Potential of Kapok Fibre as a Substitute of Cotton in Textiles

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ABSTRACT

Kapok fibre, commonly known in Kiswahili as 'sufi' is obtained from kapok plant, *Ceiba pentandra*. The conventional end uses of kapok include mattress/pillow stuffing, upholstery and thermal insulation. The market for kapok in these traditional uses has declined considerably over the past 30 years, due to the developments in synthetic materials, such as foamed plastics, which have almost replaced kapok in most of its traditional end uses. Attempts to use kapok fibre for producing textile yarn were not successful due to the slippery nature of the fibres and its britleness. However, a blend of kapok and cotton fibres was successfully spun into a yarn after blending the two in a kapok/cotton ratio 3:2. The yarn produced exhibited mechanical properties similar to most of the short staple fibres. The fabric produced was lustrous, slippery and with a smooth, soft handle. The fibre yarn resulting from blending kapok with cotton is potentially suitable for producing woven textile fabrics. In addition to its potential use as clothing material, the fabric is being considered for suitability as reinforcement to thermosetting polymeric materials such as polyester and phenolic resins.

KEY WORDS

Kapok, cotton, textile

1.0 INTRODUCTION

Kapok fibre is obtained from the plant *Ceiba pentandra*. It is a natural vegetable fibre which together with cotton, is classified as a seed fibre. Barker, 1965 identified three varieties of *Ceiba pentandra*, namely; *Var. caribaea*, *Var. guineensis* and *Var pentandra* synonymous to *Var. indica (DC) Bakh.* *Var. pentandra* is a natural hybrid between *Var. carbaea* and *Var. guineensis*. *Var. caribaea* is reported to occur wild in American tropics and in evergreen, moist, semi-reciduos and gallery forest of West Africa. Kapok is said to have reached Java by the 10th century and that it is the Arab traders who took kapok from West Africa to India and far East.

In East Africa the most common species is *Var. pentandra*. The tree is reported to give the best yield and quality of fibre when grown at less than 441 m above sea level (Kirby, 1963). In Tanzania (formerly Tanganyika), the plant has been largely grown in Mbeya, Morogoro, Tanga, Kilimanjaro and Coast regions. There are reports of scattered kapok trees in several other regions. Kapok plant has existed in this country even before the first world war and it is said to have been brought by missionaries (Hadjivayanis G., Personal communication).

It is estimated that Tanzania and Kenya had by 1959, over 480,250 kapok trees from which about 873,182 kg of kapok fibre was exported (Kirby, 1963). In the same year India and Thailand exported about 514,091 kg and 10,298,636 kg of kapok fibre respectively. Generally, difficulties to spin kapok fibre with conventional cotton spinning systems have been experienced. This has mainly been due to the brittle nature of the fibre. However, incidents where the fibre has been spun into yarn and used as a textile material have been reported (Purseglove, 1987).

The traditional end uses of kapok fibre include mattress/pillow stuffing, upholstery and thermal insulation. The market for kapok in its traditional end uses has declined considerably over the past 30 years due to the developments in synthetic materials such as foam mattresses, which have almost replaced kapok fibre in most of its traditional end uses. The fibre, therefore, lost its value and peasants have almost abandoned it as a commercial crop. Possibilities of spinning the kapok fibre, alone or in blends, into yarn and making textile materials can revive it as a commercial textile fibre. This would additionally bring back to life the Tanzanian ailing industry, which has failed to cope with rising prices of raw cotton fibre.

Most plant fibres exhibit hydrophillic properties, sometimes absorbing moisture to levels of up to or more than, their own weight. This makes plant fibres unfavourable for reinforcement, because high moisture leads to swelling making the composites dimensionally unstable. Kapok fibres are potentially good as reinforcement to plastics due to mainly their low specific gravity and low moisture uptake. However, the slippery nature of the fibres may affect bonding characteristics at the matrix-fibre interface, resulting in composites with poor strength. The surface of the fibres may therefore have to be chemically modified to provide a surface with better wettability and adhesive properties.

Successful development of textiles and composite materials using kapok fibre will result in a resurgence of the kapok fibre industry, and increased demand may stimulate increased production of the fibre. This will provide new jobs thus improving the standard of living of the rural population where the *Ceiba pentandra* which yields the kapok fibre is grown. Also, this new development offers new prospects of recovery for the ailing textile industry in Tanzania, which is failing to cope with rising prices of raw cotton.

Large scale manufacture of kapok fibre plastics in the form of plain or corrugated panel will reduce the demand for wood and timber products in the construction industry, thus slowing down the deforestation rate. The composites may also be used to manufacture a variety of domestic items and furniture.

This paper examines the potential of kapok cotton fibre blend as a useful textile material for clothing.

2.0 Experimental Methods

Kapok fibre used was obtained from traders in Morogoro, Tanzania. It was spread on a wet canvas cloth for 72 hours. The fibre tensile strength was determined using the Pressly tensile strength tester. The 2.5% spun length of fibres together with its maturity was determined using a Digital Fibrograph model 530. Moisture regain was determined in accordance with ASTM D 2495. The fibre was not conditioned due to lack of conditioning facilities. These same parameters were not determined on cotton fibre because all machine settings applied for processing the kapok/cotton fibre blend were based on cotton physical properties such as staple length and tensile strength.

About 25% of cotton fibre was mixed with kapok fibre at the blenders in the blow room. Only one cleaner was used to avoid damage on kapok fibre. The pressure at the calender rollers at the scutcher lap forming was set to suit kapok fibre.

The cards were operated at 78 draft without using the pneumatic system. Schubert and Sulzer type 4110 drawframes were used. The drawframes, with an input of 8 slivers, were set to operate at a draft of 8 and a deliverly speed of 250 m/min. The pressure at the drafting zone was reduced from 300 N to a minimum. Carded cotton fibre was increased at this stage to about 40%. The second drafting in a drawframe was operated at low speed than at the first drafting stage. The roving was produced on a speedframe Schubert and Sulzer type 4303 and run at a delivery speed of 25 m/min. The distance between the nips of successive sets of rollers (ratch setting) in a drawframe was set to accommodate the staple length of cotton fibres.

The yarn was spun on ringframes Schubert and Sulzer type 4409. The ringframe speed was 10,000 RPM with a draft of 26. It was then wound in cones, doubled and twisted.
A 50m warp beam was prepared for weaving. Picanol loom, type President M.D.C. was used. A reed of 6.2 ends per cm was used. The loom was run at a speed of 178 revolutions per minute (RPM). This speed at 100% efficiency gives an insertion of 10.7 picks per minute and and a fabric production of 17.2 m/hr.

Zweigle type F410 single yarn tensile strength tester was used. The test was carried out in accordance with BS 1932. The fabric strength was determined using Zwick tensile strength tester type 1141 and the test was carried out in accordance with BS 2576. The materials were tested at laboratory temperature which ranged between 27°C and 29°C. The relative humidity was about 80%.

3.0 Results and Discussion

The mechanical and physical properties of kapok fibres, kapok-cotton yarn, and textile cloth are shown in Table 1. Spinning of kapok fibres is difficult. The slippery and lustrous characteristic of kapok fibre is probably due to the waxy continuous covering and the structure of the fibre. The slipperiness contributes to the poor cohesion between fibre and fibre, fibre and calendee rollers, and fibre and drafting rollers, which then resulted in difficulties to form a lap at the scutcher. The same problem is experienced at the drafting zone in a drawframe.

Kapok fibre in a drawframe has been observed to form detached groups. This resulted into sliver breaks at delivery end with 75:25 kapok/cotton blend ratio. It was after experiencing this problem that cotton was increased to 40%.

Difficulties have been encountered during weaving with the cloth roller and a rough faced cloth take up roller had to be used. However, slipping tendency was not easily observed at the ring frame during yarn spinning. Kapok fibre tended to break easily when under pressure at calender rollers, and drafting rollers. At the cone winding a lot of fibre dust was generated into the air during the winding process. This fibre dust was assumed to consist, mostly, kapok fibres because during the same cone winding process and at higher speeds, cotton yarn does not produce so much amount of cotton dust.

The tensile strength obtained in this work for kapok fibre is quite similar to the tensile strength of some of the Indian cotton fibres such as Short A V797 which Ratnam and Chellaman (1988), reports that it has a tensile strength of 0.241 N/tex. Although the moisture content of kapok fibre is higher than that of cotton fibre, it is known to be water repellant and buoyant (Purseglove, 1984).

Kapok fibre had a measured 2.5% spun length of 24.24 mm, while cotton fibre used had spun length of 25.5 mm. This is considered to be fairly compatible fibre length for blending. Kapok fibre tensile strength and modulus, found to be 0.24 N/tex and 12 N/tex respectively are within the range of most natural fibres. For instance non-medullated wool is reported to have a tensile strength of about 0.14 N/tex and st. vincent cotton has a nominal tensile strength of 0.45 N/tex.
Some synthetic fibres have even much less nominal tensile strength, for example, low density polyethylene has a tensile strength of about 0.08 N/tex (Morton and Hearle, 1975).

The increase of warp and weft yarn per centimetre from 6.2 x 6.8 in the reed to 7.1 x 7.4 after doffing, is due to the relaxation of the fabric. It is possible to spin blends of kapok and cotton fibres with less than 40% cotton fibre in the blend. Surface treatment on kapok fibre will mean a partial or total removal of the waxy covering reported to be on the surface of kapok fibre and, therefore, an improvement on frictional and fibre cohesive forces. This fibre surface treatment will ultimately bring about improvement on kapok fibre spinnability and high production.

The formation of kapok fibre groups during drafting in a drawframe is probably caused by undesirable ratch ratio. Lord *et al.* (1992) observed that if an optimum ratch ratio is not maintained fibres will tend to travel in groups in a drawframe. This effect is expected to be more pronounced with fibres with poor cohesive forces, and in this work kapok fibres were seen to travel in groups partly because it is shorter than cotton but more so because of its poor cohesive forces.

Table 1. Properties of kapok and cotton fibre, cotton and kapok/cotton yarn and cotton and kapok/cotton fabric

	Kapok fibre	Cotton fibre	Cotton yarn	Kapok-Cotton blend yarn	Cotton fabric	Kapok-Cotton blend fabric
Appearance	White-yellowish, lustrous	Dull	Dull	Lustrous	Dull	Lustrous
Handle	Slippery and smooth	Soft	Soft	Slippery, smooth	Soft	Slippery, smooth
Moisture content (%)	9.9	7.5	-	-	-	-
2.5% Spun length (mm)	24.4	25.5	-	-	-	-
Fibre maturity (%)	93	86	-	-	-	-
Fineness (micronnaire)	0	4	-	-	-	-
Diameter (μm)	25	15	-	-	-	-
Linear density (tex)	-	-	100	34	-	-
Breaking extension (%)	2	7	13	5.5	7	8
Tensile strength (N/tex)	0.24	0.47	0.45	0.13	360 N/50mm	180 N/50 mm
Tensile modulus (N/tex)	12	6.7	3.5	2.4	-	-
Irregularity (Ulster %)	-	-	9	5	-	-
Construction (warp x weft) yarn/cm	-	-	-	-	7 x 7	7 x 7
Weight (g/m^2)	-	-	-	-	142.47	97.23

A success in getting economical blends of kapok/cotton fibres and/or production of wholly kapok fibre textile materials will have tremendous social and economic impact to our ailing textile industry and social status of the rural peasants, where the plant *Ceiba pentandra* is mainly grown. It will also mean a great relief on the current dependence on cotton as a sole ingredient on the manufacture of fabrics and other end uses.

4.0 CONCLUSION

i) The addition of cotton to kapok improves the friction between the fibres and the spinning machines thus facilitating the spinning process.

ii) Kapok fibre has mechanical properties comparable to cotton, with the added advantage of water repellency.

iii) Textiles produced from the kapok - cotton blend have a good lustre and are suitable as a clothing material.

5.0 Recommendations for Future Work

i) It is recommended that further research be carried out to determine the economical kapok/cotton blend ratio and the possibility of spinning 100% kapok fibre textile materials.

ii) An evaluation of the mechanical and physical properties be made on composite materials to be produced using the developed textile cloth (kapok-cotton blend) with polymeric matrices.

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