An Investigation on the Spinning Behaviour of Different Types of Coir Fibres in the Mechanised Spinning Process

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Abstract

Coir fibre is obtained from the fruit of coconut tree. Coir fibre is extracted from the husk of coconut after the removal of nut. Two types of coir fibres are available in the coir industry. White fibres are extracted from immature green coconut after a very long retting period of 9 to 12 months. Brown fibres are extracted from mature coconut fibre after a short retting period of one week. White fibre is bright and pliable. Brown fibres are coarse and stronger. The spinning performance, yarn realisation and yarn quality characteristics of yarn made from white and brown fibre samples were studied. It was observed that the spinning performance, breaks per spindle hour was observed to be better while processing white fibres. The fibre shedding was found to be relatively low which resulted in better yarn realisation. Since white fibres are finer and pliable, white coir fibre yarns are stronger and have more elongation than yarns made from brown fibre. They are stronger than brown fibre yarns by 24% in coarse and medium counts and 43% in fine count. The mass irregularity, the Coefficient of Variation % of mass of one meter cut length of yarn samples are found to be high in the brown fibres yarn due to coarseness and higher flexural resistance. White fibre yarns have lower CV% than brown fibre yarns by 4 to 5% in coarse and medium counts and 7% in fine count. About 50 to 70% reduction yarn breaks and 2 to 3% improvement in yarn realisation were observed while processing white fibres.

Key words: *Coir fibre, white fibre, brown fibre, , mechanised spinning, ply yarn.*

1. Introduction

Coconut fibre, Coir is obtained from the fruit of Coconut tree (Cocos Nucifera L) [1]. Coir is the by product of coconut after the removal of the nuts and extracted from the husk [2]. The major constituents of coir fibre are cellulose and lignin [3]. The high percentage of lignin in the coir fibre makes it stiff and rigid. The tensile strength of coir is low compared to other plant fibres and has good resistance to microbial action and salt water damage. Coir fibre is used in agriculture, civil construction and geo textile applications [4].

2. Types of coir fibres

White fibre and Brown fibres are the two types of coir fibres are available in the coir industry [5]. White fibre is extracted from green coconuts after processing through a long retting process followed by hand beating and drying process. Brown fibre is obtained from matured coconut husk and has undergone a conditioning period of one week. White fibre is relatively flexible compared to brown fibres.

3. Spinning System and Yarn Structure

Two systems of coir spinning, hand spinning and mechanised spinning are practiced in the coir spinning industry [6]. Hand spinning is a traditional system followed in the rural segments of the southern states Tamilnadu and Kerala in India. White fibre is mostly used in the hand spinning process. Mechanised spinning is employed to spin brown fibres. Mechanised spinning is popular due to its higher production speed, higher yarn realisation and knot free yarn over a long length. Mechanised spinning system follows the open end spinning principle and is shown in figure 1 [7]. The single yarn produced is a core sheath type yarn where the core component is a polyester mono filament and the sheath component, coir fibres wrap around the core.

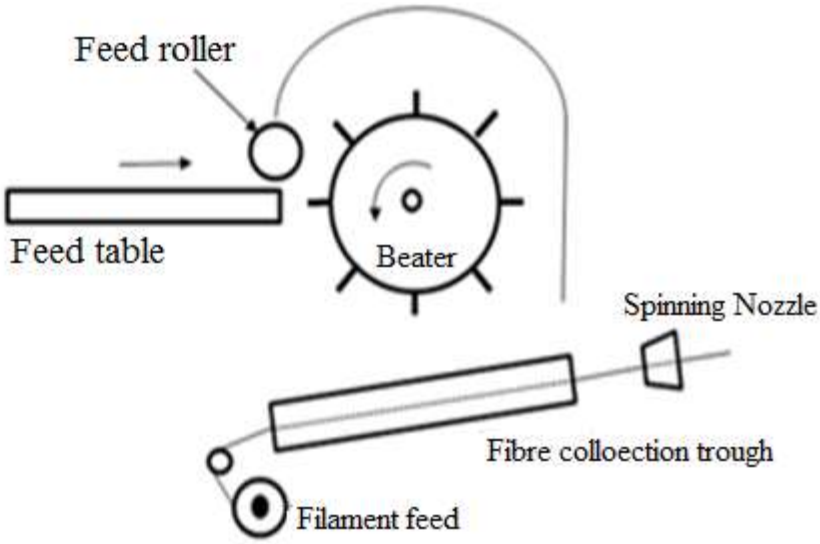

Figure 1. Principle of mechanised coir spinning

The process flow of the mechanised spinning is shown in figure 2. The coir bales are opened and the fibre tufts are processed through a pin type pre opening beater. The opened fibres are treated with water allowed to condition for 4 hours. Conditioning improves the spinning behaviour and reduces the fibre shedding.

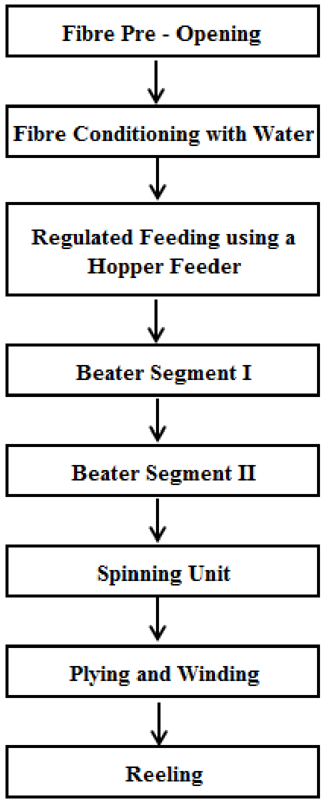

Figure 2. Process flow of mechanised spinning

The SEM images of cross sectional and longitudinal views of coir fibre yarn spun from the mechanised spinning is shown in figure 3 and 4 respectively.

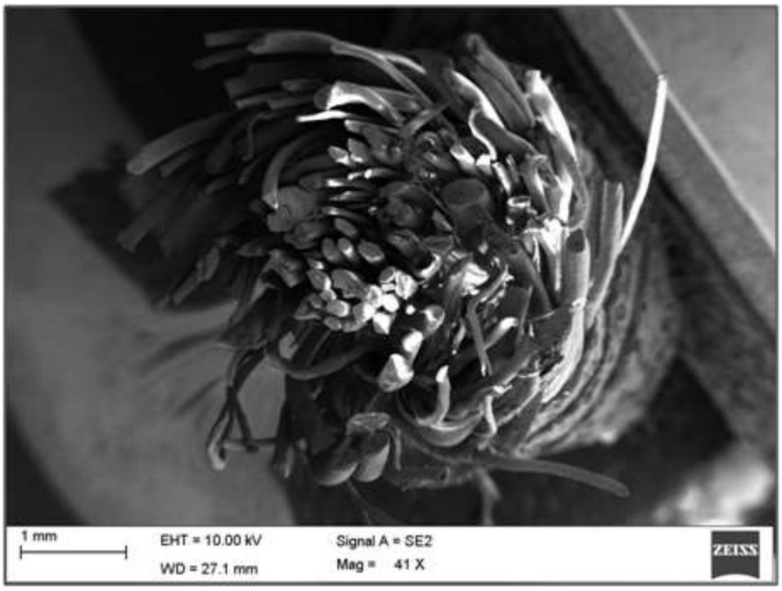

Figure 3. Longitudinal image of mechanised spun single yarn

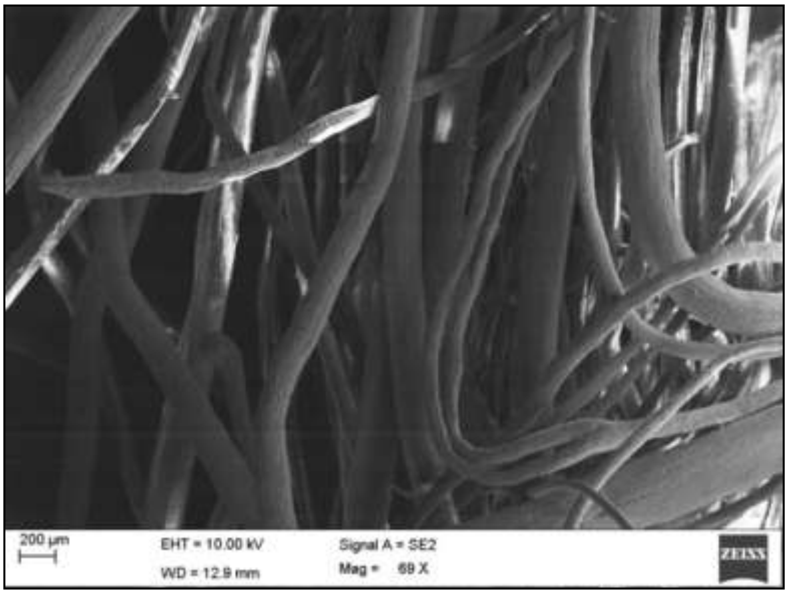

Figure 4. Cross sectional image of mechanised spun single yarn

In the mechanised spinning, two single yarns spun from the two adjacent spinning heads are combined together to form a two ply yarn as shown in figure 5. The two ply yarn produced is wound on a spool and the yarn is converted to hank.

Figure 5. Plying of single coir fibre yarns

In the study, the spinning performance, yarn realisation and the quality characteristics yarns made from both white and brown fibres were studied.

4. Materials and Methods

The quality characteristics of the brown and white fibres used in the study are shown in table 1. Brown fibres are stronger and coarser, as they are extracted from the matured coconut fruit. On the other hand, the white fibres weaker and finer, as they are extracted from the green husks, which undergo long retting processes. White fibres have relatively low flexural rigidity.

Table 1. Quality characteristics of brown and white fibres

Fibre Quality	Unit	Brown Fibres	White Fibres
Fibre Length			
Maximum fibre length	mm	300	265
Mean fibre length	mm	122	106
Fibre Strength	gf	366	290
Fibre Elongation	%	13.65	13.44
Fibre fineness	Tex	80.22	66.67

Yarn samples were produced with these fibres keeping the process parameters identical for the same linear density of yarns. Yarn samples of 140, 160 and 180 runnage were produced in a mechanised spinning process using both the white and brown coir fibres. The tensile characteristics of coir yarns were tested on a Universal Strength Tester Instron 5500R with a gauge length of 300 mm with strain rate of 300 mm per minute (100% strain rate). The tensile values of two-ply yarns and the corresponding single yarns were tested. Average of fifty samples were taken and considered for the results and discussions.

The mass irregularity of the yarn samples were assessed by calculating the Coefficient of Variation (CV %) of weight of one meter cut length of yarn samples. The CV% is calculated based on the sample size of fifty.

Yarn realisation was determined by collecting and weighing the waste generated during the spinning process. The yarn realisation was calculated using the formula (1).

$$\text{Yarn realisation (\%)} = \frac{Quantity\ of\ yarn\ produced}{Quamtity\ of\ coir\ fibre\ taken} \times 100 \qquad (1)$$

5. Results and Discussions

5.1 Tensile Strength and Elongation of white fibres

The tensile strength of single and ply yarns made from coir are for the three runnage are given in figure 6 and 7. The tensile strength and elongation of yarns made from white fibres are found to be higher than that of yarns made from brown fibres in all the count considered in the study.

The increase in the number of fibres in the yarn cross section and ability to follow the twist flow in the yarn structure make the white fibre yarns stronger than brown fibre yarns. Coarse and medium count two ply yarns made from white fibre are about 24% stronger than brown fibre yarns and in finer count white fibre yarns are stronger by about 43%. While processing finer yarn (180 runnage) with brown fibres, the higher incidents of yarn breaks were observed which made the yarn a weaker. With the brown fibres considered in this the study the maximum spinning limit would be 160 runnage and any finer yarn beyond this will not provide a acceptable yarn quality with a satisfactory spinning performance.

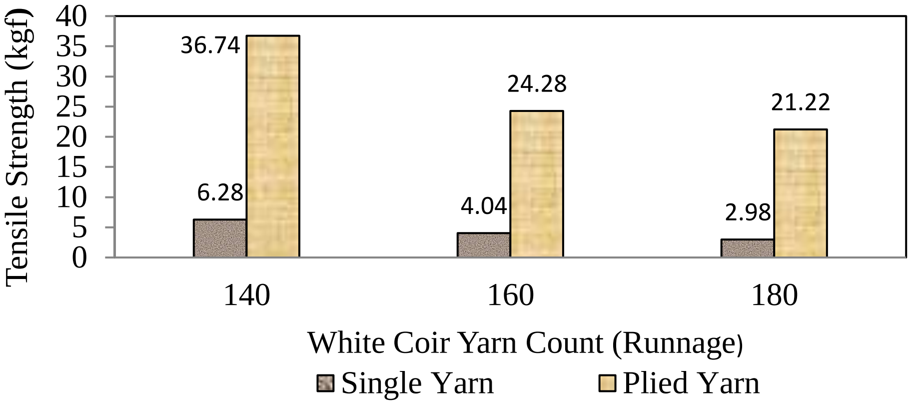

Figure 6. Tensile strength of white fibre yarns

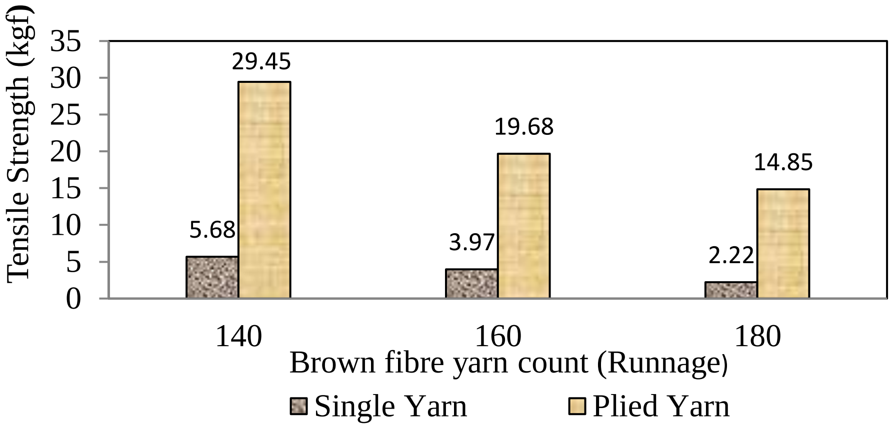

Figure 7.Tensile strength of brown fibre yarns

5.2 Effect of plying on the tensile strength of coir fibre yarns

Plying or doubling improves the tensile strength and elongation and reduces the yarn mass irregularity. With coarse and medium count the plied yarns are stronger by about 5 times than their corresponding single yarn samples in white fibres and 4 times higher in brown fibre yarns.

The yarn elongation of single and plied yarns made from white and brown fibres are given in figures 8 and 9. Yarn elongation follows the trend of yarn strength. Elongation of single and plied yarns made from white fibres is higher than that of brown fibre yarns.

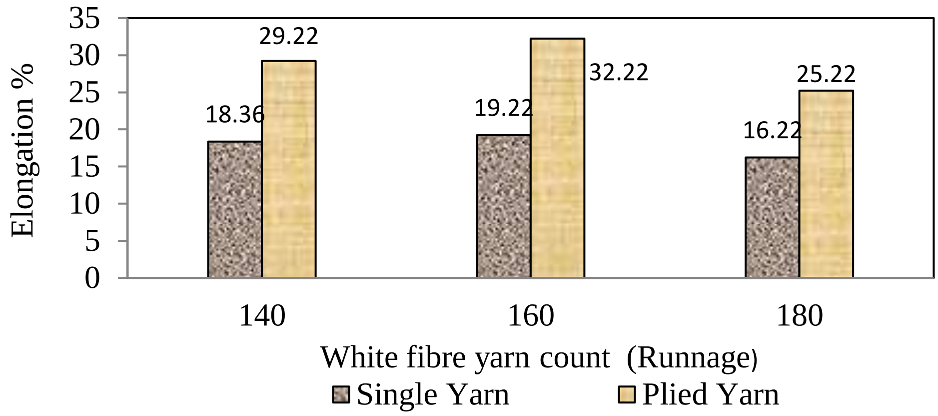

Figure 8. Elongation of white fibre yarns

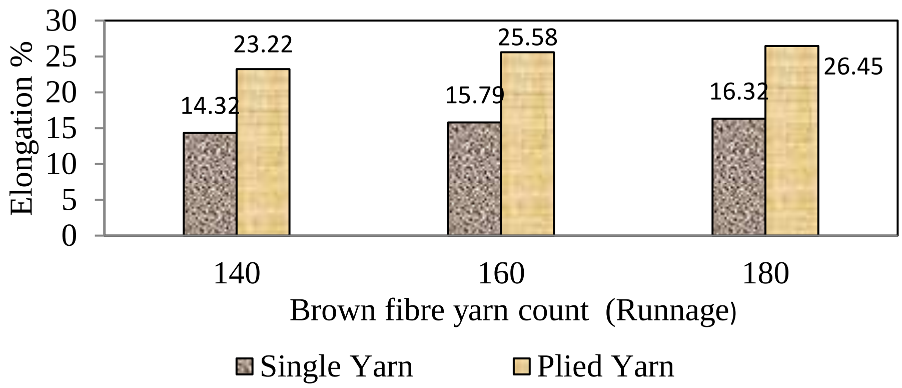

Figure 9. Elongation of brown fibre yarns

Yarn elongation of two ply brown fibre yarns is lower by about 6% in coarse and medium count and 2 % lower in the finer count. The higher single yarn elongation could be the reason for the higher elongation of two ply yarn. With finer yarns there is no much improvement in the yarn elongation.

5.3 Coefficient of Variation of Mass of One Meter Cut Length of Yarn Samples

The co efficient of variation of mass of one meter cut length of single and two ply yarns of white and brown fibres are measured and the results are given in figure.10 and 11. Yarns made white fibres are more regular than brown fibre yarns. In coarse and medium count yarns from white fibre, the CV% values are lower by 4 to 5% and in finer count lower by 7% than brown fibre yarns. This could be due to relatively low flexural resistance of white fibre made them to follow direction of twist in the yarn structure also there was less waste generation due to less fibre shedding while processing of white fibre.

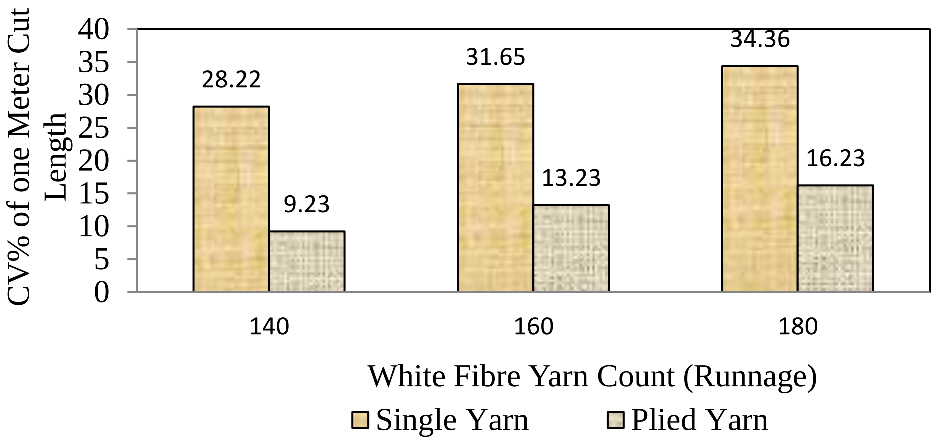

Figure 10. CV% of one meter cut length of single and plied yarns made from white fibre

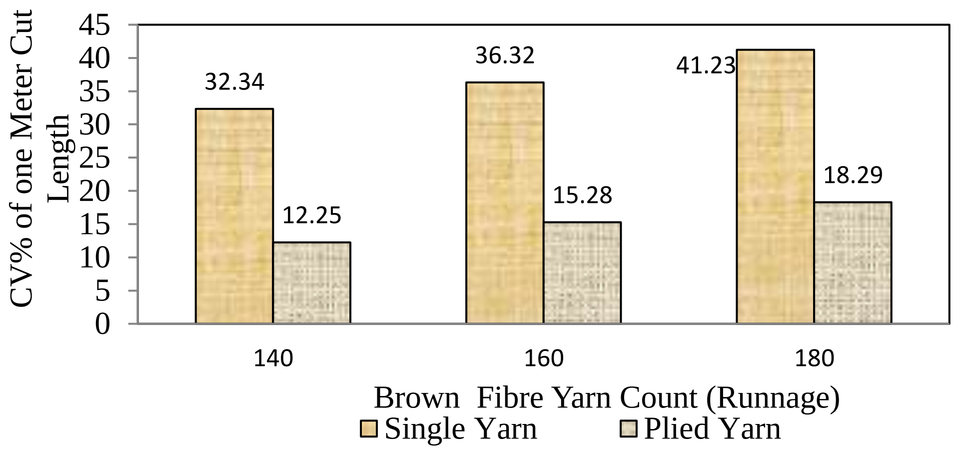

Figure 11. CV% of one meter cut length of single and plied yarns made from brown fibre

Due to plying there is about 18 -19% reduction in the one meter cut length CV% of two ply yarn made white fibre in comparison with their corresponding single yarns. The reduction in the CV% are found to be higher (about 20 – 22%) with brown fibres.

5.4 Spinning performance of Brown and White Fibres

Performance of any spinning system is assessed in terms of yarn breaks during spinning and yarn realisation. The yarn breaks rate is expressed as the number of breaks per spindle hour. The observed breaks per spindle hour for different runnage of yarns for the white fibre yarns and brown fibre yarns are given in figure 12. In all the yarn runnage, the end breaks rate was found to be significantly low while processing the white fibres. This could be due to the relative low flexural rigidity of white fibre. Most of breaks were due to the accumulation of fibres in the yarn path leading to the chocking of spinning nozzle. While processing white fibres there is about 50 to 60% reduction of yarn breaks in coarse and medium count and about 70% reduction in fine count.

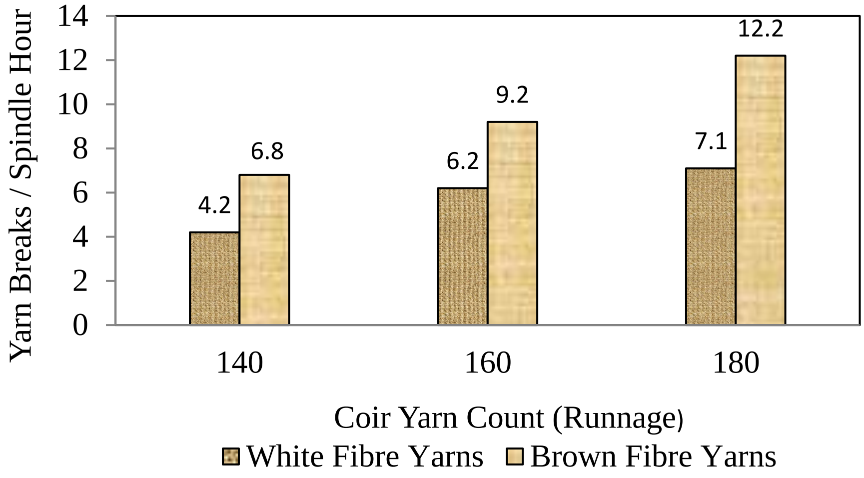

Figure 12. Yarn breaks per spindle hour for white and brown fibre yarns

5.6 Yarn Realisation

The quantity of waste generated at the different stages of spinning process determines the quantity of yarn produced from a given quantity of fibre material. The % of waste generated at the different sections of the spinning is shown in Table.2

Table 2. Waste generated and yarn realisation

Fibre Type	Feeding Segment	Beater Segment I	Beater Segment II	Spinning Segment	Winding Segment	Yarn Realisation %	
						Range	Mean
White Fibre	2	1	0.5	3	0.5	91-95	93
Brown Fibre	2	2	1	4.5	0.5	88 -90	90

Since white fibres are finer and more pliable than brown fibres, the waste generated at different stages of the spinning process is found to be relatively low. This results in better yarn realisation while processing brown fibre in the mechanised spinning system.

6. Conclusions

Two ply coir yarns are the output of mechanised spinning process. The arrangement of fibres in the yarn structure is not in order and the fibres are not following the direction of yarn axis. Since white fibre is more pliable and finer, the spinning behaviour of white fibre is found to be better. White fibre yarns are stronger than brown fibre yarns due its fineness and improved pliability and higher number of fibres in the yarn cross section. With finer yarns (180 runnage), the strength of brown fibre yarns are inferior. Elongation of the coir fibre follows the same pattern as that of yarn strength. Higher elongation is observed in white fibre yarns. CV% of mass of one meter cut length of yarn samples is found to be low with white fibre yarns. The spinning performance, yarn breaks per spindle hour was observed to be very low while processing white fibres. The ability of white fibres to follow the twist in the yarn due to its low flexural resistance reduces the fibre shedding reducing the yarn breaks. Due to low fibre shedding and waste generation, yarn realisation of white fibre is found to be higher than that of brown fibre. With brown fibres, spinning of finer yarns (180 runnage) resulted in higher incidents of yarn break with poor quality of yarns.

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