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Utilization of Kenaf Raw Materials

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Introduction

Kenaf will displace forest products in certain industrial applications in the future. The emergence of this new crop from research to commercialization is occurring, and larger scale use appears to be inevitable and simply a matter of time.

Background Information

KP Products Inc. was formed in 1990, with the mission "To economically produce the most environmentally positive paper products." Doing business as Vision Paper we are a privately held corporation, registered in the state of New Mexico, and a strategic partner with the United States Department of Agriculture's "Alternative Agricultural Research and Commercialization Corporation" (USDA/AARC). USDA/AARC is a private corporation owned by the Department of Agriculture, created by Congress in order to promote and assist companies working to introduce new crops and new uses into industrial (non-food, non-feed) applications. My company is involved in applying government and university research to produce commercial products and processes from kenaf in partnership with USDA/AARC. We have been producing and selling kenaf based papers since 1991.

Identifying the need

World Population Growth

Population growth fuels the consumption of products. Table 1 shows the dramatic growth in population for a four-hundred-year period. Since the time when industry began using trees to make pulp for paper, the world population has grown by nearly five times. And it continues to grow at a rapid pace.

Table 1.

Year	1650	1750	1850	1950	2050
World Pop./ Millions	550	725	1175	2490	9857

Source: UN FAO

Production and consumption of paper

Population growth explains, in part, the increased global demand for pulp and paper products. Another reason for increased pulp and paper consumption is the emergence of literate societies in many formerly underdeveloped parts of the world.

One example of the increase in pulp and paper production is shown in Table 2.

World Pulp and Paper Production
Table 2

Year	1961	1970	1980	1990	1997
MT/YR/ millions	61,862	102,840	128,310	165,873	178,550

Source UN FAO

Raw material price trend.

The cost of wood fiber in the US is consistently rising. Table 3 shows an Indexed Price Trend over a thirty-one-year period for Northwest and Southeast timber. Taking the effects of inflation into account, the relative cost of timber is trending strongly upward. At the same time, the economics of kenaf are improving.

Table 3
Source: Rayonier "Southeast Fiber Supply" - TAPPI

About Kenaf

Kenaf (Hibiscus cannabinus L.) is an annual row crop related to cotton and okra. The United States Department of Agriculture (USDA) selected it as a promising "new" crop as a result of the New Crops, New Uses program started in the 1950's by then President Dwight David Eisenhower. After studying over 500 plants, the USDA study determined that kenaf was the most viable replacement for trees in papermaking.

The potential benefits attributed to kenaf include;

a) a) diversification of farm crop selection which promotes sustainable agriculture;
b) b) a new low risk cash crop for farmers which reduces the need for subsidies and price supports;
c) c) low or no chemical applications are required to grow it;
d) d) reduced energy and chemical use to convert the raw material to pulp,
e) e) its rapid growth rate indicates it absorbs CO2 two or three times faster than trees, thereby helping to alleviate global warming, and
f) f) it provides an environmentally sound alternative to cutting trees to make paper, which will benefit national forests and promote more management options on private forest lands.

Growing kenaf

Kenaf is easy to grow in many areas. The best climate offers 120-150 frost-free days, with 24-36 inches of rainfall during the growing season. Adequate soil moisture must be present to assure a good early start, and some kenaf is grown with irrigation.

Individual farms are typically 200 acres or more in size, and the kenaf does not replace other crops that the farmers regularly grow. There are many parts of the U.S. which have under-used farmlands. In 1987 we had over 60 million (60,000,000) acres of idle farmland, with the amount projected to double by the year 2012.[i]

In the places where the right farms and local support exists, we advise on which type of kenaf seed to plant. This decision is based upon the climate, what fiber types are desired, and the existing soil conditions and possible pests. There are over 240 varieties of kenaf, but only about 10 are commonly grown.

Few chemicals are needed to grow kenaf. To insure good soil conditions, some fertilizer and a single herbicide treatment may be used to control weeds. No insecticides are used because the crop is the fibrous stalk and insects rarely cause much damage.

One key to success is to work in areas that offer some type of infrastructure, which can help with risk management. Generally, some level of community support and government support will exist. It is best when a farmer's cooperative or private company will take a leadership position. Local citizen awareness and involvement is good, because kenaf can produce jobs and economic benefit.

The economic competitiveness of kenaf is important in its ability to displace wood fiber. The following data (Table 4) is a result of averaging 10 crop budgets from different areas of the south with company data that is based upon actual production experience. While specific costs may vary by region, the total cost of kenaf fiber is believed to be within 10% of the totals shown. This cost of production does not include harvest and transportation costs.

Kenaf Growing Costs, Dollars per Acre
Table 4

Direct Costs	
Fertilizer	$ 46.55
Herbicide	$ 17.06
Seed	$ 20.50
Labor	$ 22.11
Machinery	$ 47.58
Interest	$ 8.33
Total Direct Costs	$162.12
Total Indirect Costs	$ 75.17
Total Costs	$237.29
Kenaf fiber FDT/ACRE	6
Cost of Field Dried Standing Crop $/ton	$ 39.54

Source: KP Products

Each new crop has a story unto itself, and kenaf is no different. Depending on end-use, and market potential, different allocations of research and development resource dollars will apply. Consequently, the rate of improvement varies.

Table 5 shows an averaged improvement of yield for four randomly selected crops over a thirty-eight-year period. As indicated by this and other similar data, the greater the period of experience producing a crop, the more productive and economical it becomes.

Crop Improvement History
Table 5

Units/acre						% Yield Increase
	1961	1971	1981	1991	1998	
Pop Corn	22	29	35			59%
Oil Crops	25	30	35	40	45	80%
Sugar Beets	37	45	50	46	50	35%
Rice	38	52	54	64	64	68%

Source: USDA/ARS

A conservative analysis of this and other new crop data indicates that current kenaf yields will improve significantly over time.

Processing Raw Kenaf Fiber - Harvesting and Storage

Once the crop has grown, it must be harvested in a way to meet the processing needs. Standard equipment is used to harvest kenaf in the Southern U.S. A forage chopper is

often used. After the fiber is harvested, it is pressed into large modules, and stored until needed. The storage can be near the farms, and outdoors. A good plastic cover will protect the fiber. We have stored kenaf this way for up to four (4) years, and still made excellent paper from it.

Fiber Separation

Currently, the fiber is mechanically separated into bast and core portions. The bast fiber is then condensed into high-density bales. The high-density is necessary to get the full weight in a truck and to ship kenaf economically. The core fiber is being used in a number of other products such as oil absorbents. The necessity to separate the two fiber components for certain applications incurs an additional cost of processing, and any subsequent application must be able to bear that cost. Whole stalk pulping of kenaf appears to offer the best economics for the papermaker.

Raw Materials for Specialty Paper Production

The kenaf raw material we have used for pulping is about 80% bast and 20% core and in high-density bales. The moisture of the fiber is about 10%. It is important that there are no plastic or other foreign materials in the kenaf fiber

Pulping and Bleaching

The kraft AQ process has been used to cook kenaf fiber with good success. Batch digesters followed with a single-stage hydrogen peroxide (H2O2) bleach process is the method most commonly used in the production of our products.

Kenaf Fiber – Approximate Characteristics

Kenaf consists of two fiber types, the outer bast and the inner core. These two fibers provide functional characteristics similar to hardwood and softwood fibers.

Average fiber length of the bast is 2.6mm, and the core is .6mm. The lignin percent of the bast is 7.7% and the core is 17.4%. This lower lignin amount accounts for the lower chemical and energy need in pulping. The average cellulose content for the whole stalk kenaf is Crude=54% and Alpha 37.4%

Fiber comparison

Kenaf's fiber structure compares favorably with wood fibers. Because kenaf fiber is so similar to wood, it can replace wood fiber in a number of application areas.

Fiber length chart
Table 6

Fiber Comparison		Fiber length in mm			Fiber diameter in microns		
		Min	Max	Avg.	Min	Max	Avg.
Long Fibers	Soft wood	2.7	4.6	3.7	32	43	38
	Kenaf Bast	1.4	5	2.6	14	23	21
	Hemp bast	5	55	20	16	50	22
Short Fibers	Hard wood	0.7	1.6	1.2	20	30	25
	Kenaf core	0.4	1.1	0.6	18	37	30
	Hemp core	NA	NA	0.55	NA	NA	25
	Wheat straw	NA	NA	1.5	NA	NA	15

Source: TAPPI Textbook Series "Secondary Fibers and Non-Wood Pulping" and KP Products Inc.

Papermaking with kenaf pulps

Once the pulp is made, a variety of paper products can be produced. Uncoated offset printing paper using 100% kenaf pulp is the product most commonly manufactured. The typical technical values for this paper are brightness of 72 ISO, opacity of 95+, and surface strength (wax pick) of 14. These values are for papers produced from semi-bleached pulp that is totally chlorine-free (TCF).

Today, we are recycling kenaf wastepaper and blending it with recycled wood fiber wastepaper. The wood fiber is post-consumer wastepaper (PCW) and pre-consumer wastepaper. The kenaf wastepaper is from our envelope making and other trimmings. The products we have made are 100% recycled with 30% kenaf wastepaper and 30% post-consumer wastepaper and 40% pre-consumer wastepaper. We have also made 100% recycled paper with 50% kenaf wastepaper and 50% post-consumer wastepaper. Because of a limited supply of kenaf wastepaper, we are currently working on 50% kenaf pulp blended with 50% post-consumer wastepaper. The basis weights produced so far are between 66 g/m2 and 218 g/m2.

Recycling the kenaf wastepaper requires no special handling. It is a high quality fiber source and it provides excellent blending properties. The kenaf fiber adds strength. The technical values of the product are equal to or better than for recycled wood fiber alone. We have not yet studied the removal of ink from printed kenaf paper.

Conclusion

Based upon the population and consumption trends outlined herein, coupled with the economic competitiveness and functional characteristics of kenaf fiber, kenaf will realize greater utilization in place of forest products. It is not a question of if, it is only a question of when.