Kenaf Fibre (*Hibiscus cannabinus* L.): A Viable Alternative to Jute Fibre (*Corchorus genus*) for Agro-Sack Production in Nigeria


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**Abstract:** This study centered on finding locally available and alternative material to imported Jute fibre and agro-sack for packaging and exporting Nigerian agro-products. The agro-sack industries in Nigeria have turned to the use of hydrocarbon/synthetic sack in packaging of indigenous agro-products like cotton, cocoa, onions, kola nut, palm kernel, potatoes, grain, sugar, coffee, cassava etc., which have led to it being rejected and the products bought at a discount rate at the international market, which have affected our gross domestic product (GDP) and increased post-harvest food loss across the country due to poor material selection and inadequate packaging system. There is urgent need to explore the use of indigenous Kenaf fibre as alternative to Jute fibre and discourage the use of hydrocarbon/synthetic bags. Standardized process for Kenaf fibre extraction, quality evaluation of extracted fibre and standardizing fibre grade, chemical and anatomic microscopic properties, mechanical and optimal load caring capacities, yarn preparation and experimental weaving were evaluated from indigenous Kenaf fibre plant. Kenaf bast fibre compared well with Jute fibre in terms of fibre length range of 2.0-2.7 mm, 2.02-3.2 mm, fibre diameter; 17.7-21.1μm, 15.9-20.7μm, density; 0.98-1.2g/cm³, 0.99-1.3g/cm³, ash content; 0.6-2.35%,0.5-1, moisture content; 9.18-10.05%,17.0-12.5%, while cellulose content; 57.7-60.2%, 51-84%, lignin; 19.2-20.0%,14-29%, hemicellulose; 18.06-20.03%, 12-20% and tensile strength; 450.0-816.7 MPa, 393-800 MPa, elongation at break; 1.4-2.8 %, 1.6-1.8% and young’s modulus; 20-39.0GPa, 24-26Gpa for Kenaf and Jute fibres respectively.

**Key words:** Kenaf fibres - Retting - Spinning - Weaving - Agro-sack

**INTRODUCTION**

Kenaf (*Hibiscus cannabinus* L.) is a fast growing short duration multipurpose crop. It is among the most valuable hard industrial fibre crop after cotton and can be grown in a wide range of ecologies in the country. Kenaf has a high growth rate of between 5-6 months, rising to heights of 12-18 feet in about 4-5 months and its yield is about 6-11 tons (new varieties may reach 22 tons) of dry weight per hectare per year which is 5-10 times greater than the yield for most conventional trees which can take from 7-40 years to reach harvestable size. It is a plant that produces fibres similar to hardwoods and softwoods. Kenaf has a single, straight, un-branched stem consisting of two fibre parts the outer, bast fibre which is about 35% the stalk’s dry weight, as long as the stem, relatively strong, considered as the most important fraction of Kenaf bast plant and the inner, core fibre which comprises about 65% of the stalk’s dry weight [1]. Kenaf fibre being regarded as an alternative fibre to Jute plant which is an annual fibre, grows in marginal land, with less weeding, high yield with high industrial value, requires less water to grow than Jute and is now grown in several countries in Europe, Africa, South America, Mexico, the United States, Japan and China aside the major fibres producing countries such as India, Bangladesh, Myanmar, Nepal, Malaysia and Thailand. From the report of the Food and Agriculture Organization (FAO) [2] and the International Jute Study Group (IJSG) that the demand for Kenaf is growing higher but there is still a low level in technical advancement in mechanization.
In the Nigerian scenario, Kenaf plant is being grown in over twenty (20) states of the federation including the state capital Abuja. It is established that Nigeria has potential of over one million hectares suitable for cultivation of Kenaf. The production of Kenaf assumed national significance in Nigeria in 1960s when the federal government established two cottage factories to produce sacks/natural bags for packaging of agricultural produce (cotton, cocoa, palm kernel etc.) for domestic and international market (the Nigeria Fibre Industries Co. Limited –NIFINCO, Ibadan and the ‘Jute’ bag factory, Badagry, the Northern Nigeria Fibre Products Limited (NNFP) and Nigeria Agro-Sacks Company (NASCO)), Jos. The project failed and the factories closed down due to technical constraints. Following the closure of the two fibre factories in the country, farmers resorted to the use of synthetic/hydrocarbon bags for packaging agricultural produce, which contribute to post harvest food losses across the country, poor protection, reduced shelf life, health and environmental issues. However, the use of synthetic bags for packaging agricultural produce has been banned by the international committee on commodity exports effective in 1999, due to damage and negative effect on the quality of agricultural produce. A new array of hope is emerging for increase demand for natural fibres made bags and consequently kenaf in the country. This is happening alongside the renewed vigour by Nigerian government to expand production of certain crops (e.g. cocoa, cotton, onion etc) for export, which thus adds even to the domestic prospect of kenaf.

There is urgent need to make a policy on use of agro-sacks produced from Kenaf rather than imported Jute sack or hydrocarbon/ synthetic fibres (i.e. polypropylene etc.). Kenaf fibre agro-sacks improve air permeability and are suitable for haulage and storing agro-products.

Value Added Products from Kenaf: Virtually all parts of Kenaf (like the oil palm) have industrial applications. The stalk of Kenaf can be used almost entirely. Kenaf leaves and stems have a potential as livestock feed. Dried leaves contain about 30% crude protein and are used as vegetables in some part of the world. In recent years, with increasing concerns for environmental protection, Kenaf has found more applications. The breakthroughs and advances in environmental/bio-technology have resulted from intensive testing and research in the industrial application Kenaf fibre. Here are some examples:

Agro-Sack Production: Retted and processed Kenaf fibre is used to manufacture twine, cordage and rope as well as agro- sacks and hessian cloth as alternative to Jute fibre (Corchorus genus), sisal (Agave sisalana) and hemp (Cannabis sativa) which have been established through R&D in FIIRO. It has great demand in the global market with various designs of bags such as shopping bags, school bags, wine bags, ladies bags, alternative to plastic bag etc.

Pulp & Paper Production: Kenaf plant is a unique raw material for pulp and paper production with high growth rate. The cost of production of a ton of pulp from Kenaf fibre is much lower than other tree based pulp, because of lower lignin content, cost efficiency both in energy and chemicals required for pulping. To reduce imported long fibre pulp and attain self-sufficiency in local demand for pulp and paper products in Nigeria through FIIRO-R&D, the federal government of Nigeria established three major paper mills such as: Nigerian paper mills limited, Jebba Kwara State, Nigerian Newsprint manufacturing company, Oku-Iboku, Akwa-Ibom State and Nigerian National paper manufacturing company, Iwopin Ogun State.

Kenaf in Geo-Textiles Application: Woven Kenaf Mesh and Net with potential application in highway Engineering/soil erosion control on cuttings and slopes

Agro-Textiles: Kenaf fibre in various agronomical and horticultural applications such as plant nets, harvesting nets, nursery pots and sheets, wind shields, mulching materials etc.

Oil & Chemical Absorbency: The core portion of Kenaf fibre is a very good absorbent used to clean up oil spills, absorption of oil from sea water and similar chemicals. The uniqueness of Kenaf in its use to absorb is that it absorbs oil before taking water.

Kenaf Fibre/Particle Reinforced Composite (FRP/PRP): incorporation of Kenaf fibre with synthetic polymers/resins as matrix for low load bearing applications such as automotive industry (car bumpers, dash boards, door panels, transmission shelves etc), packaging and construction industries.

Construction & Housing Industry: Kenaf reinforced composite molded into lightweight panels, can replace wood and wood-based products in many applications. Engineered plastic lumber as building materials, home furniture, ceiling corrugated sheet and plaster of Paris reinforcement, door frame and panels etc.
**Food and Non-Food Packaging Industry:** Pellets made from a Kenaf/plastic compound can be molded into commercial food storage containers and Non-food related packaging materials including bulk chemical and pharmaceutical packaging; parts packaging in the electrical and electronics industries; and disposable packaging for large consumer appliances such as egg crates, boxes for storing agricultural product both fresh food and fragile/perishable goods.

The advantages to be derived from the development of commercial Kenaf production and utilization in Nigeria are quite obvious.

**Way Forward of Kenaf rejuvenation in Nigeria**

- Increase commercial production and utilization of Kenaf plant
- Establishment of new agro-sack producing factories and resuscitate of the old ones.
- Improve Scientific R&D of Kenaf: through technical processing, genetic manipulation to improve high yielding varieties and biotechnology retting for better quality of fibres and uniformity.
- Development of prototype machine in the processing and handling of Kenaf plant
- Extensive training and re-training of farmers
- Providing loan to both farmers and processors
- Establishment of Kenaf packaging act for compulsorily packaging of food grains & sugar etc

**Prospects:**

- The demand for agro sacks (natural bags) to service a growing commodity export economy for crops such as groundnut, cotton, cocoa, palm kernel etc has been on increase in Nigeria from pre-colonial days to date. The present sacks/natural bags requirement of the country is established over 90million bags per annum while production is almost nil.
- The process technology for the processing and production of Kenaf fibres is simple, easily adaptable and locally available.
- It is estimated that Nigeria has over one million hectares of land suitable for cultivation of Kenaf which is sufficient to produce retted fibre that can meet the raw material requirement of the natural fibre industry.
- The current high level of importing all our Jute-like bags requirement and long-fibre for paper industry is consuming huge foreign exchange earning of the country, local production of Kenaf fibre for both local consumption and for international market will go a long way to aid the ailing economy of the country.
- National food security (reducing harvest & post-harvest food loss across the country)
- Provides on-farm and off-farm based employment (small and marginal scale farmers and processors) and rural industrialization for wealth creation
- Developing products made from indigenous agricultural & underutilized material for industrial/domestic need

**Challenges:**

- In terms of Kenaf production, there is a lack of high yielding varieties. It is reported that the current Nigerian variety yields between 6 to 11 ton per hectare while in the United States and China you can get varieties that can produce as much as 20 to 22 tons per hectare.
- Kenaf is currently processed using the traditional methods of retting. This is very tedious and time-consuming with its attendant drudgery.
- Machinery and equipment for processing are not locally available. Processing and production of agro-sacks will largely depend on imports.
- Absence of local fabricators of machinery and equipment that is willing to pick up the local designs and mass-produce and multiply them.
- Investors apathy in investing in Kenaf processing and production
- Inability of producers and processors to use R&D tested and proven results
- Absence of appropriate legislation/policies
- Policy summersaults and inconsistencies especially in agriculture
- Lack of finance/ funding.

**MATERIALS AND METHODS**

Kenaf was sourced from Institute of Agricultural Research and Training (IAR&T), Ibadan Nigeria and anatomic microscopic analysis of Kenaf fibre carried out at Forestry Research Institute of Nigeria (FRIN). The design and construction of controlled system retting tank and detail fibre processing and characterization was carried at Federal Institute of Industrial Research Oshodi (FIIRO).
Table 1: Burning Test

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Melt Near Flame</th>
<th>Shrink From Flame</th>
<th>Burns In Flame</th>
<th>Continues To Burn outside flame</th>
<th>Appearance Of Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenaf Fibre</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Slightly-Slowly</td>
<td>Light Grey</td>
</tr>
<tr>
<td>Jute fibre</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Slightly-slowly</td>
<td>Light Grey</td>
</tr>
</tbody>
</table>

Table 2: Properties of Kenaf fibres as alternative to Jute

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Kenaf fibre</th>
<th>Jute fibre (literature value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content (wt. %) @ 105°C,3.4-4.5mins</td>
<td>9.18-10.05</td>
<td>17.0-12.5</td>
</tr>
<tr>
<td>Fibre Density (g/cm²)</td>
<td>0.98</td>
<td>1.3</td>
</tr>
<tr>
<td>Ash Content (wt. %)</td>
<td>0.6-2.35</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Water absorbency (%)</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td>Cellulose (wt. %)</td>
<td>57.7-60.2</td>
<td>51-84</td>
</tr>
<tr>
<td>Hemicelluloses (wt. %)</td>
<td>18.06-20.03</td>
<td>12-20</td>
</tr>
<tr>
<td>Lignin (wt. %)</td>
<td>19.2-20.0</td>
<td>14-29</td>
</tr>
<tr>
<td>Tensile Strength (MPa)</td>
<td>450.0-816.7</td>
<td>393-800</td>
</tr>
<tr>
<td>Elongation % @ Break (%)</td>
<td>1.4-2.8</td>
<td>1.6-1.8</td>
</tr>
<tr>
<td>Young’s Modulus (GPa)</td>
<td>20.39.0</td>
<td>24-26</td>
</tr>
<tr>
<td>Fibre Length (mm)</td>
<td>2.0-2.7</td>
<td>2.02-3.2</td>
</tr>
<tr>
<td>Fibre Diameter (µm)</td>
<td>17.7-21.1</td>
<td>15.9-20.7</td>
</tr>
</tbody>
</table>

Fig. 1: Extracted Kenaf bast and core fibres

![Fig. 1: Extracted Kenaf bast and core fibres](image1.png)

Fig. 2: Graph of Tensile Strength of Kenaf & Jute Fibre against elongation @ Break

![Fig. 2: Graph of Tensile Strength of Kenaf & Jute Fibre](image2.png)
Fibres Extraction and Processing: An extensive investigation was carried out at Federal Institute of Industrial Research, Department of Chemical, Fibre and Environmental Technology, Polymer and Textiles Research Laboratory. Starter culture for low time retting of fibres was also developed by Environmental Microbiology Division. Kenaf fibre was extracted and processed using controlled system tank retting (CSTR) method. Quality evaluation of extracted fibres and fibre grades were studied, anatomic microscopic analysis in terms of fibre length, diameter, lumen width, cell wall thickness, Runkel ratio, coefficient of flexibility, felting power and wall rigidity. Mechanical and optimal caring capacities of the fibre in term of tensile strength (stress @peak), elongation @break, young’s modulus, strain, breaking load (force@break) according to ASTM 3822-07 Standard were followed. The chemical constituent of Kenaf bast fibre were determined based on approved standard of technical association of pulp and paper industry (TAPPI) and Direct method of cellulose, hemicellulose and lignin [3], respectively. Spun yarn prepared and experimental weaving evaluated. The results are presented in Tables 1 and 2, were experimental spun yarn and woven agro-sack are displayed in Figure 1, 2, 3 and 4, respectively.

RESULTS

The above table summarizes the effect of flame in contact with fibre samples using standard method as described in technical manual of the American association of textile chemists and colorists (AATCC-1981/82). The following observations were made (if fibres melt or shrink from flame, if fibres are self-extinguishing outside flame, if fibres burn in flame, the odour, colour and nature of residue ash).

DISCUSSION

By visual inspection of kenaf bast fibers bundles after extraction, appears to be coarse and stiff. The spun yarns are hairy and an attempt was made in modification of the fibres with various softening treatments for obtaining soft and pliable fibres, to determine the best process for large-scale production. The researchers investigated the traditional process using the filament yarns in weaving kenaf Agro-sacks. The findings showed that the conventional process was very time consuming with higher level of fibre breakage, thus not appropriate for the present demands. Therefore, this research explored open-ended rotor spinning process for even kenaf yarn and Agro-sack development.

The basic considerations of fibre a characteristic is centered with the mechanical properties and it application. Apart from improving fibre quality through improving texture, colour, low extensibility, weight per unit reduction through fibre purification, abrasion resistance etc. for industrial utilization of fibre, adequate strength, fineness, length is essential as a fundamental property which governs certain end use requirement.
Under ideal condition, they are fixed values for specific natural fibres of the same origin. The experimental results in Tables 1, 2 and tensile strength of Kenaf & Jute Fibre against elongation @ Break also in Fig. 2 led to the conclusions, that both fibres are similar, the experimental spinning and weaving showed that Kenaf fibre possess sufficient strength, fineness and relatively flexible which enable it withstand the stress and strain of spinning and weaving. This study has also shown that Kenaf fibres is of similar properties and behavior with Jute fibre and it implication is that if well developed and processed will be an alternative to imported Jute fibre and agro-sack in Nigeria

CONCLUSION

There is need to increase the production of Kenaf and supply of retted fibre in the country to aid the production of agro-sacks from Kenaf for packaging of agricultural produce. The establishment of pilot plant for this project will promote commercial production, awareness, the vast usefulness of the plant, provide on-farm and off-farm based employment (small scale, marginal farmers and processors). Also, the plan of the Federal Government on the ban on the importation Jute agro-sacks in 1989 to encourage local Jute-like agro-sacks production will be achieved and adequate packaging material for our high valued agro-produce to reduce the post-harvest food loss across the country will achieved. Presently there is no factory producing Jute-like sacks. Hence, Jute substitutes need to be considered, by establishing Pilot Plant for the processing and production of Kenaf Fibres and the making of Agro Sacks from the produced Kenaf Baste Fibres. This would serve as a cluster and center for the processing of Kenaf.

REFERENCES