The Effect of Spinning Methods on the Quality of Kenaf Yarn

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Abstract

The quality of kenaf yarn is very important for its application in different industries and this makes it very important for farmers and processors to target quality production cum production rate. Meanwhile, manual spinning of kenaf fibres has been the oldest and the most common method of kenaf yarn production in Nigeria until the development of a kenaf spinning and reeling machine for small scale farmers. To compare the quality of yarn production from manually and mechanically spun kenaf yarn, three varieties of kenaf fibres were spun with the production rate of 1.23m/hr, 0.81m/hr and 0.97m/hr when spun manually and 18.8m/hr when spun mechanically for Tianung 2, Cuba 108 and Ifeken DI 400 respectively. For the mechanically spun yarns, a spinning and reeling speeds of 90 and 80 rpm combination were used for the production while the different spinning experts were selected to also spin the same varieties of kenaf fibres. The spun yarn samples using the different methods were subjected to mechanical test for the determination of the stress, strain, young modulus, tensile strength, extension which were used to determine the quality ratio of the the different yarns. It was discovered that the methods of spinning yarn affects the quality of spun yarn and the use of the kenaf spinning and reeling machine to produce a better quality of yarn with Ifeken DI 400 (148%), Tianung 2 (91%) and Cuba 108 (67%) while the quality ratio for manually spun yarn are Ifeken DI 400 (41%), Tianung 2 (49%) and Cuba 108 (27%).

Keywords: Kenaf; fibres; yarn; spinner; quality-ratio, yarn-count.

1. INTRODUCTION

All the components of kenaf are harvestable and useful to mankind (Atta and Ogunniyan, 2024) and this has made the crop very useful beyond the textile industry, especially when spun to yarn (Tegu *et al.,* 2023). Over the years, fibre production from kenaf has been the major purpose for its cultivation across the globe due to its properties (Sen and Jagannatha, 2011) which has made India, Banglahdesh, United States of America, Indonesia, South Africa, Malaysia, Viet Nam, Thailand, parts of Africa and to a small extent in South Eastern Europe for fibre production (Raji and Aremu,

2017) to be recognized with its production and farmers tend to retain or increase its growth due to its increasing potentials across different industries when spun to yarn (Atta *et al*. 2021). Despite the availability of several spinning methods for fibres, the staple nature of kenaf has made ring spinning methods very adaptable for the development of a kenaf spinning and reeling machine for mechanical spinning while several practice improves the skills of personnel that soins manually which makes them proficient over time. While several spinning ethods can be sued to develop equipment for small scale farmers that are into artificial fibres, In Nigeria, there are five major varieties of kenaf that are commercially available for kenaf farmers and recent studies made it evident that the different varieties have different engineering properties which in turn affects the properties of the yarn spun making them suitable for different applications. When kenaf are spun manually, the fineness and diameter are carefully narrowed to its purpose of production which are majorly either to form ropes or yarn that serves as raw materials for some textile industrial applications (Samad *et al*., 2002). The kenaf spinning and reeling machine Productions of quality yarn for different applications was factored into the development of the kenaf spinning and reeling machine. Also, some farmers are happy with the development of some local varieties of kenaf for the production of quality yarn as they serve as a viable replacement for foreign varieties (Atta *et al.,* 2021). The quality of fibres affects the quality of the yarn produced from such fibre and this has made the fibre crop a very important crop (Atta *et al.,* 2024). The quality of fibres, varieties and spinning methods form the basis for the quality of yarn made from kenaf. The development of kenaf spinning and reeling machine was reported to save time and also produces yarn with quality ratio between 58.4% - 82.3% (Atta and Owolarafe, 2023).

MATERIALS AND METHODS

Figure 1 shows a picture of a developed kenaf spinning and reeling machine which is found suitable for the production of single or double ply yarn for small kenaf processors while Figure 2

shows how kenaf fibres are spun manually in a kenaf laboratory. Three varieties of commercially available kenaf (Ifeken DI 400, Cuba 108 and Tianung 2) were spun using both spinning methods at the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan. The fibres were mechanically spun into yarn at spinning and reeling speeds of 90 rpm and 80 rpm respectively. Samples were weighed and data taken for the determination of the yarn count, tensile stress, strain, young modulus and tensile strength with the use of an Universal Instron Testing Machine (USA, 50kN). Data collected were used for the determination of the quality ratio of the samples using equation (2)



Figure 1: Kenaf Yarn being spun manually



Figure 2: Kenaf Twinning Machine (Single Ply Yarn)



Figure 3: Kenaf Spinning Machine (Double Ply Yarn)

Production of Yarn Samples Manually and Mechanically

Figure 1 shows the method of manual spinning used majorly by trained spinners at a Kenaf laboratory. Time used for the production of yarn was taken with the use of a timer with much preference for low count yarn as raw materials for textile industry. For mechanical spinning, the kenaf spinning and reeling machine uses ring spinning method for endless length of kenaf yarn production. The machine was used to join different length of kenaf yarn as a single ply of 10m on two bobbins and then used for double ply yarn production. This means that for a double ply yarn production, production rate is multiplied by 3 for three different operations carried out on the machine for adequate comparison.

Yarn count (C_Y) for Samples

It is the measurement of a unit length of spun yarn. It is measured kg/m or in tex. Samples spun either mechanically or manually were measured duly and data taken.

Production speed or yarn delivery speed (N_3) for Double Ply Yarn

The yarn delivery speed was determined as

$$N_3 = [\pi\, d_r\, (N_2 - N_1)] / 3 \quad (1)$$

where V = yarn delivery speed,

d_r = diameter of the reeling pulley (cm)

N_2 = speed of the reeling pulley (rev/min),

N_1 = speed of the twisting/spinning cone (rev/min).

Production or yarn delivery speed is measured in centimeter per minute.

Determination of Quality Ratio

The following formula was used to determine the quality ratio of the spun yarn according to Samad *et al*. (2002);

$$\text{Quality Ratio} = \frac{Tensile\ strength\ (lbs)}{Yarn\ Count\ (\frac{lbs}{spy})} \times 100 \quad (2)$$

Statistical Analysis

The paired t-Test of two samples assuming equal variance was used to compare the manual spinning and mechanical spinning data. This was to determine if the means measured are totally different and if the difference are away from what is attributed to chance or experimental error and difference was considered as significant at $t_{computed} > t_{table}$ (95% confidence) levels as given in equation (1).

$$t = \frac{\sum D/N}{\sqrt{\frac{\sum D^2 - \left(\frac{(\sum D)^2}{N}\right)}{(N-1)(N)}}} \quad (3)$$

Where:

$\sum D$ = summation of the differences.

$\sum D^2$ = summation of the squared differences,

$(\sum D)^2$ = summation of the differences squared.

N = number of samples

RESULTS AND DISCUSSION

Table 1 shows the result table of the quality parameters for the three varieties of kenaf that were spun manually and by mechanical means. For the production rate of kenaf yarn produced by the two different methods of spinning (Figure 4), it was discovered that the production range was

between 0.81 m/hr to 18.8 m/hr with a twist number range of 113 to 183 turns per minute (Atta *et al.,* 2023). This indicates that for any kenaf or related fibre that is fed into the machine at the varying speed combination, the production rate will be in the range (0.81 m/hr – 18.8 m/hr). However, it is also important to understand that it is not enough to have high production rate of yarn but with good strength characteristics and quality.

Despite the recommendation of twisting over the use of adhesives as a better way of binding fibres, over-twisting of kenaf fibre to produce yarn may reduce the strength and quality of yarn before it eventually breaks (Hosne, 2011).

Table1. Result for the quality parameters of different varieties of kenaf spun manually and mechanically

S/N	Variety	Production rate (m/hr)		Yarn Count lbs/spy(tex)		Tensile strength N		E Modulus (gf/tex)		Mean Quality Ratio (%)	
		Manual	Mechanical	Manual	Mechanical	Manual	Mechanical	Manual	Mechanical	Manual	Mechanical
1	Tianung 2	1.23	18.8	45.59 (1571.)	31.09 (1071)	98.70	126.00	608.97	1491116	49	91
2	Cuba 108	0.81	18.8	38.90 (1340)	31.55 (1087)	47.38	94.10	891.91	707887	27	67
3	Ifeken DI 400	0.97	18.8	34.47 (1187)	9.61 (331)	62.95	63.30	162.41	174288	41	148

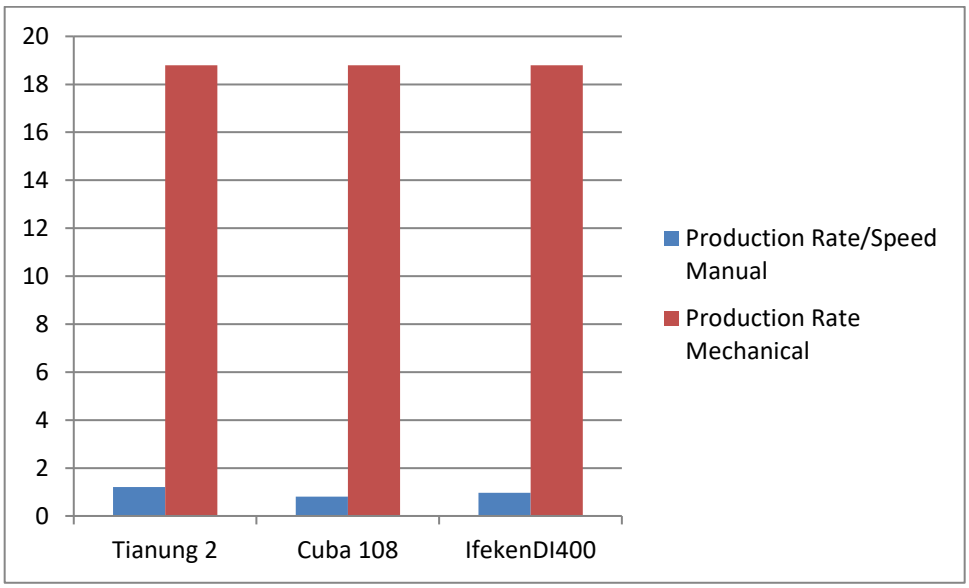


Figure 4: Production rate for manual and mechanical production of Kenaf Yarn

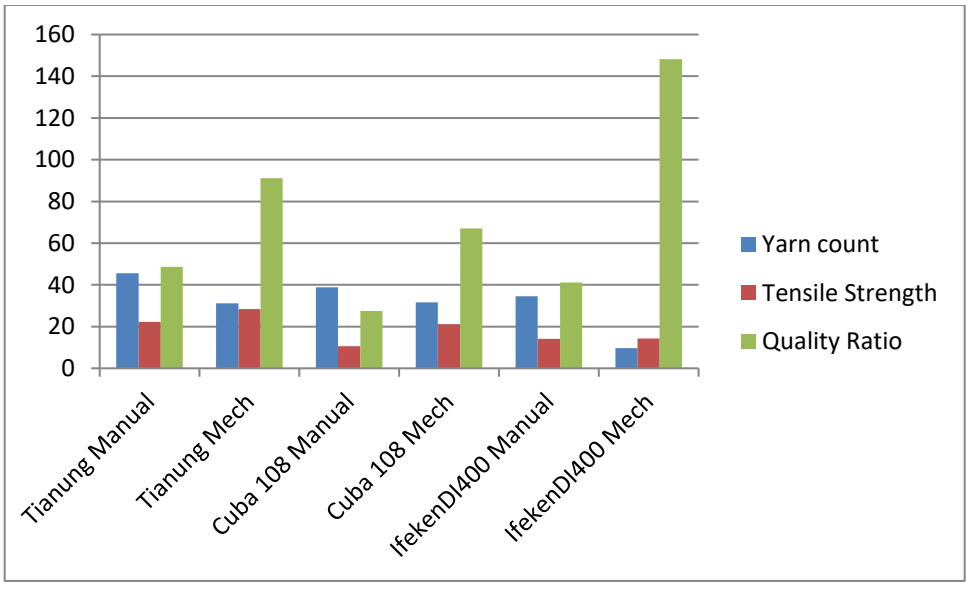


Figure 5: Quality Parameters of Kenaf Yarn Spun Manually and Mechanically

Yarn count and Tensile strength of manually and mechanically spun kenaf yarn.

For both methods of spinning, the yarn counts are physically appreciated but the count of the yarn produced by the kenaf spinning and reeling machine is finer than the yarn count of the manually

spun (Table 1). Figure 5 showed that Ifeken DI 400 produced the lowest yarn count with 1187 tex (35 lbs/spy) and 331 tex (9.61 lbs/spy) for manually spun and mechanically spun yarn respectfully. All the varieties produced by the machines produced lower yarn count when compared with the manually spun yarns making the equipment produced yarn with very low yarn counts which makes the products has the finest property (Aisyah *et al.*, 2018) and also possesses the highest potential to be acceptable in the textile industry (Kadoglu, 2006; Atta *et al.* 2024). Also, IfekenDI 400 yarns spun by the machine that were found to have the with the finest yarn was seen to possess the least tensile strengths. This is in support to the report of Atta *et al.* (2024), Shah *et al*. (2013) and Aisyah *et al*. (2018) who affirmed that yarn count directly affects the tensile strength of kenaf yarn which in turn affects the quality of yarn (Samad *et al.*, 2002).

Comparison of the Quality Ratio of Manually and Mechanically Spun Kenaf Yarn

Comparison of tianung, cuba 108, and ifeken DI 400 yarn quality ratios of manually spinning with mechanically spinning was present graphically in Figures 1. The graphical analysis (Figure 1) showed a very apart association of the bars of the manually and mechanically spinning quality ratio of the tianung, cuba 108, and Ifeken DI yarn, respectively. The processes – the manually and mechanically spinning yarn quality ratio computed data (Table 2). It showed that the data were not closely aligned. The percentage error bar showed a statistically significant different which revealing its mean reliability treatment (Figure 1). This showed that there was no correlation with the quality ratio data obtained from the manual and mechanical spinning operations. When the means of the manual and mechanical spinning output capacities were compared statistically as shown in Table 3. It was revealed that there is highly significant difference between the means at 5% level of significance, since the t stat (calculated "t") value (6.25277) is greater than the t critical (table "t") value (2.200985).

Table 2: Kenaf Yarn Quality Ratio

Kenaf Specie	Sample	Yarn Quality Ratio	
		Manual Spinning	Mechanical Spinning
Tianung	1	55.906	91.191
	2	32.891	91.191
	3	65.033	91.191
	4	48.709	91.191
Cuba 108	1	41.753	67.101
	2	17.622	67.101
	3	17.408	67.101
	4	27.405	67.101
Ifeken DI 400	1	18.423	148.234
	2	66.013	148.234
	3	48.136	148.234
	4	41.098	148.234

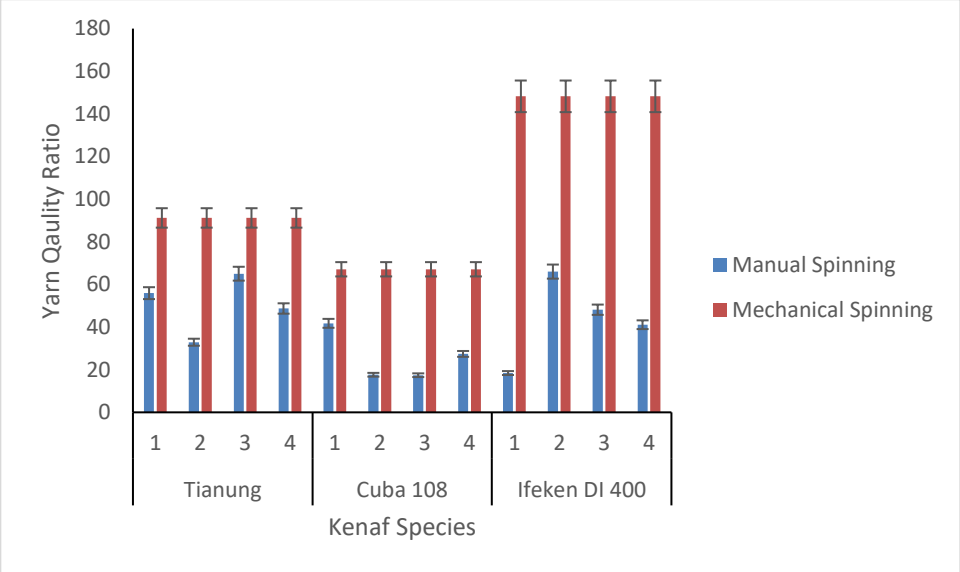


Figure 1: Yarn Quality Ratio vs Kenaf Species

Table 3: Paired t-Test Sample for Mean

	Variable 1	Variable 2
Mean	40.03308	102.1753
Variance	308.0497	1262.642
Observations	12	12
Pearson Correlation	0.309014	
Hypothesized Mean Difference	0	
Df	11	
t Stat	6.25277	
P(T<=t) one-tail	3.12E-05	
t Critical one-tail	1.795885	
P(T<=t) two-tail	6.24E-05	
t Critical two-tail	2.200985	

2. CONCLUSION

Apart from higher rate of production, kenaf fibres spun mechanically were found to be finer and with higher quality ratio than fibres that were spun manually. Farmers could adopt the use of a kenaf fibre spinning and reeling machine for the production of kenaf yarn that will be acceptable in the textile industry. The quality of the yarn spun by both methods were also found to be suitable to be used for various industrial and homecare applications.

3. ACKNOWLEDGMENT

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