibers (class 5). For STR, 71% of cotton accessions have very strong fibers (class 5), which shows the importance of these white fiber cotton accessions native to the Peruvian Amazon region. For FE and Mc, all cotton accessions have very high fiber elongation rates (class 5) and good fiber maturity (class 4), respectively. Overall, these results show the wide diversity for most fiber quality properties of white fiber cotton accessions native to the Peruvian Amazon region.

3.2 | Fiber quality properties between the two cotton groups

Considering the grouping of the 14 white fiber cotton accessions into two groups, group 1, composed of the two unknown cotton accessions (*Gossypium* sp.), has greater fiber length, length uniformity, and fiber strong when compared to group 2, constituted by 12 accessions of Pima cotton (*G. barbadense* L.) (Table 3). These results show the importance of the two unknown cotton accessions (*Gossypium* sp.) as possible superior parents in fiber length, uniformity, and strong for crop genetic improvement programs. Most fiber quality traits have

TABLE 3 Mean values of fiber quality traits for the two unknown cotton accessions (*Gossypium* sp.) and for the 12 Pima cotton accessions (*Gossypium barbadense* L.) collected in the Amazonian indigenous communities of the La Convención Province, Cusco, Peru.

	Cotton fiber quality properties						
	SL (mm)	**UI (%)**	**SFC (%)**	**MIC (unit)**	**STR (g tex^{-1})**	**FE (%)**	**Mc (unit)**
Cotton group[a]							
Group 1	29.9 ± 1.5 a	84.0 ± 1.8 a	5.0 ± 2.3 a	6.9 ± 0.6 a	46.0 ± 3.4 a	11.4 ± 1.4 a	0.90 ± 0.02 a
Group 2	25.6 ± 0.6 b	79.2 ± 0.8 b	7.7 ± 0.9 a	6.4 ± 0.2 a	32.2 ± 1.4 b	13.3 ± 0.6 a	0.86 ± 0.01 a
***F* test**							
Probability > *F*	0.020	0.033	0.300	0.438	0.003	0.257	0.133
CV (%)	8.10	3.24	44.24	12.85	14.04	15.42	2.89

Notes: Means followed by different letters in the column show significant differences in the *F* test at 5% probability.
Abbreviations: CV, coefficient of variation; FE, fiber elongation; Mc, maturity coefficient; MIC, Micronaire index; SFC, short fiber content; SL, staple length; STR, fiber strength; UI, length uniformity index.
[a]Group 1: *Gossypium* sp. (unknown cotton). Group 2: *Gossypium barbadense*.

a coefficient of variation (CV) of less than 20%, a value considered adequate for field experiments. Only the SFC had a high CV variation value (i.e., 44.24%) (Table 3).

3.3 | Correlation analysis between fiber quality properties

The dispersion of data from the correlation analysis between fiber quality traits reported that there are complex interactions between the distinct fiber properties of white fiber cotton accessions native to the Peruvian Amazon region. A highly significant and positive correlation was found between MIC and Mc ($r = 0.81$, $p < 0.001$) (Figure 2).

STR and FE are traits that indicate the durability and flexibility of cotton fibers and have a significant and negative correlation ($r = -0.57$, $p < 0.05$). STR has a significant and positive correlation with UI ($r = 0.64$, $p < 0.05$) and Mc ($r = 0.55$, $p < 0.05$). FE has a significant and positive correlation with SFC ($r = 0.53$; $p < 0.05$), and a significant and negative correlation with Mc ($r = -0.72$; $p < 0.01$).

These analyses provide a better understanding of the interrelationships between the fiber quality properties of cotton accessions native to the Peruvian Amazon region. They are fundamental for selecting new genotypes to improve some cotton fiber quality traits to meet the demands of textile industries, contributing to production efficiency and innovation in the clothing industry. These fiber properties are interrelated, and all these cotton fiber characteristics offer a high-quality natural product.

3.4 | Canonical variable analysis between fiber quality properties

Canonical variable analysis was performed between fiber quality properties and two cotton groups native to the Peruvian Amazon region, and the result is shown in Figure 3. This multivariate analysis reported that the canonical variables were able to capture 100% of the data variability and thus showed the differences that existed between the two groups of cotton native to the Peruvian Amazon region (unknown cotton or *G. barbadense* L.). The results indicate that fiber quality properties are capable of discriminating individuals from the population of the two cotton groups. For group 1, consisting of the two unknown cotton accessions (*Gossypium* sp.), the properties that determine the fiber quality of these genotypes are SL, U, MIC, FS, and Mc (Figure 3).

Figure 3 shows that the two groups of cotton (*Gossypium* sp. or *G. barbadense* L.) have remarkably different fibers in their qualitative characteristics. This may be due to the different climate, soil, or cultivation method of these cotton species in each indigenous community in the Peruvian Amazon. This is an important discovery that could help farmers and the textile industry better understand how to obtain better quality cotton fibers.

4 | DISCUSSION

The maintenance of native cotton accessions of Amazonian communities in the La Convención Province, Cusco, Peru, was described by Morales-Aranibar et al. (2023). However, no information is related to the fiber quality traits of these cotton accessions described by Morales-Aranibar et al. (2023). Nonetheless, this information is important to determine, through the quality properties of the fiber, the possibility of recommending or using cotton accessions with a high standard of fiber quality. The separation of white fiber cotton accessions from the 147 cotton accessions native to the Peruvian Amazon region collected by Morales-Aranibar et al. (2023) is the basis of this scientific research.

The present study provides, in an unprecedented way, a first characterization and a detailed assessment of fiber quality properties determined by the HVI method in 14 native cotton accessions from different indigenous communities in the

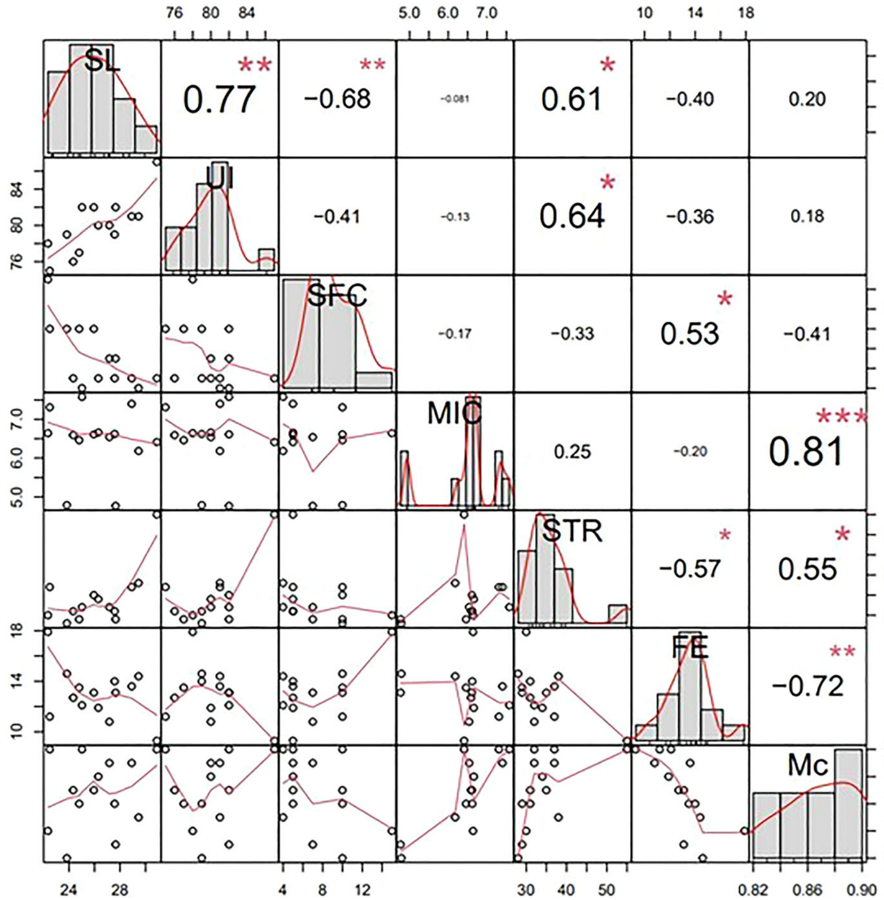

FIGURE 2 Scatter diagram based on the analysis of Pearson correlation coefficients between fiber quality properties of the 14 white fiber cotton accessions native to Amazonian indigenous communities in the La Convención Province, Cusco, Peru. *, **, or *** indicate the significance of the Pearson correlation coefficients at the 5%, 1%, and 0.1% probability levels, respectively. FE, fiber elongation; Mc, maturity coefficient; MIC, Micronaire index; SFC, short fiber content; SL, staple length; STR, fiber strength; UI, length uniformity index.

Peruvian Amazon region. SL is one of the traits that greatly affect fiber quality, and cotton accessions have wide variability in fiber length (Table 2). The two unknown cotton accessions (*Gossypium* sp.) collected in the native communities of Koribeni and Poyentimari and one Pima cotton accession (*G. barbadense* L.) collected in the native community of Timpía stood out for their long fiber length (>28 mm) (Hayat & Bardak, 2020). This is because longer cotton fibers allow finer spinning and greater resistance (Orcón Basilio et al., 2019). Therefore, currently, the minimum fiber length required by the textile industry is 28 mm (Hayat & Bardak, 2020). The three long fiber length cotton accessions collected in this study have average stable length values between 29 and 31 mm (Table 1).

These two cotton accessions without classification at species level (information that must be obtained from molecular studies), among the eight unknown cotton accessions collected by Morales-Aranibar et al. (2023), were selected for the white color of their fibers. In addition to this characteristic used as a premise in this study (fiber color), we also consider that these two unknown cotton accessions have attributes such as flower length, bract length, bract width, capsule width, and length and width of the leaf that differentiate these accessions from the other species initially collected in the study by Morales-Aranibar et al. (2023).

Fiber length uniformity is the ratio between the average length of total fibers and is an important characteristic for manufacturing a uniform fabric (Wang & Memon, 2020). Furthermore, fiber length uniformity is an important indicator used in selecting cotton genotypes (Hayat & Bardak, 2020). In this study, the unknown cotton accession (*Gossypium* sp.) collected in the native community of Koribeni stood out for its very high fiber length uniformity (87%). Length uniformity represents the homogeneity of the fiber length of the cotton bale, and this value must be greater than 83% (Hayat & Bardak, 2020; H. Wang & Memon, 2020).

SFC expresses the percentage of short fibers in the cotton bale and is another fundamental qualitative trait for fiber quality. The SFC should be less than 10% since longer fibers provide greater yield and better fabric quality (H. Wang & Memon, 2020). Indeed, López et al. (2018) reported that lower SFC could lead to higher quality textile products. In this study,

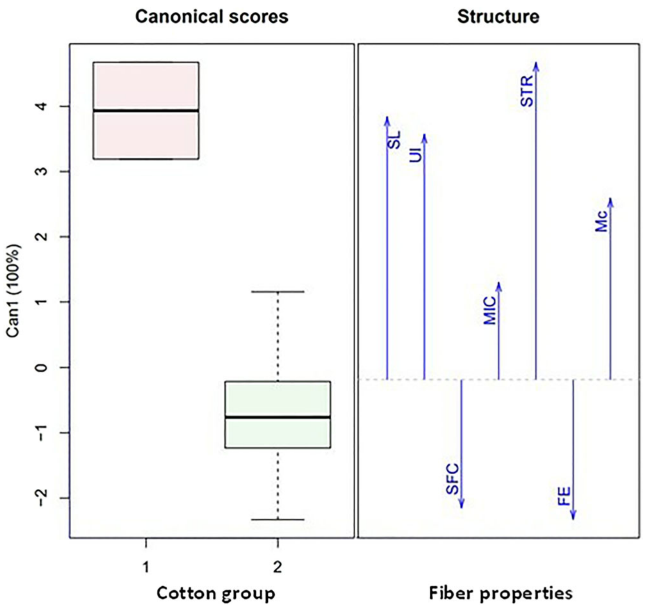

FIGURE 3 Analysis of canonical variables between fiber quality properties and two cotton groups (unknown cotton [*Gossypium* sp.] and Pima cotton [*Gossypium barbadense* L.]) collected in the Amazonian indigenous communities of the La Convención Province, Cusco, Perú. FE, fiber elongation; Mc, maturity coefficient; MIC, Micronaire index; SFC, short fiber content; SL, staple length; STR, fiber strength; UI, length uniformity index.

only one accession of Pima cotton (*G. barbadense* L.) collected in the native community of Koribeni had SFC greater than 10%, being classified as having a high content of short fibers (15%) (Table 2). Therefore, these results indicate that most cotton accessions native to the Peruvian Amazon region have an adequate percentage of short fibers.

The MIC measures fiber diameter. Although the appropriate fiber diameter may vary depending on the final application of the fabric, it is advisable that this index has a value between 3.8 and 4.5 (Hayat & Bardak, 2020). In this study, most cotton accessions have coarse fibers with an MIC value greater than 6.0 (Table 2). Only two cotton accessions (*G. barbadense* L.) collected in the native communities of Chacopishiato and Camisea were classified as medium fine fibers with MIC values between 4.0 and 4.9 (Table 2). Fineness is a fiber property that affects the dyeability of the fiber, and fibers of fine and very fine fineness are undesirable for the textile industry as they impair the adhesion of the dye to the fiber thread during dyeing (H. Wang & Memon, 2020).

Fiber STR is the ability of the fiber to withstand a load until it breaks. STR is essential for the durability of the fabric, and fibers with a higher STR value (>28 g tex^{-1}) are generally preferable (Serquen-Lopez & Iglesias-Osores, 2019). In this study, most cotton accessions native to the Peruvian Amazon region have strong (29–30 g tex^{-1}) or very strong fibers (>31 g tex^{-1}) (Table 2). These results highlight the importance of the plant material collected as a source of useful genes to recover this characteristic in commercial cotton genotypes currently cultivated worldwide.

The fiber's elongation capacity is an important factor in the quality and flexibility of the fabric (Hayat & Bardak, 2020). Indeed, Broetto et al. (2013) reported that fiber elongation is a vital parameter in cotton quality. Fiber maturity is the percentage of the development of the fiber's secondary wall. The value of this index must be greater than 0.86 (H. Wang & Memon, 2020). Fiber maturity is the percentage of the development of the fiber's secondary wall. The value of this index must be greater than 0.80 (Hayat & Bardak, 2020) since good fiber maturity is essential to guarantee adequate spinning and dyeing performance (Wang & Memon, 2020). In this study, all 14 cotton accessions native to the Peruvian Amazon region have good fiber maturity with Mc between 0.82 and 0.90 (Table 2).

In general, the results presented here showed that the two *Gossypium* sp. accessions (unknown cotton), especially the cotton accession collected in the native community of Koribeni, may be promising options to be used as high-quality fiber progenies in cotton genetic improvement programs. These cotton accessions meet most of the ideal criteria for high fiber quality cotton genotypes. Integrating the results of this study with the literature emphasizes the complexity and multifaceted nature of cotton fiber quality. The choice of an ideal cotton genotype may depend on several factors, including the destination of the fabric, textile industry processing techniques, and consumer preference and requirements. Collaboration between empirical research, technological advances, and the experience of the textile industry can lead to a more qualified and objective selection of high-quality cotton genotypes in future research and industrial applications (Morales-Aranibar et al., 2023; Paz-López & Piñero, 2019).

The contribution of this study to the international literature is significant, as this study provides detailed and practical assessment of the fiber quality properties of different cotton accessions collected in several native communities of the Peruvian Amazon. Future research could benefit from incorporating quantitative methods and comparison with other cotton species to further improve the understanding of cotton fiber quality and its applicability in different industrial contexts.

The data collected in native communities provide very valuable information related to the conservation and use of genetic resources as the first stage of a crop improvement program to be able to access and understand the genetic diversity present in these communities. This scientific research lays the foundation for future studies that can further clarify the information available about the native accessions of unknown origins that we use in this study. From the seeds obtained from these genetic materials collected in native communities of the Peruvian Amazon, new studies will be carried out to elucidate the species and evaluate these same characteristics related to fiber quality traits through experiments under controlled or field conditions. These results will allow us to evaluate the value in relation to the fibers that these unknown accessions have and other characteristics that could be incorporated to evaluate in relation to the sample of cotton fibers from the same and other species, as well as from commercial cotton cultivars of high quality and wide adaptability.

The comparative study of the fiber quality of cotton accessions (*Gossypium* sp. and *G. barbadense* L.) native to the Peruvian Amazon region represents a valuable contribution to scientific knowledge in the area of agronomy and the textile industry. The research focused on evaluating the fiber quality traits of 12 Peruvian Pima cotton accessions (*G. barbadense* L.) and two unknown cotton accessions (cotton characterized only in terms of the genus, without classification at the species level to date [*Gossypium* sp.]) natives to the indigenous communities of the Province of La Convención, Cusco, Peru. To identify cotton accessions with high-quality fibers, our study shows the importance and uniqueness of the two unknown cotton accessions collected in the Peruvian Amazon region. The results of fiber quality traits allow a detailed understanding of the profile of these native cotton accessions, with potential implications for their use by regional farmers, in the textile industry, or crop genetic improvement programs.

The generation of technical-scientific data on the fiber quality of cotton accessions native to the Peruvian Amazon region will allow the continuation of research work with the purpose of generating technology to produce high-yield, high-quality cotton. These studies could strengthen local and artisanal cotton farmers in their quest to establish stronger associations with the textile industry, guaranteeing them the supply of high-quality fiber for their production processes. Furthermore, this study has contributed to the appreciation of local farmers and the preservation and conservation of the biodiversity of native and wild populations of *Gossypium* sp. existing in native communities in the Peruvian Amazon region.

AUTHOR CONTRIBUTIONS

Luis Morales-Aranibar: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization; writing—original draft; writing—review and editing. **Marite Yulisa Nieves Rivera**: Conceptualization; formal analysis; investigation; methodology; resources; software; validation; visualization; writing—original draft; writing—review and editing. **Hebert Hernán Soto Gonzales**: Formal analysis; funding acquisition; investigation; methodology; software; validation; visualization; writing—original draft; writing—review and editing. **Carlos Genaro Morales Aranibar**: Conceptualization; formal analysis; investigation; resources; validation; visualization; writing—original draft; writing—review and editing. **Nataniel Linares Gutiérrez**: Data curation; funding acquisition; investigation; methodology; project administration; validation; visualization; writing—original draft; writing—review and editing. **Francisco Gamarra Gomez**: Funding acquisition; investigation; methodology; project administration; validation; visualization; writing—original draft; writing—review and editing. **Alan Mario Zuffo**: Conceptualization; investigation; methodology; project administration; validation; visualization; writing—original draft; writing—review and editing. **Jorge González Aguilera**: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; resources; software; validation; visualization; writing—original draft; writing—review and editing. **Fabio Steiner**: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; software; supervision; validation; visualization; writing—original draft; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Luis Morales-Aranibar https://orcid.org/0000-0002-9421-9833
Marite Yulisa Nieves Rivera https://orcid.org/0000-0002-1862-9996
Hebert Hernán Soto Gonzales https://orcid.org/0000-0002-9936-1943
Carlos Genaro Morales Aranibar https://orcid.org/0000-0002-4184-2365
Nataniel Linares Gutiérrez https://orcid.org/0000-0003-2323-0645
Francisco Gamarra Gomez https://orcid.org/0000-0002-3737-5610
Alan Mario Zuffo https://orcid.org/0000-0001-9704-5325
Jorge González Aguilera https://orcid.org/0000-0002-7308-0967
Fabio Steiner https://orcid.org/0000-0001-9091-1737

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