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A Comparative Study of the Technological Characteristics of Cotton Fibers from Two Types of Gins in Côte d'Ivoire

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Abstract

Production of this crop is experiencing significant challenges, resulting in a decline in seed and fiber quality. To address this challenge, generations of high-performance cotton plants of the *Gossypium hirsutum L.* species have been developed and are currently being commercialized. This study evaluated the impact of gin types on the agro-industrial quality of cotton in Côte d'Ivoire. To this end, cotton from the G3, R1, and R2 generations was harvested, sampled, and ginned on machines with 10 and 170 saws in the localities of Ouangolodougou, Ferkessédougou, Korhogo, M'Bengué, Boundiali, Séguéla, and Mankono, as well as at the Centre National de Recherche Agronomique CNRA) in Bouaké. The results demonstrated that cotton fibers obtained from ginning on 10-saw machines exhibited superior quality compared to those from 170-saw machines. Fiber length, fiber length uniformity, and short fiber rate exhibited the highest deviations according to gin type. The use of 170-saw gins resulted in a notable decline in quality. Conversely, micronaire index, fiber tenacity and elongation, and reflectance remained consistent across machine types. These results will enable us to more effectively regulate and advise cotton-processing factories, which primarily utilize 170-saw gins to enhance agro-industrial quality in Côte d'Ivoire. Furthermore, these results will assist breeders in incorporating them into their processes to enhance the quality of the varieties they offer to farmers.

Keywords

Agro-Industrial Quality, Technological Characteristics, *Gossypium Hirsutum L.*, Saw Gin, Côte d'Ivoire

1. Introduction

Cotton is a plant fiber derived from the cotton plant, a shrub belonging to the Malvaceae family. From 2017 to 2018, the total area of cotton cultivated worldwide was estimated at 35 million hectares, with a global production of approximately 25.6 million tons of fiber [1]. The African countries that produce cotton using the CFA Franc are among the world's most significant production regions, according to the Comité Consultatif International du Coton (CCIC) [2]. In Côte d'Ivoire, cotton is cultivated on approximately 300,000 hectares with an average seed cotton yield of 1200 kg/ha [3].

Furthermore, the quality of the cotton, and thus the price set on the international market, is significantly influenced by the ginning techniques employed. Ginning is the process of separating the fibers from the seed. This is the initial stage of processing seed cotton. The quality of the fiber for spinning mills and the seed for oil mills and seed companies is determined by this process [4]. Thus, [5] demonstrated that roller ginning produces higher performance fibers than saw ginning. The same author and his collaborators, during the tours organized in the ginning factories in Cameroon showed that the speed of ginning in the factories, as well as the state of the different components of the ginning system influence the quality of the fiber [6]. It is therefore crucial to implement effective ginning techniques in order to ensure the optimal financial value of this crop. Consequently, when developing new varieties, breeders consider this stage to assess their agronomic performance. Furthermore, the Centre National de Recherche Agronomique (CNRA) has only one 10-saw gin. However, the gins used in the various factories in Côte d'Ivoire are primarily composed of 170 saws. In response to persistent concerns from industrialists regarding the technological attributes of Ivorian cotton, the CNRA, responsible for developing the varieties cultivated in the country, initially sought to evaluate the impact of two gin types (10 and 170 saws) under identical harvesting conditions. This assessment aimed to ascertain their influence on the agro-industrial quality of the cotton.

With this objective in mind, this study was initiated to determine the impact of different gin types on the agro-industrial quality of cotton.

2. Materials

2.1. Study Sites

Cotton ginning was conducted at seven locations (**Figure 1**), which are major production areas comprising eight mills (**Table 1**), as well as at the Centre Nationale de Recherche Agronomique (CNRA) in Bouaké.

Table 1. Number of tests per mill on 170-saw gins.

Factories	Number of tests
Ouangolodougou	2
Ferkéssédougou	1

Continued

Korhogo 1	2
Korhogo 2	1
Korhogo 3	1
M'Bengue	2
Boundiali 1	2
Séguéla	1

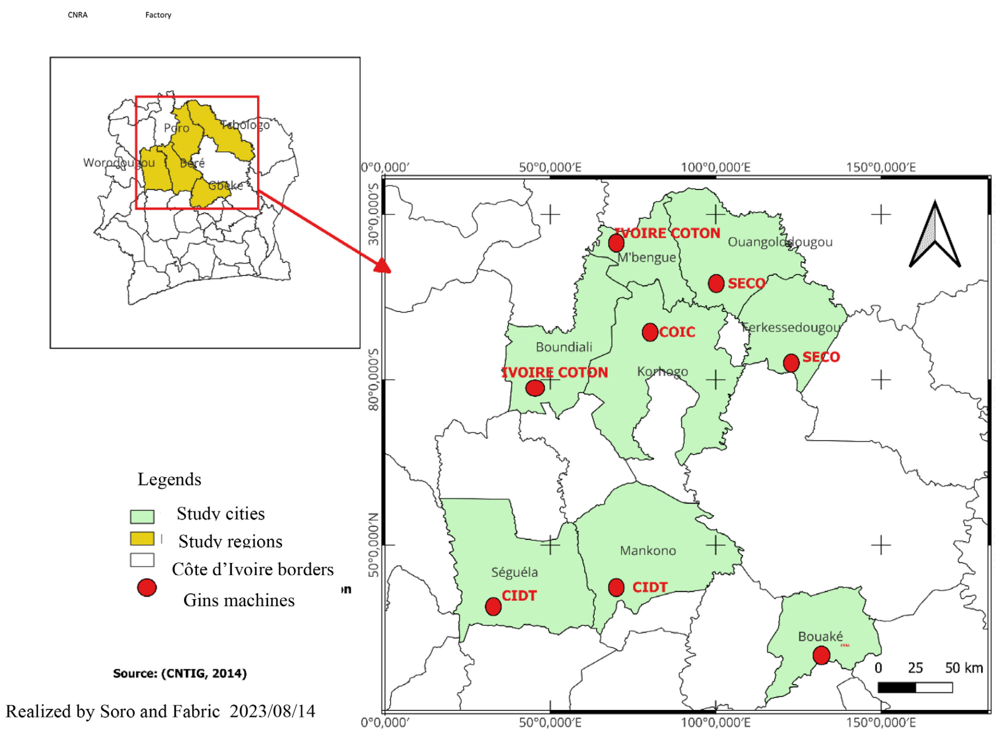

Figure 1. Map of Côte d'Ivoire with study sites.

2.2. Plant Material

The plant material used in this study was seed cotton of three varieties: CI-123, CI-128 and Gouassou Fus1, all from the *Gossypium hirsutum* species grown in Côte d'Ivoire. These are the varieties currently being popularized in Côte d'Ivoire. They have been selected and sold to cotton companies for cultivation.

2.3 Technical Equipment

Gins, including a 10-saw gin (Figure 2(a)) used for ginning seed cotton samples at research level and a 170-saw gin (Figure 2(b)) used for ginning seed cotton in factories. These two types of gin are the only gins involved in cotton ginning in Côte d'Ivoire. Additionally, an integrated measurement chain (CMI) type HVI was employed to determine the technological characteristics of fiber (Figure 2(c)). Finally, a scale type (CAMRY Price camputing scale) was used to weigh samples of seed cotton and lint (Figure 2(d)).

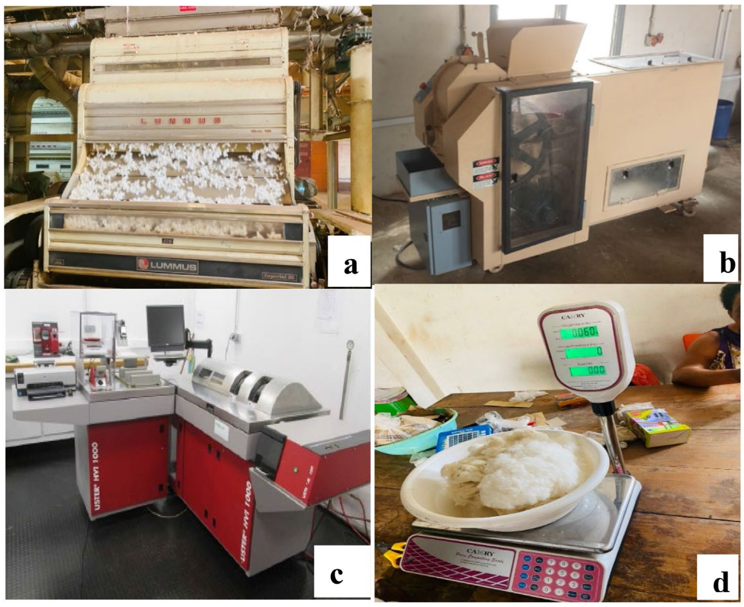

Figure 2. Technical equipment used for the study.

a: 170-saw gin; b: 10-saw gin; c: HVI integrated measuring chain (CMI); d: electronic scale.

3. Methods

The study was based on ginning trials carried out on lorries of seed cotton selected at random from the factories, with 4 replicates per variety. Thus, 12 trials were carried out on the 3 varieties undergoing extension, *i.e.* 4 trials per variety.

3.1. Stages of Data Collection at the Mill (170-Saw Gin)

The data collection process commences with a verification of the measuring instruments, followed by a cleaning of the ginning system. This is then followed by the collection of data and finally the preparation of cotton samples for processing on the 10-saw gin.

3.2. Checking Measuring Instruments

At the factory, the measuring instruments were calibrated to ensure accurate lint and seed cotton weights. This involved checking the weighing bridge and the bale weigher. It is of the utmost importance that these instruments provide accurate values during the weighing process, as any discrepancies could lead to errors in the subsequent data processing.

3.3. Gins Cleaning

Prior to commencing the ginning process, a comprehensive cleaning of the machine circuit was conducted, encompassing the area where the gin cars are positioned and extending to the point where the fiber bales are formed. This process also included cleaning the saw teeth and replacing any that were no longer functional.

3.4. Factory Data Collection

The data collected primarily included mass measurements for seed cotton, fiber bales, seed, and waste.

3.5. Preparation of Cotton Samples for Processing and Comparison with the 10-Saw Gin (CNRA)

The samples taken at the mill included 5 kg of seed cotton and seed cotton free of waste taken from transport trucks and gin aprons, respectively, as well as 500 g of cotton fiber, fiber after Lint Cleaner, and from bales. The 5 kg of seed and waste-free cotton were ginned on 10-saw machines at CNRA in 1 kg batches, with three replications. The remaining 500 g samples (cotton lint, lint after Lint Cleaner, and lint on bales) were utilized as relative controls to assess the comparative agro-industrial performance of the two gin types (10-saw and 170-saw).

3.6. Agro-Industrial Seed Cotton Quality Parameters Calculated

The parameters calculated were cotton fiber and waste rates.

3.7. Waste Content of Seed Cotton

The percentage of waste contained in seed cotton (%), determines the proportion of waste in relation to seed cotton. As the percentage increases, the fiber content per unit mass decreases. The percentage is calculated using the following formula:

$$\text{Waste rate} \quad (\%) = \frac{\text{Weight}(\text{g})\text{ of waste}}{\text{Weight}(\text{g})\text{ of seed cotton}} \times 100$$

3.8. Cotton Fiber Content

The percentage of cotton fiber content (%), in relation to seed cotton, determines the proportion of fiber in the overall composition. The calculation is made according to the following formula:

$$\text{Fiber rate} \quad (\%) = \frac{\text{Fiber weight}(\text{g})}{\text{Cottonseed weight}(\text{g})} \times 100$$

3.9. Agro-Industrial Quality Parameters of Seed Cotton Determined

Cotton samples collected in the mills and those obtained after ginning on the 10-saw gin were analyzed using an integrated HVI 1000/1000 measuring chain [7]. This fully automated device has three modules for determining technological characteristics from a 100 g sample of fiber, offering a high level of efficiency and precision. The primary technological characteristics evaluated were fiber length (UHML), fiber tenacity (Str), fiber length uniformity (UI), short fiber index (SFI), fiber elongation (Alg), and reflectance (Rd).

3.10. Statistical Analysis

A Student's T-test was used to compare the technological characteristics of gins with 10 saws (CNRA) with those of factories with 170 saws. To evaluate the effect of waste on the quality of the cotton produced by the agro-industrial process, all the aforementioned analyses were conducted using Excel 2016 and STATISTICA version 7.1 software.

4. Results

4.1. Cotton Technological Characteristics According to Two Gin Types (10-Saw and 170-Saw)

4.1.1. Effects of the Two Gin Types on Cotton Fiber Length (UHML)

The statistical analysis revealed a significant difference in fiber length for the same cotton, with a value of 29.03 mm after ginning on 10-saw gin and 27.52 mm when the cotton was processed at the factory, which uses gins with 170-saw (**Figure 3**).

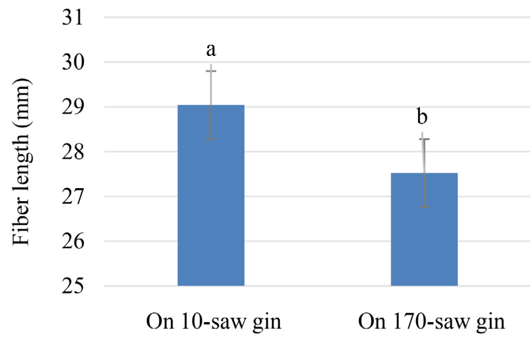

Figure 3. Cotton fiber length by gin type.

Diagrams bearing the same letter are not statistically different according to the Student-Newman-Keuls test with a threshold of 5%.

4.1.2. Effects of the Two Gin Types on the Micronaire Index of Cotton Fibers (Mic)

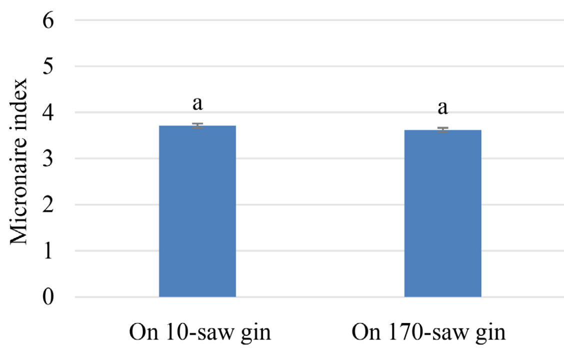

Figure 4. Micrometric index (Mic) of cotton fibers according to gin type.

Diagrams bearing the same letter are not statistically different according to the Student-Newman-Keuls test with a threshold of 5%.

The type of gin had no impact on the micronaire index (**Figure 4**). The micronaire index of fibers obtained after ginning on 10-saw gin (3.71) and that of fibers ginned at the mill with 170-saw gin (3.62) were found to be statistically identic.

4.1.3 Effects of the Two Gin Types on Cotton Fiber Tenacity (Str)

The results for cotton fiber tenacity are presented in Figure 5. The average fiber tenacity values obtained by using gin with 170 saws and gin with 10 saws were 27.49 g/tex and statistically identical. There was no observed variation in tenacity according to gin type.

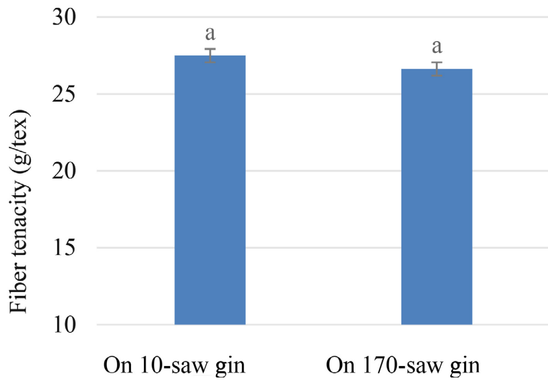

Figure 5. Fiber tenacity (Str) by gin type.

Diagrams bearing the same letter are not statistically different according to the Student-Newman-Keuls test with a threshold of 5%.

4.1.4. Effects of the Two Gin Types on Cotton Short-Staple Content (SF)

The rate of short fibers (15.08%) at the factory (Figure 6) was found to be statistically higher than that obtained after ginning on 10-saw gin (10.28%).

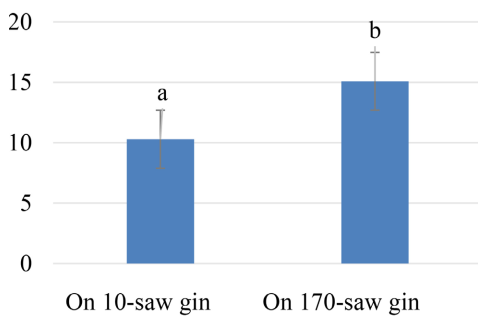

Figure 6. Short fiber content by gin type.

Diagrams bearing the same letter are not statistically different according to the Student-Newman-Keuls test with a threshold of 5%.

4.1.5. Effects of the Two Gin Types on Cotton Fiber Length Uniformity (IU)

The average rate of uniform fibers obtained with a gin equipped with 10 saws (81.66%) was higher than that of cotton processed at the factory with 170-saw gin (78.70%).

4.1.6. Effects of the Two Gin Types on Cotton Fiber Elongation (Alg)

The results of the cotton lint elongation tests are presented in Figures 7-8. The statistical analysis demonstrated that there was no significant difference between the elongation values obtained with the 10-saw machine (6.09%) and those obtained with 170-saw machine (5.76%).

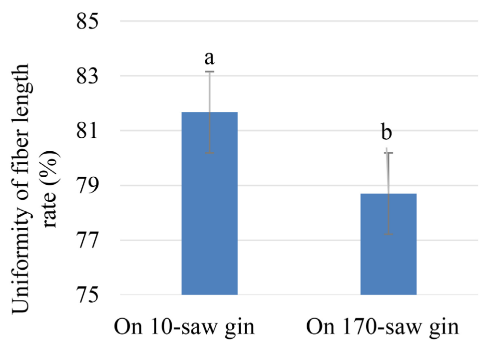

Figure 7. Uniformity of fiber length according to gin type.

Diagrams bearing the same letter are not statistically different according to the Student-Newman-Keuls test with a threshold of 5%.

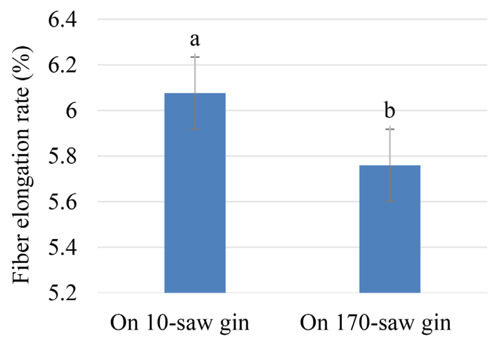

Figure 8. Fiber elongation by gin type.

Diagrams bearing the same letter are not statistically different according to the Student-Newman-Keuls test with a threshold of 5%.

4.2. Differences in Technological Characteristics between Gins with 10 and 170 Saws

Table 2. Differences in technological characteristics between fibers from 10-saw gin and 170-saw gin.

Parameters	UHML	Mic	UI	SF	Str	Alg	Rd
Deviation	1.51	0.09	2.96	4.79	0.87	0.31	0.19
Standards	≤ 1	≤ 1	≤ 1.5	≤ 2	≤ 1	≤ 1	≤ 1

UHML: Cotton fiber length; **Mic:** Cotton fiber micronaire index; **UI:** Cotton fiber length uniformity; **SF:** Short fiber rate; **Str:** Cotton fiber tenacity; **Alg:** Cotton fiber elongation; **Rd:** Reflectance.

The deviations between the technological characteristics of cotton ginned on a 170-saw gin and a 10-saw gin and the tolerable deviations are given in **Table 2**. The differences between the characteristics of fibers from the two types of gins are 1.51 mm for length, 0.09 for micronaire index, 2.96% for uniformity, 4.79% for short fiber content, 0.87 g/tex for tenacity, 0.31% for elongation, and 0.19 for brightness. In accordance with the tolerable values, the differences obtained in length (1.51 mm), length uniformity (2.96%) and short fiber content (4.79%) are out of the norm.

5. Discussion

The objective of this study was to evaluate the impact of gin type on the agro-industrial quality of cotton in Côte d'Ivoire.

The analysis of technological parameters as a function of gin type revealed notable differences in lint quality between the two machines. The length (UHML), uniformity (UI), and short-staple content (SF) of the cotton were found to be of poor quality when seed cotton was ginned at the mill. Saw gins are machinery utilized primarily in the cotton industry for the separation of cotton fibers from seeds. The following outlines the key distinctions between 10-saw and 170-saw gins. Machines with 10 saws have a lower processing capacity, making them well-suited for smaller operations or small-scale processing requirements. These machines are less efficient in terms of processing speed, which can result in longer processing times. However, 170-saw gins are designed for large-scale operations, capable of processing large quantities of cotton in a short time. They are more rapid and efficient, enabling faster processing and higher productivity. It should be noted that the use of gins with 170 saws results in shorter, less uniform fibers. The inferior quality of the cotton is attributed to either the sizing or the extended circuit of the 170-saw machine [8]. It should be noted that the use of a highly efficient machine for the purpose of optimizing profitability may also result in the degradation of fibers and seeds [9]. The distinction between the two gins also hinges on machine maintenance, as malfunctioning saws and bars diminish cotton fiber size [10] [11]. It is crucial to prevent deterioration in fiber quality due to improper adjustment or excessive speed, particularly in West and Central Africa, where value chains are highly dependent on the prices paid for superior fiber quality [12] [13]. It is important to note that lint classification alone does not provide a reliable measure of the impact of ginning. There are many factors that can influence the outcome, including the quality of the incoming seed cotton, the type of equipment used, and the number and settings at each stage of the ginning process [14]. The quality gap between industries and small farms appears to be largely attributed to differences in working speed, saw settings from seed cotton cleaning to ginning, and varietal selection.

Indeed, 170-saw gins are designed for large-scale operations, capable of processing large quantities of cotton in a short space of time. They are equipped with cleaning systems that degrade the fiber when the cotton is dirty and clean it thoroughly. This is what [8] found in his work on ginning in West African mills in 2006. Work by [9] comparing the characteristics of fiber from micro-gin and industrial gin also showed that the length and uniformity of laboratory ginning were 1.02 mm and 1.7% higher than those of industrial ginning respectively. The poor fibre quality is thought to be due either to the calibration of industrial gins [10] [11], or the speed of industrial gins [12].

On the other hand, machines with 10 saws have a lower processing capacity, which is suitable for small-scale ginning requirements. They are less efficient in terms of processing speed, which may result in longer processing times, but, like roller gins, produce much better quality fibre [13].

It is essential to avoid deterioration in fibre quality due to poor setting or excessive speed, particularly in West and Central Africa, where value chains are highly dependent on the prices paid for superior fibre quality [14] [15].

6. Conclusions

The objective of this study was to analyze the impact of different gin types on the agro-industrial quality of cotton in Côte d'Ivoire. The results demonstrated a clear impact of gin type on the agro-industrial quality of the cotton, particularly in terms of length, uniformity, and short-staple rate. The differences in these technological parameters were significant and exceeded the norm. However, the differences in micronaire index and reflectance were minimal in comparison to the standard. It is recommended that breeders using the 10-saw machine integrate the 170-saw machine before the varietal releases. Furthermore, industrialists will be able to examine the impact of gin settings on the economic viability of these improvements to the agro-industrial quality of seed cotton in Côte d'Ivoire.

Good adjustment, a reduction in machine speed, and awareness of producers so that they harvest sufficiently clean seed cotton are the solutions to produce good-quality fiber in factories.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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