2
Jute

K B KRISHNAN, I DORAISWAMY
and K P CHELLAMANI

2.1 Introduction

Jute is grown mainly in India, Bangladesh, China, Myanmar, Nepal and Thailand. The total area under cultivation, yield and total production of jute/mesta[1] in these countries are given in Table 2.1 (see also Appendix B on page 82). These figures cover the total production of 'jute and similar' bast fibres, which are: white jute (*Corchorus capsularis*), tossa jute (*C. olitorius*), kenaf (*Hibiscus cannabinus*) and rosella (*H. sibdoriffa*). Abaca (*Musa textilis*) is not included as the fibre is obtained from the leaf sheath of the plant and is therefore not a bast fibre. India and Bangladesh account for more than 93% of the jute fibres produced all over the world.

There are over thirty *Corchorus* species but only two of them are widely known, *Corchorus capsularis* (white jute) and *Corchorus olitorius* (tossa jute) These are commercially grown in Bangladesh, India and Nepal. Kenaf and mesta (rosella or roselle), the other fibres allied to jute, are grown in China and Thailand. Mesta is also grown and is commercially important in India and Thailand. White and tossa jute cannot normally tolerate water-logged conditions but can be grown on high land that is normally subject to flooding.

Jute is mainly used for manufacturing products for the packaging of grains, sugar, cocoa, coffee and other food crops as well as for cement, fertilisers, salt, cotton, etc. These, i.e., hessian (burlap) and sacks, currently account for 80% of

Table 2.1 Area, yield and total production of jute/mesta in major producing countries (season 2001–2002)

	India	Bangladesh	China	Myanmar	Nepal	Thailand
Particulars						
1. Area ('000 hectares)	980.0	519.6	52.0	53.5	11.3	19.2
2. Yield (tons/hectare)	1.93	1.78	2.62	0.95	1.45	1.54
3. Production ('000 tons)	1890.0	924.7	136.0	50.8	16.4	29.5

Source: JMDC – *Indian Jute* Vol. XIII, No. 1, June 2003, Courtesy: FAO Statistics.

jute production. The use of jute fabrics as carpet backing is a later addition in jute products and accounts for about 15% of the world's fibres consumption. Other uses of jute include carpet yarn, cordage, felts and paddings, decorative fabrics and other items for industrial use.

Raw jute production was originally concentrated in eastern Bengal which, after the partition of the Indian Sub-continent in 1947, became East Pakistan and later in 1971 became an independent country, Bangladesh. After partition measures were taken in India to increase the production of raw jute in order to supply raw material to its jute mills. The expansion of Indian jute production together with the growth in kenaf production in China during the 1950s are largely responsible for the fall in the share of Bangladesh's total world production from 80% in 1949/50 to 35% in 1969/70 and to 25% by 1979/80.

Although jute has been an economically[2] important crop in Bangladesh and India it has, to some extent, lost its past importance in the economy of these countries, although it still has a high socio-economic value. As an important cash crop of the region it contributes to the economy of these countries in various ways. In agriculture as well as in industry, in both these countries, jute directly and indirectly supports employment, commerce and other economic activities. There are 76 jute mills in India with installed capacity of 45,012 looms and in Bangladesh there are 72 jute mills with installed capacity of 26,020 looms. In Bangladesh the jute sector provides about 10% of total employment, 12% of gross domestic product (GDP) and around 30–35% of total export earnings. In India, the jute sector provides about 1% of total employment in the organised sector and 0.5% of GDP and 0.5% of export earnings.

However, in Bangladesh and India about four million farm families cultivate jute as an important cash crop. In India, the jute industry provides employment for about 2.5 million workers and marketing and related activities provide employment for another 1.5 million. (This does not include the ten million hand loom weavers mentioned in Sections 5.2 and 5.3.) In Bangladesh about 227,000 workers and 25,000 management and staff are employed in the jute industry. Allied trades, industries and services such as marketing, transportation, etc. provide employment for millions more.

Jute and jute products occupy an important place as a foreign exchange earner, particularly in the case of Bangladesh. Prior to independence jute was the principal source of Pakistan's foreign exchange. After independence jute provided about 84% of Bangladesh's total foreign exchange but although there has been since then a gradual but noticeable decline, jute still provides about 30–35% of the country's foreign exchange earnings. Jute is also a source of revenue for the Governments of India and Bangladesh. The Indian government receives annually more than Rs.640 million (US$13.3 million) by way of taxes and levies while the West Bengal Government's share under sales tax alone amounts to about Rs.120 million ($2.5 million) per year.

Table 2.2 World apparent consumption of jute, kenaf and allied fibres (2000)

Country	Consumption ('000 tonnes)	Country	Consumption ('000 tonnes)
Developing countries			
Africa	51.2	Iran	62.4
Algeria	8.9	Sudan	44.0
Ghana	5.3	Syria	39.2
Kenya	2.7	Turkey	56.8
Morocco	1.6	Bangladesh	148.5
Tanzania	3.2	China	131.2
Zimbabwe	0.9	India	1629.4
Argentina	3.2	Indonesia	7.7
Brazil	22.8	Pakistan	75.2
Mexico	1.8	Myanmar	30.1
Egypt	24.0	Thailand	36.1
Vietnam	8.3		
		Total	2394.5
Developed countries			
United States	74.0	Spain	12.3
Belgium–Luxemburg	72.4	United Kingdom	28.3
France	10.9	Australia	50.6
Germany	13.4	New Zealand	17.3
Holland	14.2	Japan	28.0
South Africa	7.5		
		Total	328.9
	Total world: 2723.4		

Source: JMDC – *Indian Jute* Vol. XIII, No. 1, June 2003, Courtesy: FAO Statistics.

World apparent consumption of jute, kenaf and allied fibres[1] is given in Table 2.2. According to the available statistics, world production of jute goods works out to about three million m tonnes (Table 2.3). Of this India accounts for about 50% followed by Bangladesh and China which account for 17% each.[1] [*Editor's note*: further information relating to jute's allied fibres is set out in appendix A.]

The statistics given in Tables 2.1–2.3 are difficult to reconcile and the differences between the totals shown are due to three factors.

1. Some countries, especially India, export fibre as well as jute goods. This shows as a lower figure in the tonnage of their apparent consumption and of jute goods produced in these countries, compared to their production of fibre.
2. Waste is produced in processing from fibre, through yarn to fabric and other jute goods, which will also show as a lower figure of goods manufactured compared to fibre produced.

Table 2.3 World production of jute goods (1995)

Country	Production ('000 tonnes)	Country	Production ('000 tonnes)
Developing countries			
Africa	41.3	Brazil	23.7
Nigeria	1.9	Cuba	10.7
Egypt	21.4	Iran	5.0
Bangladesh	524.4	China	535.0
India	1506.2	Indonesia	10.7
Myanmar	28.7	Nepal	16.0
Pakistan	76.9	Thailand	101.6
		Others	42.4
		Total	**2945.7**
Developed countries			
Greece	2.1	Hungary	1.0
Belgium--Luxemburg	2.1	United Kingdom	10.7
France	3.2	Poland	4.2
Germany	3.2	Japan	10.7
Italy	1.1	Portugal	2.1
		Others	22.7
		Total	**63.1**
Total world: 3008.8			

Source: JMDC – *Indian Jute* Vol. XIII, No. 1, June 2003, Courtesy: FAO Statistics.

3. In the production of jute goods jute fibre is sometimes blended with other fibres such as cotton, polyester, viscose, acrylic, etc. This will appear in the statistics as an increase in the weight of goods manufactured when compared to fibre produced or apparently consumed.

The present situation can be summarised as follows: production of jute fibre, 3027.4 million tonnes; consumption of jute fibre, 2816.8 million tonnes; production of jute goods, 3000.8 million tonnes.

2.2 Fibre production and early processing

2.2.1 Jute and allied fibres

Jute is the common name given to fibres extracted from the stems of plants belonging to the botanical genus *Corchorus*. Although over 40 wild species are known, only two, viz., *C. capsularis* L. and *C. olitorius* L. are cultivated commercially. Within the jute manufacturing industry, *C. capsularis* is known as 'white jute' and *C. olitorius* as 'Tossa' jute.

There are many plants similar to *Corchorus* that grow in the tropics and sub-tropics, and from which fibres can be extracted from the stem.[3] The plants are all woody-stemmed herbaceous dicotyledons, having the fibre located in the bast, between the epidermis and the woody core. The most important of these from the point of view of textile fibres are two species of the genus *Hibiscus*, viz., *H. cannabinus* L. and *H. sabdariffa* L., both of which are commonly referred to as kenaf, although *H. sabdariffa* L. is, more correctly, rosella.

Hibiscus species are more tolerant of variations in growing conditions than jute, and many countries, especially in Africa and Asia, grow kenaf as a preferred crop, usually for internal use only, the international market for Kenaf being quite small. A third plant of similar type, Urena lobata L., grows well in Africa but the fibre is not often seen on the international market. All fibre-bearing plants have their own distinctive botanical attributes, but the fibres extracted from them are markedly similar to one another in appearance and are not readily distinguishable from jute itself. They are all suitable for converting into yarn on jute spinning systems and in marketing statistics are often grouped together as 'jute and allied fibres'.

'White' jute (*Corchorus capsularis*) which is usually golden yellow, is one of several closely related types in textile use.[4] The cell wall of the fibre varies in thickness. The fibres are coarse, generally 20–25 μm in diameter; the length of the ultimate fibres is only 1–5 mm. Spinnable fibres are composed of ten or more ultimate fibres placed in overlapping fibre bundles joined together by non-cellulosic material, usually lignin. Though jute is a strong fibre, its very low extensibility results in stiff, non-stretchy fabric. In developing countries, jute is much used for woven hessian, sacks, packaging and tarpaulins. Figure 2.1 shows a

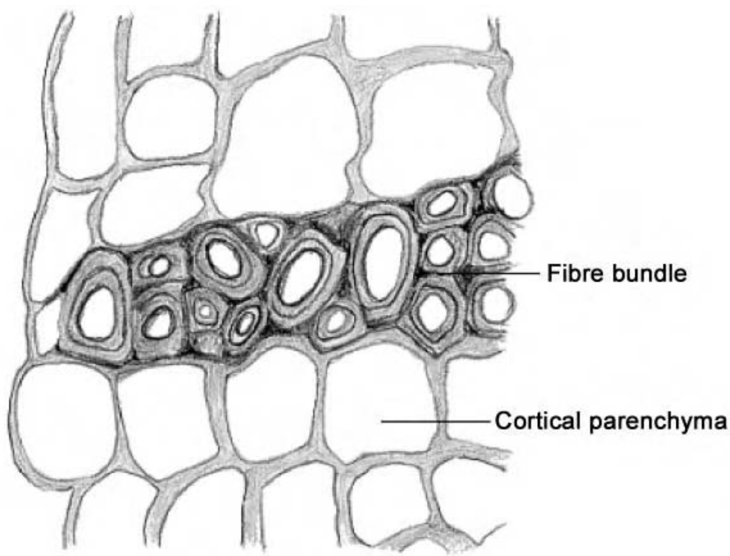


Figure 2.1 Cross-section through jute fibres (×640). Source: Gesamtverband der Deutschen Versicherungswirtschaft. Courtesy: www.tis-gdv.de.

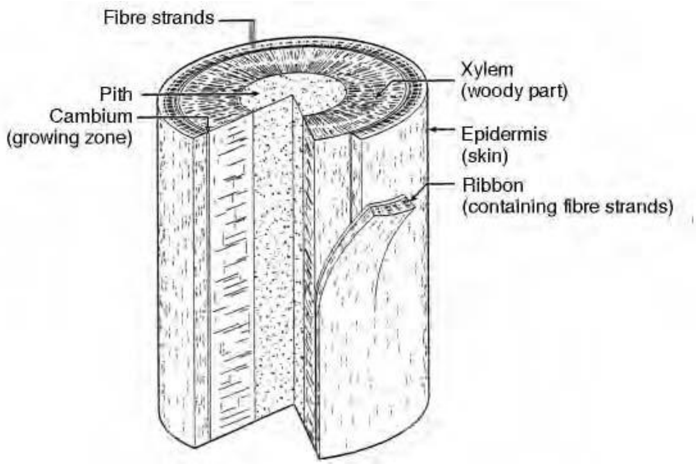


Figure 2.2 Diagram of the anatomy of a jute stem. Source: C. Jarman, *Plant fibre and processing: A handbook*. Courtesy: Intermediate Technology Publications, UK.

line drawing of a cross-section of *C. olitarius* (tossa jute) fibres. Figure 2.2 is a diagrammatic illustration of a jute stem showing the positions of the fibre bundles.

Jute is mainly cultivated in India, Bangladesh, China, Nepal, Thailand, Indonesia and a few other South-East-Asian countries. It can be cultivated under quite a wide variety of conditions but for ideal growth it requires a high level of humidity (40–97%). The ideal temperature lies between 17 and 41 ºC with an amount of precipitation of 1500 to 2000 mm per year. The pure fibre content of the unretted plants lies between 4.5 and 7.5%. About 90 to 120 days after sowing the stems may be harvested and water retted. In the process the stems are carefully sorted according to thickness and the lower, very wooden part of the stalk is cut off. The fibre bundles of this part of the stems are called ‘cuttings’ and cannot be used for fine yarns due to their coarseness. After retting the stems are decorticated and the fibre bundles are washed and dried.[90]*

2.2.2 Kenaf and roselle (see also Appendix A on page 78)

These two species produce similar fibres and they are processed in the same way as jute. The mean fibre diameter of kenaf is 20 μm (Fig. 2.3 – magnification 640×) with a range from 12–36 μm. Ultimate fibre length may be from 2–6 mm. Kenaf is more lustrous, harder and stronger than jute and is lighter in colour. Kenaf is used to make rope and string, coarse fabrics, mats and carpets.

The potential development of the use of jute and kenaf fibres in composite materials is discussed in Chapter 10.

Even though the kenaf plant is grown and used in many countries, in an inter-

* J. Müssig, private communication, 2004.

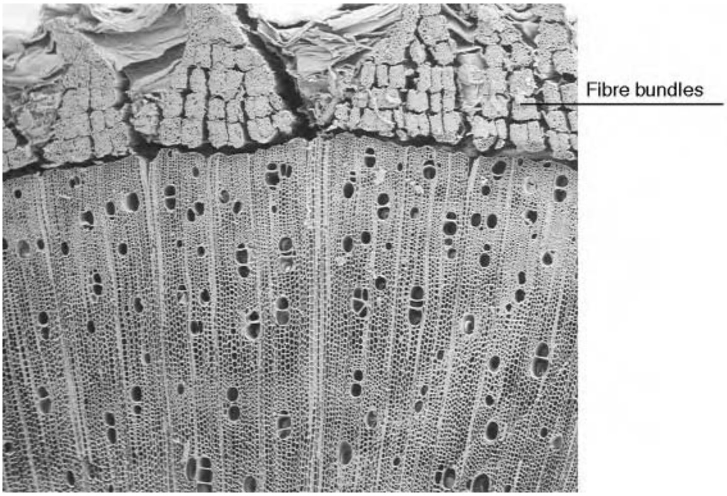


Figure 2.3 Photomicrograph of cross-section of kenaf stem (×20). Courtesy: Roger M. Rowell, Forest Products Laboratory and University of Wisconsin.

national comparison its cultivation is clearly on a smaller scale than that of jute. Kenaf requires less water to grow than jute plants do; it is cultivated in Europe, South America, Mexico, USA, Japan and China. With about the same stalk length of 2.5–3.5 m, kenaf needs many hours of light per day for its vegetative growth and in terms of soil quality and climate it can be cultivated in a broader variety of soils and climates than jute.[91] The fibre content is stated at 15 tons/year/hectare.[92] According to the Rowell and Stout report, the precise time of harvest is of decisive importance for ideal fibre quality. Ideally the kenaf plant should be harvested when about 10% of the buds are in bloom. After harvesting the stalks are retted. This must be done with great care if good quality fibres are to be obtained.[91]*

2.2.3 Retting and fibre extraction (decorticating)

Before fibres such as jute can be extracted from the plants, they need to undergo a process called retting. This is required to eliminate the gummy substances which cement the fibre to the rest of the tissues in the stem, and to each other. In the case of jute and allied fibres this involves steeping the stems in water, where enzymes produced by bacterial action remove the pectin and gummy materials, after which the fibres can be stripped from the woody core. The fibres are then washed and hung out to dry before being taken to the local market for sale to balers and exporters.[6] Retting takes between 10 to 20 days, or more depending on the water and on its temperature. Extraction of the fibres from the retted stalks (decortication) is, in the case of jute and similar fibres, still usually done manually (Fig. 2.4).

* J. Müssig, private communication, 2004.

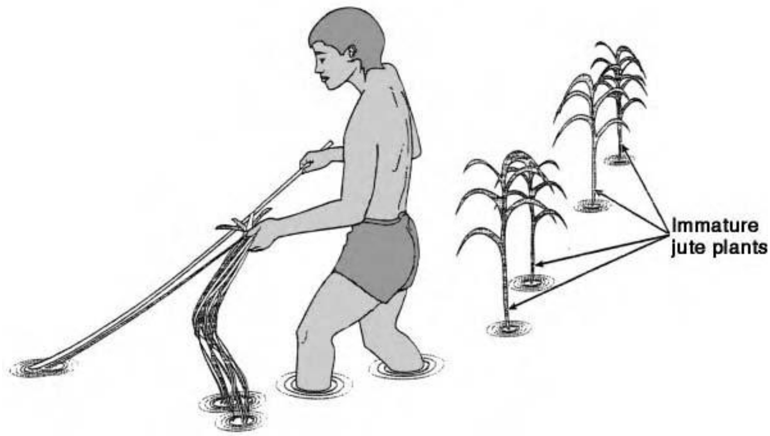


Figure 2.4 Manual stripping of jute fibre from retted stem. Source: C. Jarman, *Plant fibre and processing: A handbook*. Courtesy: Intermediate Technology Publications, UK.

Mechanical decorticators of the kind mentioned in section 2.2.4 are not yet commonly used. In manual decortication the fibres are stripped from the woody core of the stem using knives. In the retting process, the thicker parts of the stem take longer to rett than the thinner parts. Consequently, if the butt end of the stem is correctly retted, the apex will be over-retted and may suffer damage. Retting is therefore terminated when the main part of the stem is adequately retted, and, if necessary, fibre from the butt end, which may still have pieces of bark adhering to it, will be cut off and processed separately from the 'long jute' as 'cuttings'. The various factors affecting retting of jute and mesta are types of water, temperature, pH and macro-nutrients.

Water appears to be the most important of the various factors affecting retting. An abundant supply of clean water is a prerequisite for proper retting. Retting in slow-flowing water produces the best fibre.[7,8] In stagnant water, the products of the fermentation process accumulate near the stems and tend to affect the colour and lustre of the fibre, whilst in slow-flowing water these are removed by the current before they can produce any adverse effects and the fibre appears very bright and glossy. In faster, running water, retting is adversely affected. The inside bundles of the stack of stems, or 'juck', ret faster than the outer stems and this produces fibres of uneven quality.[9] For satisfactory retting, the stem-to-water ratio should be around 1 : 20. Retting is quicker in soft than in hard water and the colour and lustre of the fibre is remarkably improved by immersing the stack under water with bamboo poles and coir ropes. Concrete slabs as weights also give excellent results.

A temperature of 34 ºC with a pH value in the range of 6.0 to 8.0 is the optimum for good retting. Various chemicals, particularly nitrogen and phosphorous compounds, have been tried to boost the retting of jute and nitrogenous compounds and have proved to be the best stimulants. In general, cations such as NH_4, K, Ca and Mg and anions such as SO_4, NO_3 and PO_4 have beneficial effects while chloride ions at high concentrations slow the process down.

Conventional and ribbon retting: advantages and disadvantages

In conventional retting, whole stems are steeped in water, but in ribbon retting only the ribbons of green bark extracted from the stems are immersed in water. These ribbons are removed from the stems after harvesting in the fields. From four to six stems are decorticated manually at the same time. This produces a ribbon-like bundle of long fibres whilst decorticating after the conventional retting process produces fibres of between 15 cm to 25 cm in length. The quantity of water required for ribbon retting is much less than for the conventional method.

Ribboning of an entire jute stem is not possible; some of the bark always remains on the stem, especially at the top of the stalks. Any ageing of harvested stems further aggravates this loss of bark on ribboning because a certain amount of fibre always remains stuck to the bark. During the vegetative growth phase, jute plants may be attacked by insects, apion in particular, and it has been found that apion infected jute stems also entail an additional loss of bark during ribboning. Besides, the amount of labour involved in the whole process of ribboning is really forbidding. About one man day is required to ribbon three bundles of jute stems, which yields only 6.5 kg of raw jute. The disadvantages of the ribbon retting of jute so far observed are: longer retting period indicating poor rettability of jute ribbon;[11] heavy loss of fibre strength; loss of fibre yield (19–30%); downgrading of fibre quality; entanglement of retted fibre during washing and high labour cost.

On the other hand, transport costs are lower for ribbon retted fibre, retting takes less time, fibre quality is improved, pollution is much reduced and less water is required in comparison with conventionally retted fibre. The comparison between stem and ribbon retting is shown in Table 2.4.[12] For a detailed account of recent improvements in retting techniques readers are referred to Appendix C on page 83.

2.2.4 Machinery for jute decorticating

The Jute Agricultural Research Institute, Barrackpure, West Bengal has developed a decorticating machine[15] for the mechanical extraction of jute fibres. The machine is designed to extract and scrape out barky material from the stems of bast fibre crops such as jute, mesta, sunnhemp, urena, etc. The machine breaks down the inner woody cores of the stems into pieces and scrapes the bark, especially at the root ends of the stalks. The production of commercial fibres by

Table 2.4 Comparison between stem retting and ribbon retting process

S. No.	Criteria	Procedure	
		Stem retting	Ribbon retting
1.	Transport	Whole stalks carried to the pond	Ribboning done at the field, only ribbon (40% of stem) to be carried
2.	Retting period	10–20 days or more	7–10 days
3.	Pond volume required	435 m^3/ha of crop: (120 days)	Less than 100 m^3/ha of fibre crop; (120 days)
4.	Retting arrangement	Need stakes, cover & weights, if soil is used, fibre quality is reduced	Very convenient, ribbons submerge by themselves, no weights needed, only a support preventing contact with mud
5.	Fibre extraction	Needs stripping and washing, slow (60–90 man-day/ha)	Only washing required
6.	Fibre quality	Lower quality, barky hard ends requiring 'cuttings'	Superior quality, barky ends minimised
7.	Quality of sticks	Long sticks obtained, easy to handle, structural uses possible	With decorticator use, sticks are broken. Ribboners yield long sticks
8.	Plant nutrient loss	Large qualities removed with stalks	Returned to soil if the cores are incorporated to the soil
9.	Impact on environment	Over 10 tonnes/ha of organic matter released, excessive water pollution	Only 3 tonnes/ha of organic matter released, water pollution minimised

Source: Mitra, B C, *Data book on jute*, January 1999. Courtesy: National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata.

these machines requires only five or six days including retting. The capacity of the machine is about a tonne of green jute plants per hour with a 5 hp prime-mover. Five men are needed to operate the machine, two for feeding stems into the machine and three for arranging, bundling and steeping of the extracted material. If required the capacity of this machine can be increased.

The best stage in the growth of the plant for decortication is at 115 $\pm$ 10 days after germination. Decortication should be done immediately after harvesting and can be continued for two to three days if the stalks are kept under cover. Defoliation is not necessary before feeding the stems into the machine. The plants are fed into the machine butt-end first. Two to eight plants are fed into the machine at a time, depending upon their diameter. It has been found that the optimum diameter for decortication by these machines is around 12 mm.

Improved results are obtained if the stalks are sorted into two groups; one group of 12 mm diameter and below and the other of 12 mm and above.

2.2.5 Fibre sorting for quality

After retting and decorticating,[90] various fibre qualities are used in trade that differ particularly in the properties of colour, fineness, strength, density, root proportion and tendering. Both types are sorted into a total of eight categories in India: 'tossa jute' (TD1 to TD8) and 'white jute' (W1 to W8). In Bangladesh 'white jute' and 'tossa jute' are divided into five classes (A to E). According to Rowell and Stout[91] the classification of fibres still takes place using organoleptic methods but as the classification systems are different in each country international comparison is difficult.*

2.3 Physical and chemical properties

2.3.1 Physical properties

Jute and kenaf are strong fibres, exhibiting brittle fracture, but having only a small extension at break. They have a high initial modulus, but show very little recoverable elasticity. Tenacity measurements recorded in the literature vary widely, and although some of this variation is due to differences in the methods of measurement, a major part arises from variation in linear density of the fibres themselves.†

Taking into account all the available evidence, a tenacity of 70 g/tex is a reasonable middle value for a wide range of jute fibres, based on single fibre test lengths of 10 mm or less and a time to break of 10 sec. This value of tenacity is appropriate to fibres of linear density 1.8 tex, and it is important to state the linear density, for statistically an increase of 0.1 tex reduces the tenacity by about 1.5 g/tex. This inverse dependence of tenacity on linear density is common to most fibres and also to fine metal wires.

The elongation at which a fibre breaks is a more invariant and fundamental property than the load at which it breaks. It is not affected significantly by changes in linear density, nor by changes in the method of loading. Length of test specimens does have an effect, however, as irregularities in diameter prevent all sections of a long fibre from being elongated equally. For test lengths of 10 mm the elongation of the jute fibres is generally between 1 and 2% of the initial length, but is difficult to measure accurately on such short lengths. In one particular case, 500 fibres from a bulk of medium-quality jute had a mean elongation of 1.60% (of the 10 mm test length) with a coefficient of variation

* J. Müssig, private communication, 2004.

† See also the tables in the appendix to Chapter 1 for further published data on the physical characteristics of jute fibre.

(CV) of 25%. The breaking load[16] of the fibres, however, had the much higher CV of 40%. It may be noted that 1.6% elongation corresponds to a spiral angle of 10º12′, which although slightly greater than the Herman's angle reported is still within the uncertainty of the comparison.

The initial Young's modulus of the fibres, calculated from the slope of the load-elongation curve, has a mean value of about 4×10^3 g/tex/100% extension. The value for any particular group of fibres will, of course, be dependent on the linear density, to some extent owing to the dependence of tenacity values on this factor. The bending of jute fibres has been studied by Kabir and Saha, who calculated the Young's modulus from measurements of the force required to deflect the free ends of a fringe of fibres arranged in cantilever fashion.[17] For this calculation it is necessary to know the fibre diameter instead of the linear density and this causes a difficulty because the cross-section of the fibres is irregular in outline and often far from circular. The authors assumed an elliptical configuration and measured minimum and maximum diameters of a number of cross-sections microscopically for insertion in the appropriate formula. Their calculations showed that over a wide range of commercial fibre qualities, Young's modulus decreased from about $2.0 \times 10''$ dynes/cm^2 at 46 μm average diameter, to $0.8 \times 10''$ dynes/cm^2 at 68 m. These values correspond to 3050 and 815 g/tex/100% extension, respectively and again demonstrate the marked effect of variations in fibre dimensions. Extrapolations of Kabir and Saha's data to smaller diameters show that the tensile value for the modulus of 4000 g/tex/100% extension would be reached at a mean diameter of about 40 μm.

Young's modulus may also be calculated from the fundamental frequency of transverse vibration of a single fibre fixed at one end as a cantilever. For a variety of bast fibre types, including jute and kenaf, the modulus lies between 3 and $8 \times 10''$ dynes/cm^2, and for jute fibres appears almost independent of diameter, unlike the tensile values.[18] In making these dynamic measurements, it was found that each fibre had two resonant frequencies corresponding to vibration along the major and minor axes of the cross-section respectively. The extent of the difference between the two frequencies gives an indication of the departure from a circular outline.

Kabir and Saha also examined the effect of delignification on the bending modulus of jute, using the fringe technique, and showed that successive extractions of lignin on the same fibres resulted in increasing flexibility and decreasing Young's modulus.[19] The delignification method used was treatment with sodium chlorite solution followed by extraction with sodium bisulphate; the removal of 10% of lignin reduced the modulus from 1.10 to $0.79 \times 10''$ dynes/cm^2. At the same time, however, the diameter of the fibres was reduced significantly and this may have affected the flexibility. Physical properties of jute fibres are set out in Table 2.5.[20]

When buried in soil, incubation tests have revealed that the jute fibres and similar fibres retain their tensile strength to a much higher degree, at about well

Table 2.5 Physical properties of jute fibres

Sl. No.	Property	White jute	Tossa jute	Roselle
1.	Unit cell length (mm)	0.8–6.0	0.8–6.0	2.0–11.0
2.	Length/breadth ratio	110	110	140
3.	Hermann's Angle of orientation (X-ray)	7°–10°	7°–9°	9°–12°
4.	Specific gravity	1.4–1.45	2.00–5.00	3.50–5.50
5.	Moisture regain (%) at 65% RH	12.5	12.5	13.0
6.	Transverse swelling (%) in water	20.0–22.0	20.0–22.0	20.0–22.0
7.	Tenacity – single fibre (g/tex)	27–36	16–35	16–40
8.	Elongation at break (%)	1–1.5	1.0–2.0	1.0–2.0

Table 2.6 Strength loss in jute due to soil burial

Type of jute	% retention of tensile strength after soil burial for 3 days
White jute	56.3
Tossa jute	68.3
Roselle	86.5

over 50%, when compared to other fibres such as pineapple and sisal. Natural fibres lose strength when buried in the ground due to the growth of micro-organisms. The micro-organisms play a predominant role in the degradation of fibre cellulose by the secretion of enzyme cellulose, the ultimate result of which was the loss in tenacity values (Table 2.6).

The high retention of the tensile strength of the *Hibscus* genus fibre, roselle (mesta) in comparison with the two *Corchorus* genus fibres (white and tossa jute) may be due to the fact that roselle has a higher length to breadth ratio and also that its Herman's angle of orientation by x-rays is higher; roselle's is 9° to 12° whilst that of the jute fibres is around 7° to 9°.

2.3.2 Fine structure

The locations of the three main chemical components of the fibres are reasonably well established. Alpha cellulose forms the bulk of the ultimate cell walls with the molecular chains lying broadly parallel to the direction of the fibre axis. The hemicellulose and lignin, however, are located mainly in the areas between neighbouring cells, where they form the cementing material of the middle lamella, providing strong lateral adhesion between the ultimates. The precise nature of the linkages that exist between the three components and the role played by the middle lamella in determining the fibre properties are incompletely understood. Professor Lewin,[21] some years ago, in an interesting literature survey on the middle lamella of bast fibre, brought together a great deal of relevant information that illuminated many of the problems but a thorough understanding of the intercell structure is still awaited.

X-ray diffraction patterns show the basic cellulose crystal structure but in jute and kenaf, although the crystallite orientation is high, the degree of lateral order is relatively low in comparison with flax. There is also considerable background x-ray scattering arising from the noncellulosic content of the fibre. The cellulosic molecular chains in the secondary walls of ultimate cells lie in a spiral around the fibre axis. The effect of this is to produce double spots in the x-ray diffraction patterns, the centres of the spots being separated by an angular distance of twice the Bragg angle. For large angles, such as occur in coir fibre and some leaf fibres such as Mauritius hemp, the two spots are visibly separated but for the small angles found in jute and kenaf, the spots overlap. In this case the distribution of intensity across the width of the spots, instead of reaching a peak at the centre of each, is spread out into a single flatter, peak. The [002] equatorial reflection shows these effects particularly well and analysis of the intensity distribution allows calculation of the Herman's RMS spiral angle. A wide range of bast and leaf fibres has been examined in this way,[22] with results showing the Herman's angle to range from about 8° for jute and kenaf up to 23° for sisal. Coir fibre, *Cocos nuciferos*, is exceptional in having a Herman's angle of about 45°.

The leaf fibres in this study are particularly interesting because as well as covering a good range of spiral angles, they also cover a wide range of ultimate cell dimensions. The results indicate that among this group of fibres, the spiral structure averages a constant number of turns per unit length of cell, about ten per millimetre, and with this arrangement in the spiral angle then depends solely on the breadth of the cell. Whether this constancy of turns applies to individual cells, or whether as in wood, the longer cells tend to have steeper spirals, was not, however, investigated.

For the secondary bast fibres, the cell dimensions show little variation between plant species, but the number of spiral turns per unit length of cell averages only about four per millimetre, appreciably less than for the leaf fibres. The importance of the spiral angle measurements lies in the control that the spiral structure exercises on the extension which the fibre can withstand before breaking. Regarding the structure as a helical spring, the extension necessary to straighten a spring of initial angle θ, to the axis is $(\sec \theta - 1) \times 100\%$. A 10° spring will thus extend by 1.54%, a 20° spring by 6.4% and a 30° spring by 15.5%.

2.3.3 Chemical properties

Retted fibres such as jute have three principal chemical constituents; alpha-cellulose, hemicellulose and lignin. The lignin can be almost completely removed by chlorination methods in which a soluble chloro-lignin complex is formed and the hemicellulose then dissolved out of the remaining holocellulose by treatment with dilute alkali. The final insoluble residue is the alpha-cellulose constituent, which invariably contains traces of sugar residues other than glucose.

The hemicellulose consists of polysaccharides of comparatively low molecular weight built up from hexoses, pentoses and uronic acid residues. In jute, *capsularis* and *olitorius* have similar analyses, although small differences occur between different fibre samples. For fibre extracted from jute plants grown in Bangladesh, the range of composition has been given as lignin 11.4–12%, alpha-cellulose 58-63% and hemicellulose 21–24%.[23]* In addition, analysis of the hemicellulose isolated from alpha cellulose and lignin gives xylan 8–12.5%, glucoronic acid 3–4%, together with traces of araban and rhamnosan. The insoluble residue of alpha cellulose has the composition glucosan 55–59%, xylan 1.8–3.0%, glucoronic acid 0.8–1.2%, together with traces of galactan, araban, mannan and rahmnosan. All percentages refer to the weight of dry fibre.

As well as the three principal constituents, jute contains minor constituents such as fats and waxes 0.4–0.8%, inorganic matter of 0.6–1.2%, nitrogenous matter 0.8–1.5% and traces of pigments. In total these amount to about 2%. The detailed molecular structure of the hemicellulose component is not known with certainty, although in the isolated material the major part is stated[24] to consist of a straight chain of D-xylose residues, with two side branches of D-xylose residues, whose position and length are uncertain. In addition there are other side branches formed from single residues of 4-0-methyl glucoronic acid, to the extent of one for every seven xylose units.

The third major constituent, lignin, is a long-chain substance of high molecular weight which, like hemicellulose, varies in composition from one type of vegetable material to another. The molecular chains are built up from comparatively simple organic units that may differ from different sources, and also in the way in which they are combined. Most of the studies in lignin have been concerned with wood and the bast fibres have been rather neglected. It seems unlikely, however, any major differences will exist between jute and wood lignin, but in any case many details of the molecular structure still remain unresolved.

2.4 Yarn production

2.4.1 Conventional spinning system and quality of in-process materials and yarn

The most commonly operated jute spinning system consists of two stages of carding, followed by three stages of drawing and finally a spinning stage.[28] The flowchart is shown in Fig. 2.5. In the first carding stage, the long lengths of fibre

* For further published data on the chemical composition of jute fibres see the tables in the appendix to Chapter 1.

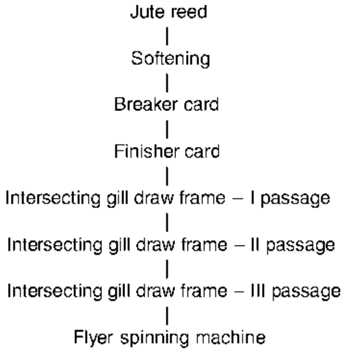


Figure 2.5 Process flowchart for spinning 100% jute yarn. Source: *Indian Jute,* A bulletin published by Jute Manufacturers Development Council, Kolkata, Vol. 12, No. 2, December 2002.

are passed through a breaker card, which breaks the continuous mesh of fibres into separate fragments, conveniently called 'entities', which are akin to the single fibres of cotton and wool. In addition to fragmentation, the pins of the breaker card have a cleaning action by removing loosely adhering non-fibrous matter from the fibre proper.

Sliver quality

Sliver from the breaker card is then passed through the second, or finisher card, which causes a little more fibre breakage and provides further opportunity for removal of non-fibrous matter. In addition, the finisher card has an important mixing effect, since a number of slivers are fed to the card in parallel and emerge finally as a single sliver. The quality parameters for the unevenness for carded sliver[29] are given in Table 2.7.

In the three drawing stages, the movement of fibre is controlled by gill pins fixed to faller bars. In modern drawing frames, the faller bars move on spiral screws, although some spinners prefer the push-bar method for the first stage. At all stages, drafting is accompanied by appropriate doubling of the input slivers. The quality parameters for the unevenness of drawn slivers[29] at the drawing stages are shown in Table 2.8. The output sliver from the final drawing stage then passes to the spinning frame, where its linear density is reduced suitably for the yarn being spun, after which the required twist is inserted. Almost universally in the jute industry, the insertion of twist is performed by overhung flyer, with the yarn winding-on to a bobbin rotating on a dead spindle, against a friction drag. Other methods of inserting twist by ring or pot-spinning are available but are little used, and then only for yarns of higher linear density.

Prior to the late 1940s, jute yarn was mainly spun from rove, the output sliver from the third stage of drawing being given a small twist to hold the fibres

Table 2.7 Unevenness for carded sliver (quality parameters)

		Product type					
	Yarn end-use	Hessian		Sacking warp		Sacking weft	
Sliver weight (lb./100 yd)		18**	15**	20*	15*	20*	15*
Weight CV% (test length = 10 yd)	Good	Below 10	Below 4	Below 10	Below 4	Below 12	Below 4
	Normal	10 to 12	4 to 6	10 to 13	4 to 8	12 to 18	4 to 8
Thickness CV%	Good	Below 15	Below 11	Below 17	Below 12	Below 20	Below 18
	Normal	15 to 18	11 to 14	17 to 20	12 to 15	20 to 23	18 to 21

Source: Norms for the jute industry – Part 1, *Quality parameters up to spinning*, Bulletin published December 1997, pp. 5–7. Courtesy: IJIRA.
* at 20% Moisture regain (MR)
** at 16% Moisture regain (MR)

Table 2.8 Unevenness of slivers at the drawing stages (quality parameters)

Type of product	Processing stage	Quality parameters				
		Weight (lb/100 yd)	Weight CV% (test length = 10 yd)		Thickness CV%	
			Good	Normal	Good	Normal
Hessian	First drawing	8 (at 16% MR)	Below 3.5	3.5–5.5	Below 10	10–12
	Second drawing	4 (at 16% MR)	Below 3.0	3.0–6.0		
	Finisher drawing	130 (grist at 16% MR)	Below 3.0	3.0–5.0		
Sacking warp	First drawing	8.5 (at 20% MR)	Below 3.5	3.5–5.5	Below 11	11–13
	Second drawing	4.25 (at 20% MR)	Below 4.0	4.0–6.0		
	Finisher drawing	140 (grist at 20% MR)	Below 4.0	4.0–6.0		
Sacking weft	First drawing	5.5 (at 20% MR)	Below 4.0	4.0–6.0	Below 15	15–18
	Finisher drawing	180 (grist at 20% MR)	Below 4.0	4.0–6.0		

Source: Norms for the jute industry – Part 1, *Quality parameters up to spinning*, Bulletin published December 1997, pp. 5–7. Courtesy: IJIRA.
MR: Moisture regain

together for transport to the spinning frame. Production of rove in this way was a slow process, however, and during the 1950s spinning from rove was superseded by spinning directly from third-drawing sliver. To hold the fibres together, the sliver is passed into a crimping box, which gives it a small crimp. This is just as effective as twist but is a much faster process.

Yarn quality

Control of fibres on the spinning frame, when sliver spinning was first introduced, was by one or more weighted rollers – the 'slipdraft' system. More recently, the 'apron-draft' system was introduced, whereby fibre control was effected either by a double-apron arrangement or by a single apron pressing the fibres against a lower fixed metal plate. Specifications for sale yarn quality parameters are shown in Tables 2.9 and 2.10.[30,31]

2.4.2 Flyer spinning systems

Developments in the flyer system have also taken place, the two-legged flyer being replaced by a rigid metal plate. The yarn runs loosely behind the plate instead of being fixed in position as previously, when wrapped round a flyer leg. Compared to the two-legged flyer, the rigid flyer results in reduced yarn tension and also permits the use of larger bobbins. In commercial spinning it is interesting to note that using similar good quality fibre, the spinning limit of a slip-draft frame fitted with two-legged flyers is commonly taken to be about 210 tex, whereas the combination of apron-draft and rigid flyer increase the fineness of the yarn to about 140 tex.

Table 2.9 Specifications for sale yarn quality parameters (8–12 lb. (276–413 tex) yarn)

Quality parameters	Specifications			
	Good		Normal	
Linear density	8–10 lb (276–345 tex)	10–12 lb (345–413 tex)	8–10 lb (276–345 tex)	10–12 lb (345–413 tex)
Count CV%	Below 5	Below 4	5 to 7	4 to 6
Strength CV%	Below 16	Below 14	16 to 18	14 to 17
Quality ratio**	Above 105	Above 110	95 to 105	100 to 110
Hairiness index	Below 10.5	Below 11	10.5 to 11	11 to 12
Total imperfections*/100m	Below 175	Below 150	175 to 200	150 to 180

Source: Norms for the jute industry – Part 1, *Quality parameters up to spinning,* Bulletin published December 1997, pp. 5–7. Courtesy: IJIRA.
* Total imperfections = thin places (–50%) + thick places (+50%) + slubs (+200%)
** See Section 4.4

Table 2.10 Specifications for sale yarn quality parameters (4.8–6 lb. (165–207 tex) yarn)

Parameters	Specifications							
	Good				Normal			
Linear density	4.8 lb (165 tex)		6 lb (207 tex)		4.8 lb (165 tex)		6 lb (207 tex)	
	Single	2-ply	Single	2-ply	Single	2-ply	Single	2-ply
Count CV%	Below 6	Below 5	Below 5	Below 4	6–8	5–6	5–7	6–8
Strength CV%	Below 20	Below 15	Below 18	Below 15	20–22	15–18	18–20	15–18
Quality ratio*	Above 95	Above 105	Above 100	Above 105	90–95	95–105	95–100	100–105
Hairiness index	Below 9	Below 11	Below 10	Below 12	9–10	11–12	10–12	12–13
Total imperfections*/100 m	Below 200	–	Below 180	–	200–250	–	180–220	–

Courtesy: IJIRA.
* See Table 2.8

2.4.3 Modern developments in jute spinning

Developments have also taken place in drawing frames, for, in addition to the fixed-draft frames in common use throughout the industry, a so-called ‘autoleveller’ is available. This machine automatically adjusts the draft according to the thickness of the output sliver and thereby maintains a more uniform linear density of sliver than is normally obtained with fixed-draft machines. Used as a second-stage drawing frame, the autoleveller can reduce the CV% of linear density between 100 m lengths of yarn from the 4–5% achievable with fixed draft to about 1.5–2%. A similar effect could have been achieved by increasing the doublings on the fixed-draft frames by a factor of six or seven times and because of this, the frame with automatic draft control is more correctly termed an ‘auto-doubler’. It is only on long lengths of yarn that levelness is improved, of course, the short-term levelness being virtually unaffected.

Careful preparation of fibre before presentation to the breaker card is necessary if the best results are to be obtained from the spinning system. Application of water, to soften the fibre, and oil, to lubricate it, is essential, except where oil is undesirable for a particular end-use, in which case a non-oily lubricant must be used. The liquids are usually applied in the form of an oil-in-water emulsion, the composition and rate of application being controlled to give the desired add-on of both water and oil.

If the breaker card is to be hand-fed with long jute, the lengths of fibre are first passed through a series of heavy fluted rollers on a jute softener, a machine that is also used for preparing cuttings. If, however, the breaker card is to be fed from rolls of fibre, a jute spreader is used to form the rolls. This is similar to the goods machine used in the hard-fibre industry, and emulsion application takes place through either softener or spreader.

High speed ring-spinning machines for spinning fine jute yarns are manufactured by Lummus Mackie, UK and N. Schlumberger, France. Also SITRA have developed a low-cost spinning machine for fine-count jute yarns but these have not yet been taken up by the industry due to the lack of demand for such yarns.

Spinning of fine jute yarn

The South India Textile Research Association (SITRA) at Coimbatore has developed a ring spinning frame to spin 100% fine jute yarns.[30] Some of the salient features of the SITRA jute ring frame include

- double-sided machine with sliver feeding creel arrangement (200 spindles/ machine)
- optimum spinning geometry with 45° roller stand angle. Angle of yarn pull is 28° and spinning angles are 21° (lappet bottom position) and 25° (lappet top position).

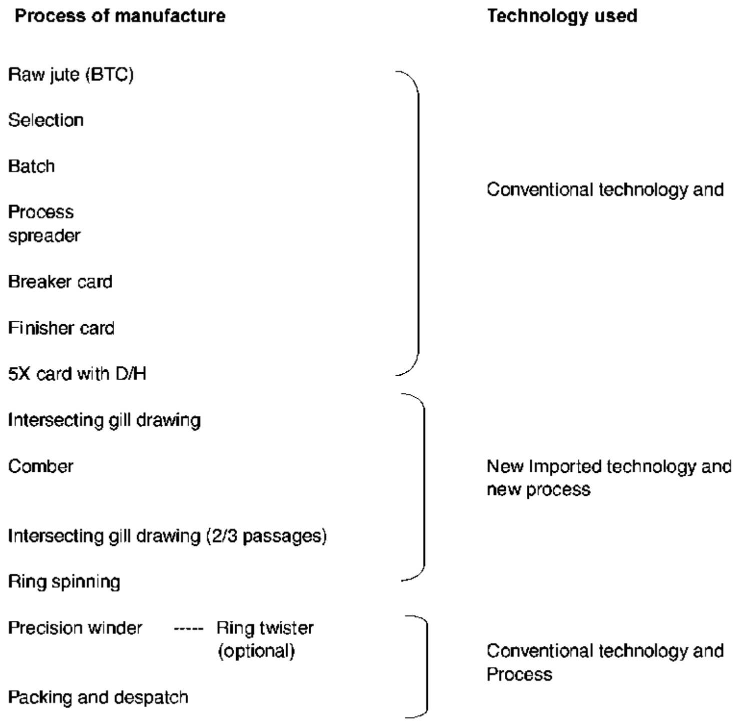


Figure 2.6 Process flowchart for fine jute and jute blended yarns.

- top arm loading with PK 1601 arm and with slip draft
- self-lubricating vertical rings or multi-grooved rings with nylon travellers
- ABC rings for balloon control
- spinnable count: 4 to 8 lb./spindle (with appropriate sliver)
- spindle speeds 6000 to 6500 rpm
- draft range 15 to 30
- twist range 3.0 to 12.0 TPI.

According to development work carried out by IJIRA[32] the spinning of fine jute yarn, i.e., 4 lb. (138 tex) is possible using imported machines. The process flowchart for producing fine jute yarn is given in Fig. 2.6. The quality characteristics of fine jute yarn and jute blended yarns produced by using imported machines are given in Table 2.11.

Spinning of jute blended yarns on the short staple spinning system

In connection with a United Nations Development Programme assignment, SITRA has also developed[33] appropriate technology and machinery to spin jute/cotton blended yarns on short staple ring spinning systems. Special purpose machinery developed by SITRA for spinning jute/cotton blends include

Table 2.11 Quality characteristics of fine jute and jute blended yarns

Material	Mass CV% (Uster – 1 cm)	Imperfections*/ 100 m	Tenacity (Rkm)	Strength CV%
(i) 4 lb. All jute combed yarn	24.16	127	13.16	21.04
(ii) 3 lb. (70/30) jute v. rayon combed yarn	20.93	73	9.44	19.22
(iii) 2 lb. (50/50) jute/ v. rayon combed yarn	25.03	128	8.31	15.25

* Thin place (–50%) + Thick places (+50%) + Slubs (+200+)

- high-production cutting machine (Patent No. 485/MAS/93)
- a sliver-making machine (Patent No. 711/MAS/93)
  a sandwich blending draw frame[34] (Patent No. 1000/MAS/94).

Counts in the range of 8s to 10s Ne were spun from a 50/50 (jute/cotton) blend. These blended yarns were used to manufacture a wide range of sample fabrics including curtain fabrics, blankets, bedspreads, floormats, industrial fabrics, pile fabrics and others. The process flowchart for spinning jute/cotton blended yarns is given in Fig. 2.7. The machinery set up developed by SITRA

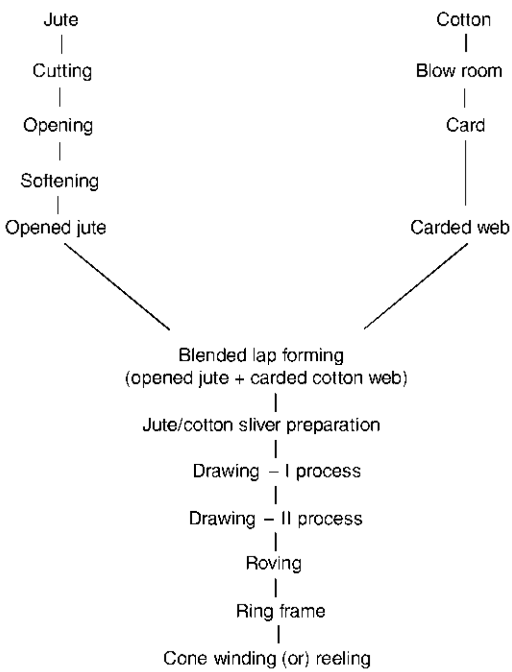


Figure 2.7 Process flow chart for spinning jute/cotton blended yarns.

for jute/cotton blended yarn spinning can also be used for spinning jute/viscose, jute/acrylic and jute/polyester blended yarns.[35]

Home textiles, curtains, furnishings, and upholstery are some of the value-added products that could be manufactured using jute/viscose blends. These products are not only cheaper than 100% viscose fabrics but also have better dimensional stability, which is one of the prime requirements for home furnishings. The fall (drape) of the fabrics made from jute/viscose blends, particularly curtains, would be an improvement on those made from 100% viscose due to the coarseness of the jute fibres.

Due to their warmth-retention property, acrylic fibres are frequently used as a substitute for wool for use in cooler climates. In this context, blending a small proportion of jute with acrylics may have cost advantages without significantly affecting the warmth-retention property of the fabric. Quality norms developed by SITRA[35] for jute/cotton, jute/viscose, jute/acrylic and jute/polyester blends spun in a short staple ring spinning system are given in Tables 2.12–2.15.

Spinning of jute blended yarns on the rotor spinning system

Ahmedabad Textile Industry research[36] has reported spinning jute/cotton blends on rotor spinning systems. In these spinning systems optimum yarn linear density is 100 tex with 30% jute and 70% cotton. Such yarns could be woven on

Table 2.12 Quality norms for jute/cotton blended yarns

Count (Ne)	6^s			8^s			10^s		
Yarn quality attributes	30/70	40/60	50/50	30/70	40/60	50/50	30/70	40/60	50/50
1. Tenacity (g/tex)	9.0	7.5	7.0	8.5	6.5	6.0	9.0	7.5	5.5
2. Elongation (%)	4.5	3.5	3.0	5.0	4.5	4.0	5.0	4.0	3.5
3. Mass irregularity (CV%)	20.5	23.0	23.5	22.0	23.5	24.5	23.0	25.0	26.5
4. Hairs/m	80	85	100	60	65	90	55	55	60

Table 2.13 Quality norms for jute/viscose blended yarns

Count (Ne)	6^s			8^s			10^s		
Yarn quality attributes	30/70	40/60	50/50	30/70	40/60	50/50	30/70	40/60	50/50
1. Tenacity (g/tex)	8.0	7.0	6.5	7.5	7.0	6.5	8.5	7.0	6.5
2. Elongation (%)	4.5	4.0	3.5	5.0	4.0	3.0	5.0	3.5	2.5
3. Mass irregularity (CV%)	19.5	20.0	20.5	20.0	20.5	21.5	22.0	22.5	23.5
4. Hairs/m	65	70	75	50	55	60	40	45	50

Table 2.14 Quality norms for jute/acrylic blended yarns (acrylic 1.5D)

Count (Ne)	6^s			8^s			10^s		
Yarn quality attributes	30/70	40/60	50/50	30/70	40/60	50/50	30/70	40/60	50/50
1. Tenacity (g/tex)	10.0	9.5	7.5	10.5	10.0	8.0	10.0	9.5	7.5
2. Elongation (%)	14.5	13.5	9.0	13.5	12.0	8.0	13.5	12.5	9.0
3. Mass irregularity (CV%)	18.0	18.5	20.5	19.5	19.5	22.5	21.5	22.0	24.5
4. Hairs/m	70	80	95	55	65	80	50	55	65

Table 2.15 Quality norms for jute/polyester blended yarns (polyester 1.4D)

Count (Ne)	6^s			8^s			10^s		
Yarn quality attributes	30/70	40/60	50/50	30/70	40/60	50/50	30/70	40/60	50/50
1. Tenacity (g/tex)	21.0	18.0	15.5	24.5	18.5	14.0	22.5	18.5	16.0
2. Elongation (%)	10.0	9.5	8.5	10.5	9.0	8.0	9.5	8.0	7.5
3. Mass irregularity (CV%)	21.5	24.0	25.5	24.5	25.5	26.0	24.0	27.0	27.5
4. Hairs/m	60	65	75	40	50	65	35	45	50

most types of looms. Some of the products made from such yarns include: denim on shuttle less looms; curtain fabrics and shawls on handlooms; and niwar (a narrow fabric) on tape looms. Lakshmi Machine Works Ltd., Coimbatore have done pioneering work on spinning jute and jute blends on short staple open-end (OE) spinning systems. They have spun counts in the range of 6s to 10s Ne on OE spinning system using 30% to 50% jute in a jute/cotton blend.[37,38]

Spinning of jute blended yarns on friction spinning systems (core yarns)

A report from the Wool Research Association (WRA), Mumbai[39] indicates that friction spinning technology could be used to manufacture core spun yarns with jute yarn as the core and shoddy woollen waste as the sheath. The core jute yarn provides the necessary strength and the sheath of staple fibres provide the necessary comfort and aesthetic appeal for manufacturing products such as blankets, dhurries (a heavy floor covering fabric) and furnishings.[39] Secondary carpet backing yarn was also developed using jute yarns as core and polypropylene fibres as sheath.[40] The yarn mentioned in this section was not on the market at the time this book was written but gives a good indication of the many possibilities for diversifying jute into new markets in the near future.

Upgrading of jute fibres

Many attempts have been made to improve the spinning quality of jute by the action of enzymes and other bio-agents. Enzymes start their bio-chemical reactions in the presence of moisture on the substrates that are specific to the enzyme involved, i.e., cellulose enzyme on cellulose and hemicellulose enzyme on hemicellulose and so on. To soften the hard tissue of bark in the 'pile' of jute stems that are to be treated the concurrent action of both enzymes and bacteria (aerobic and anaerobic) is essential. These enzymes are called hydrolases as they catalyse the hydrolic degradation of specific carbohydrates. These simultaneous actions are the hydrolic degradation of the tissues of the plants (which requires moisture) and the bacterial action, which is accelerated by the easily assimilable reaction products generated by enzymic action. The synergistic effect of the two biological systems results in both softening and upgrading the jute fibres.

Although the average filament strength of enzyme treated jute is more or less the same as that of untreated jute the quality ratio values of the treated yarns are higher than those of the untreated yarns. This is due to the fact that the enzyme and bacteria treated fibres build up to a more compact yarn. Another interesting effect of the enzyme treatment of jute fibres is the increase in equilibrium moisture regain of the treated fibres. A higher moisture retention property ensures improved spinnability of the treated fibres, even under dry atmospheric conditions. From a purely practical point of view these enzyme and bacterial treatments can help to improve spinning and weaving efficiency by about 6%.

Spinning assistants

Jute fibres have a low natural content of fats and waxes and some added lubrication is essential for good yarn regularity. Mineral oil is the commonly used lubricant, applied as an emulsion in water. The amount added ranges between 0.75 and 5% by weight and in particular cases an additional 1 to 1.5% will give the maximum single-thread breaking load. Less than 1% results in a marked falling off in strength, whilst above 2% the yarn breaking load falls steadily, but more slowly.

Mineral oils are absorbed to some extent into the body of the fibre through crevices in the surface and internal holes. Low-viscosity oils are absorbed rapidly and leave the surface relatively oil free, in a state corresponding to boundary-lubrication conditions. High-viscosity oils, on the other hand, are absorbed more slowly into the fibre and mainly remain on the surface, and so produce the appropriate conditions for hydrodynamic lubrication. It has been found that there is an optimum viscosity in the region of 250–300 seconds Redwood which gives the lowest values of percentage mean deviation (PMD), whereas, if the viscosity is increased to 5000 seconds or more the yarn regularity and strength will substantially deteriorate (ref. 28, p. 46).

Friction-increasing additives

If the added mineral oil is scoured from the yarn, which is not, of course, normal commercial practice, the breaking load of the yarn increases by 4 or 5%. This is due to increased friction between the fibres on removal of the oil, which helps to prevent slippage before the fibres break and thus enables them to achieve a higher breaking load. It would be expected that a similar effect would result from the addition of a friction-increasing substance, such as colloidal silica and this is indeed the case. If the silica is added before spinning, the result is a marked increase in irregularity but, if the addition is made on the spinning frame immediately before insertion of twist, the regularity is unchanged because all the drafting was done prior to application but the breaking load is increased by 10% or more, depending on the amount added. As with scouring, the silica prevents fibre slippage and produces more breakage. Moreover, when the fibres do break, rather than slip, the elongation of the yarn increases slightly.

Friction requirements

In a perfect yarn, where the fibres are arranged entirely at random, the PMD value will be inversely proportional to the square root of the number of fibres in the cross-section. Actual PMD values are always greater because the fibres draft not as individuals, but in groups. This results in a succession of thick and thin places along the length of the yarn. There are two opposing factors, the cohesion of the slivers being drafted and the restraint offered by the pressure of the gill pins on the faller bars. If the fibre/fibre friction is low and the fibre/steel friction is high the restraint of the gill pins will be increased, but the cohesion of the sliver will be reduced. The overall effect will be for the groups of fibres to be broken up, which leads to greater regularity. Similar frictional effects have been study by Spencer-Smith and Todd[25] for long staple man-made fibres on flax-spinning systems. These authors concluded that the ratio of the coefficient of static friction between fibres to the corresponding coefficient of static friction of fibres on steel should be as small as possible to spin the most regular yarns. Other factors, such as gill-spacing and fibre-loading on the drawing frames also affect yarn regularity, but in addition to the purely frictional effects.

The need for a low fibre/fibre coefficient of friction for good drafting is the opposite of what is required in the yarn to achieve a maximum breaking load but because of the dominant effect of the PMD in determining breaking load, the choice of lubricant must be made with good drafting in mind, even if this results in some loss of strength in the yarn owing to fibre slippage. Although mineral oils are in common use as inexpensive lubricants many chemical manufacturers supply proprietary additives of an organic chemical nature, which confer particular surface properties on fibres. Such additives are commonly long-chain fatty acids or alcohols, condensed with ethylene oxide molecules. In addition, various wax dispersions are available and although all these non-oily materials are more expensive than mineral oil, the importance of achieving the correct surface properties of fibres by using a proper choice of lubricant is an important factor in spinning the highest quality yarns.

Fine-quality jute – a new development

If the jute manufacturing industry is to have a long-term future, it seems essential that new outlets be found for their products. In textile terms, jute goods are heavy and are being steadily assailed by modern lightweight materials. With the currently available jute yarn counts there is a limit to fabric weight reduction that can be obtained without unacceptable loss of strength. In this respect, the fibre itself is a constraint because of its own higher linear density. New jute fibres are therefore needed, which will permit jute yarns of lower linear density to be spun and woven without significant loss of strength and thus lead naturally to the production of fabrics of lower mass per unit area. To make this a reality the new fibres would need to be much finer those than those presently available. At present commercially available jute fibres have a linear density (after carding) in the range of 15.0 to 30.0 denier.

Using JRC 321 seed variety, The South India Textile Research Association, Coimbatore[26] has developed, by the classical method of plant breeding and selection, a finer fibre with a fineness of 8.0 to 9.0 denier after carding. While using normal jute fibre from JRO seeds, counts finer than 56 lb. are practically not possible. However, 3 lb. and 4 lb. yarns were spun using JRC 321 fibres. These would produce fabrics with weights per square metre that would be suitable for many furnishing fabrics. Quality attributes obtained for yarns spun from JRC 321 are given in Table 2.16.

Table 2.16 Yarn quality attributes from JRC 321 fibres

Quality parameters	Count of yarn	
	3 lb	4 lb
Quality ratio (%)*	86.0	101.0
Strength CV (%)	28.0	20.0
Weight CV (%)	5.0	3.0

2.4.4 Some definitions

$$\text{Quality ratio} = \frac{\text{Single yarn strength in lb.}}{\text{Grist in lb. per spyndle}}$$

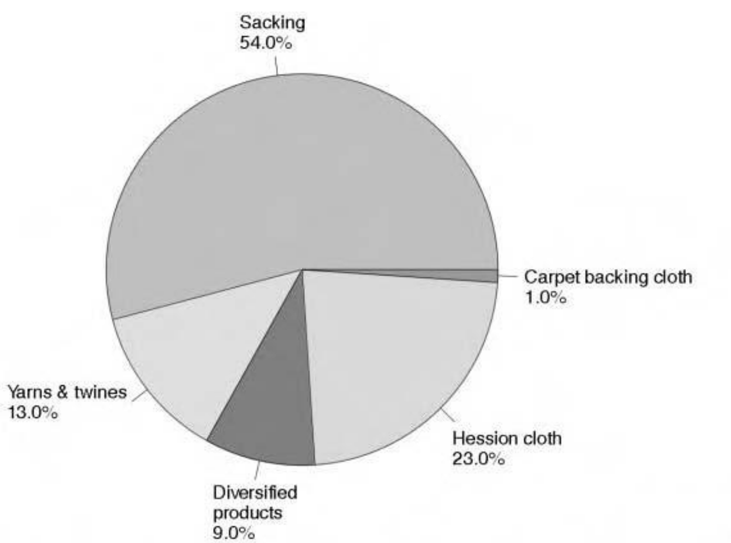
$$\text{Count in cotton system, Ne} = \frac{17.14}{\text{lb. per spyndle}}$$

$$\text{Spyndle} = \text{A length of 14,400 yds.}$$

Qualities of 3 lb. and 4 lb. yarns are considered satisfactory for fabrics intended for decorative end uses.[27]

2.5 Fabric production, end-uses and specifications

Jute yarns can be woven on automatic power looms, shuttleless looms or on handlooms. Of the world production of jute goods, which stands at about 3 million tonnes per year,[1] India accounts for about 50% and Bangladesh and China for about 17% each. In India, around 80% of the jute yarns are used for manufacturing sacking, carpet backing and hessian cloth as shown in Fig. 2.8. In Bangladesh, more than 90% of the jute yarns manufactured are utilised for manufacturing sacking, carpet backing and hessian.



*Diversified products include decorative fabrics, tarpaulins, soil savers, canvas cloth, webbings, etc

Figure 2.8 Proportions of jute fibres used for manufacturing different products in India (2001–2002). Courtesy: *Indian Jute*, A bulletin published by Jute Manufacturers Development Council, Kolkata, Vol. 12, No. 2, December 2002.

2.5.1 Powerloom weaving

Winding

One of the main purposes of warp yarn winding is to transfer yarn from the spinner's or doubler's package to another which can be used in the creel of a warping machine or for dyeing. Warping requires as much yarn as possible on each package and also a package which has been wound at comparatively high tension, but dyeing requires a soft-wound package so that dye can penetrate; a compromise is therefore sometimes needed in the matter of winding tensions. Winding also enables manufacturers to monitor and improve the quality of the yarns by passing them through yarn clearers whilst they are being wound.

ATIRA and Patwa Kinariwala Electronics[41] have developed an electronic yarn clearer. This is a microcontroller/microprocessor based system for the detection and clearing of objectionable faults such as thick and thin places and slubs in jute and jute blend yarns. The salient features of this system are:

- It is based on opto-electronic principles.
- There are settings for different grists of yarn from 4 to 16 lb. and for clearing different types of faults.
- It displays data such as lot no., spindle-run-time, idle-time, and the yarn grist.
- There is one control module for 60 spindles. Spindles are divided into user defined groups for optimum utilisation.
- A modular design ensures fast and easy serviceability.
- Performance is comparable with imported yarn clearers for jute.
- The 'online' display of different parameters on LCD screens along with central computers enables monitoring and control.
- An optional facility is available for yarn length measurement.
- Clearing efficiency is not affected by changes in winding speeds.

Warping

There are two main types of warping, beam warping and section warping, used to prepare jute and jute blend yarns for weaving. Beam warping is used for long runs of grey (loom-state) fabrics and simple patterns where the proportion of coloured yarn involved is less than about 15% of the total. Section warping is used for pattern weaving and for short runs, especially of yarn dyed fabrics where the content of coloured yarn is greater than about 15% of the total.

Sizing of jute yarn

Jute yarns need to be sized because they are hairy and they have low extensibility under tension. In the Indian jute industry, tamarind kernel powder (TKP) is used exclusively as the only suitable sizing material, the optimum add-on recommended being in the range of 3–3.5% of the weight of the yarn along with a suitable antiseptic (0.025 to 0.03% of the size paste). To achieve further improvements in weaving performance the addition of lubricants, supplementary adhesives and humectants, either as such or in the form of proprietary products, has been tried but the results obtained are not conclusive although some increase in weaving efficiency has been noted in particular cases.

However, it should be stated that in jute weaving warp breakages alone account for about one-third of the total loss of efficiency and so there is clearly scope for reducing them. In this respect it is interesting to note that at all levels of application, polyvinyl acrylate (PVAC) increases the abrasion resistance of warp yarn, for example the ratio of the number of strokes required to break the treated yarn to the number of strokes required to break the unsized yarn increases. Moreover, PVAC reduces fibre shedding during weaving. The quality ratio of warp yarns, in general, also improves on treatment with PVAC. It should also be noted that the BTRA have developed BTRACRYL sizing ingredients for jute yarns.

2.5.2 Weaving of jute yarn

Shuttle looms

The shuttle loom is the oldest kind of power loom; it is effective and versatile but it has certain disadvantages. The shuttles may cause abrasion on the warp yarn as it passes over them and this sometimes causes thread breaks. This, in turn, results in machine stoppages with consequent reduction in weaving efficiencies. They operate at a rate of about 110–220 picks per minute (ppm) which is slower than some new types of loom, and they are also noisier.

Shuttleless looms

Gripper projectile looms and rapier looms can be effectively used to weave jute yarns of any nature. There is only one kind of projectile loom used in the jute industry, air jet looms, which are used for the production of such fabrics as shirtings and denims. Air jet looms are either single nozzle or multiple nozzle types.

There are several kinds of rapier loom. One early model uses one long rapier device that reaches across the entire width of the loom to carry the weft yarn from one side of the loom to the other. Another type utilises a double rapier; one on each side of the loom. The rapier itself can be rigid, flexible or telescopic. In these looms the rapier from one side feeds the weft yarn half way through the shed of warp yarns to the rapier on the other side, which meets it half way across the warp and takes the pick back across the rest of the warp. These rapier looms are efficient and can be used to produce a wide variety of fabrics ranging from muslins to drapery and upholstery materials.

2.5.3 Handloom weaving

With the growing diversification of the use of jute in various non-traditional applications, end-uses such as curtains, upholstery and some heavier furnishing fabrics provided by the hand loom sector require lighter count jute and jute blended yarns of below 4 lb. Technically such lighter yarns could not, up to now, be produced industrially by the mill sector. However, recent developments have led to the design and development of appropriate technology and it is now possible to produce these lighter yarns from 100% jute and jute blends. Some of the specifications for fabrics produced on handlooms are given in Table 2.17.

2.5.4 Diversified products

In the case of handlooms, it was shown that from the jute yarn supplied by jute mills, it would be feasible to produce a number of value added jute/jute blended fabrics for textile applications.[42] In India, around 9% of the jute yarns are used for manufacturing diversified products.[1] The relative share of upholstery and soft luggage, tarpaulins, canvas cloth, webbings and soil savers in the total quantum of jute diversified products is shown in Fig. 2.9.

Canvas cloth contributes the major share of about 50% of all jute diversified products followed by tarpaulins (40%). Upholstery, decorative, wall coverings, soft luggage fabrics and jute soil savers contribute another 10%. But there is considerable scope for the development of these products due to a general awareness concerning the importance of using eco-friendly and biodegradable products if we are to sustain the ecological balance of the world. David Rigby

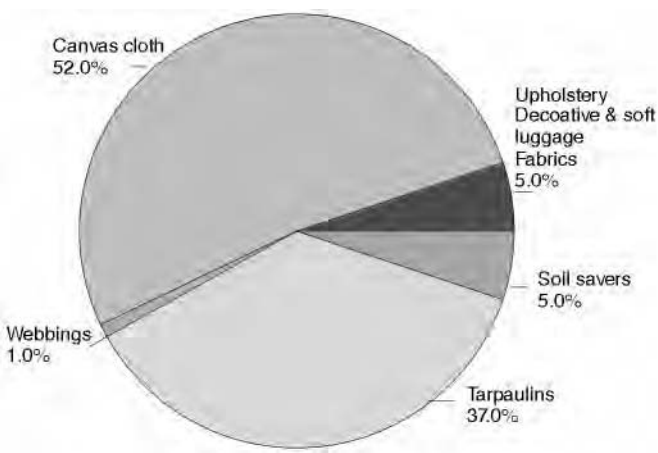


Figure 2.9 Relative share of different diversified jute products. Source: *Indian Jute*, A bulletin published by Jute Manufacturers Development Council, Kolkata, Vol. 12, No. 2, December 2002.

Table 2.17 Specification of handloom woven jute and jute blended fabrics

Characteristics	Type of fabric					
	Jute/cotton	Jute mat	Jacquard furnishing	Jute viscose fabric	Jute curtain	Export carpets
Warp count	Cotton yarn 2/20	9.5 lb. 2 ply	2/17 Cotton	3.2 lb. jute	2/17 cc	3/6 cc
Weft count	Jute & cotton yarn 9.5 single ply, 2/20 cotton	Jute yarn 11 lb., 3 ply	6s Jute	3.8 lb. jute	3.8 lb. jute	Jute 3 ply
Weave	Plain with extra weft	Diamond	Plain & float	N/A	Plain & mockleno	Plain & design
Fabric weight	500 g/m^2	100 g (13 $\times$ 18)	400 g/m^2	250 g/m^2	300 g/m^2	0.120 g/ft^2
Ends x pick /inch	36 $\times$ 36	10 $\times$ 10	40 $\times$ 36	28 $\times$ 30	36 $\times$ 36	8.1 $\times$8
Width (inch)	48	13	36	–	48	24

Table 2.18 Application areas for technical textiles and suitable jute products

Sl. No.	Type of application	Application area	Suitable jute products
1.	Agrotech	Agriculture, horticulture, forestry & fishing	Canvas cloth and tarpaulins
2.	Buildtech	Building & construction	Jute laminates
3.	Clothtech	Clothing and footwear	Jute and jute blended fabrics
4.	Geotech	Geotextiles and civil engineering	Soil savers
5.	Hometech	Furniture, interior textiles & floor covering	Curtains made from jute blends, jute wall coverings, dividers, etc.
6.	Indutech	Filtration, belting and abrasives	–
7.	Medtech	Medical and hygiene	–
8.	Mobiltech	Automotive/transportation	Non-wovens made from jute/ jute blends for sound & heat insulation
9.	Packtech	Industrial and consumer packaging	Soft luggage fabrics, laminated jute hessian cloth and sackings
10.	Protech	Personal and property protection	Flame proof and mildew proof fabrics made using jute yarn as core and other conventional/high performance fibres as sheath.
11.	Sportech	Sports and leisure equipment	–
12.	Oekotech	Environmental protection	Canvas cloth and tarpaulins made from jute/jute blends

Source: World Technical Industry and its Markets, April 1997. Courtesy: David Rigby Associates, Manchester, UK.

Associates[43] has classified 12 application areas for technical textiles and suitable jute products corresponding to these. These are summarised in Table 2.18.

Jute decoratives and wall coverings

Jute decoratives and wall coverings are becoming fashionable. The Food and Agricultural Organisation of the United Nations (FAO) has summarised the position as follows: 'For various important applications such as curtain materials, upholstery and wall coverings, jute has a special appeal'.[2] Jute as wall coverings had a considerable market in Western Europe but because of technical problems, including colour fastness, jute was displaced by alternative materials. If these defects are quickly overcome and jute items marked at competitive prices there is a chance of regaining these lost markets. Bangladesh and India have initiated measures to promote various types of furnishing fabrics and other articles such as upholstery, curtain materials, blankets, blended jute fabrics and jute felt. There is considerable demand in the domestic sector for these products but in order to meet that demand the production base needs to be strengthened and quality improved.

The production and marketing of these decorative items have a special significance for the traditional handloom industry of India which employs 10 million weavers and produces around 3,500 million metres of cloth per year. A programme for the utilisation of jute yarn to produce 100% jute or blended fabrics has been undertaken at various handloom centres. In order to achieve successful and broad-based programmes it is necessary to ensure the continuous availability of yarn, to arrange proper training, to identify product lines for upholstery, bed linen, cotton material and organise processing and marketing so that the resultant products are priced at competitive levels. In India the National Handloom Development Corporation is the government organisation that co-ordinates the development and financing of the activities of this sector.

Jute wall covering is considered as a fashion product, for which the demand pattern can change frequently and rapidly. Jute was used for wall covering, with a market of about 3 million metres in the 1970s but at present, the market is much smaller at only 400,000 metres in 1988. It is reported that the problem may lie with poor colour fastness (and the presence of lignin).[93] These problems need to be solved if this end-use is to be developed satisfactorily. Also it should be borne in mind that the export of yarn is important from the point of view of the 'image' of the fibre as some of the users in Europe of these yarns are sophisticated designers and producers of wall coverings and sales of specialised yarns to these small weavers depend entirely on quality.

Soft luggage fabrics

Soft luggage fabrics made using jute are already marketable products. The FAO summarises the position as follows: 'A market survey carried out by the Commonwealth Fund for Technical Cooperation (CFTC) identified this product as one of the most promising which needed promotional support.'[43] The main potential for jute lies in high fashion handbags and similar products and also for shopping bags, with some opportunity also for soft travel luggage. According to one estimate the market potential for shopping bags is expected to exceed two million units a year, and for other soft luggage the market is over one million units in France alone. Jute should aim at a share of this market. It is reported that the CIS of the former USSR have shown interest in this area. Jute mills in Bangladesh and India have brought out excellent bags which are being marketed domestically and exported. The specifications of some jute household, soft luggage and decorative fabrics are given in Table 2.19.

Table 2.19 Specifications of jute household, soft luggage and decorative fabrics

Sl No.	Characteristics	Household fabrics			Soft luggage fabrics			Decorative fabrics		
		Interior decoration	Curtain upholstery	Apparel bed linen	Suitcase bags	Handbags	Shopping bags	Made-up articles	Printed fabrics	Matting floor-covering
1.	Weight (g/m^2)	200–300	200–400	100–200	200–400	150–300	150–300	200–500	200–400	300–500
2.	Fibre component									
	jute %	50–80	30–60	40–50	80–100	80–100	80–100	80–100	40–50	80–100
	blend %	20–50	40–70	50–60	0–20	0–20	0–20	0–20	50–60	0–20
3.	Strength warp × weft (kg) (min) (100 × 200 mm)	60–90	60–112	30–60	76–152	57–114	57–114	76	76	114

Jute canvas

Jute canvas is a closely woven double warp plain weave cloth. It is usually made from better quality jute. Canvas is used for hatch covers, sun blinds, mailbags, tents, soil cloth, etc. Typical specifications[44] of jute canvas cloth (usual range) are given in Table 2.20.

Jute tarpaulins

Lined and laminated jute fabrics are also available to meet special packing needs of the industries to protect the contents from external moisture and also to protect the container itself from corrosion by the contents. Jute tarpaulin cloth is the base cloth for these purposes. The specifications[44] for jute tarpaulin cloth (usual range) are given in Table 2.21. The production of jute tarpaulin cloth[45–47] for the last ten years is given in Table 2.22. Jute tarpaulins are being increasingly replaced by synthetic fibre fabrics.

Jute webbing

Webbings are woven narrow fabrics, the prime function of which is load bearing, generally with multiple plies. The production of jute webbing for the last five years (1996–2001) has been around 3000 m. tonnes.

Table 2.20 Specifications of jute canvas cloth (usual range)

Characteristics	Value
Width (mm)	915–1220
Weight (g/m^2)	540–675
Ends/inch	31–35
Picks/inch	15–18

1 inch = 2.54 cm

Table 2.21 Specifications for jute tarpaulin cloth

Characteristics	Value
Width (mm)	860–1220
Weight (g/m^2) (for 1140 mm width fabric)	400–510
Ends/inch	8–10
Picks/inch	10–13

1 inch = 2.54 cm

Table 2.22 Production of jute tarpaulin cloth

Year	Production (m.ton)
1991–92	111.8
1992–93	111.8
1993–94	87.7
1994–95	86.2
1995–96	58.5
1996–97	53.1
1997–98	65.1
1998–99	37.8
1999–00	21.9
2000–01	10.3

Jute soil savers

Textiles used in the field of civil engineering are known as 'Geotextiles'. Geotextiles are designed for separation, reinforcement, filtration, drainage and protection/erosion control functions. Jute, because it is eco-friendly and biodegradable has gradually replaced synthetic fibres where durability is not a foremost concern, for example, in soil erosion control and slope protection. For other geo-textile applications such as separation, filtration, drainage, road construction, soil stabilisation and river and canal embankments, treated jute geo-textiles treated with chemicals such as copper oxide or bitumen are used so as to provide satisfactory resistance to rotting. There is a current global demand of about 100 million m^2 of jute geo-textile fabrics in North America, Western Europe, Japan and Australia. The construction and properties of some jute soil saver fabrics meant for different applications[48] are given in Tables 2.23–2.26.

Table 2.23 Jute soil saver fabrics for erosion control

Soil composition	Slope angle	Annual rainfall (mm)	Type of geo-textile fabric				
			Wt. (g/m^2)	Aperture (mm)	Width (cm)	Thickness (mm)	Threads (per m)
Debris of soil mixed with boulders and rock pieces	60–85	3000	750	20 × 20	122	7	70 × 70
Sandy silt and clay	45–85	3000	500	25 × 25	122	5	65 × 45
Sand clay and combination	Up to 45	2000	300	10 × 10	122	3	110 × 110

Courtesy: N. Arun, Implementation of Jute in GeoTech, *Man-made textiles in India*, vol. xiii, no. 6, June 2000, p. 262.

Table 2.24 Jute soil saver fabrics for river/canal embankments

Properties	Value
Type of fabric	Woven (twill) treated with rot-resistant chemicals and bitumen
Ends × picks/m	10 × 5
Weight (g/m^2)	700
Width (cm)	102
Thickness (mm)	3
Tensile strength (kN/m)	
Warp direction	25
Weft direction	25
Failure strain (%)	
Warp direction	8
Weft direction	10
Puncture resistance (N/cm^2)	400
Water permeability at 10 cm	
Water head (L/m^2/s)	20

Courtesy: N. Arun, Implementation of Jute in GeoTech, *Man-made textiles in India*, vol. xiii, no. 6, June 2000, p. 262.

Table 2.25 Jute soil saver fabrics for drainage and filtration

Properties	Value
Type of fabric	Non-woven
Thickness (mm)	7–10
Weight (g/m^2)	500–1000
Tensile strength (kN/m)	3–5
Failure strain (%)	25–30
Puncture resistance (N/cm^2)	400
Coefficient of permittivity (m/s)	1/10000–1/1000
Coefficient of transmittivity (m/s)	1/100000–1/10000

Courtesy: N. Arun, Implementation of Jute in GeoTech, *Man-made textiles in India*, vol. xiii, no. 6, June 2000, p. 262.

Jute autocarpet underlay

Driver and passenger comfort is a major concern of present-day car manufacturers, to the extent that even the boots and leg spaces of cars have cushioning layers. This is being achieved by using non-woven jute felts of about 600 g/m^2 in the lining of these spaces.

Seat backing (automobiles)

Again in pursuit of car comfort a layer of non-woven jute felt in the weight range of 300–400 g/m^2 is sandwiched between the leather seat covers with coir

Table 2.26 Jute soil saver fabrics for road construction

Properties	Value
Type of fabrics	Woven (twill) treated with rot-resistant chemicals
Ends × picks/cm	102 × 39
Weight (g/m^2)	760
Width (cm)	76
Thickness (mm)	3
Strength (kN/m)	
Warp direction	20
Weft direction	20
Strain at break (%)	
Warp direction	8
Weft direction	10
Puncture resistance (N/cm^2)	350

Courtesy: N. Arun, Implementation of Jute in GeoTech, *Man-made textiles in India*, vol. xiii, no. 6, June 2000, p. 262.

and spring layers in the backs of car seats. This gives a smooth and comfortable feeling to the seat.

2.5.5 Recent developments in the manufacture of high-performance technical textiles using jute (protective textiles and structural composites)

Protective textiles

Although jute fibres would not normally be thought of for use in apparel, the exclusive combination of certain of its properties make it the ideal fibre for use in protective clothing against fire and heat. These properties are (in some cases after appropriate chemical treatment of the fabrics) high strength, high abrasion resistance, reasonable resistance to heat, durability and washability, and relatively low cost when compared with synthetic fibres. It can be used for protective aprons and gloves for protecting those working in oil installations and refineries, fire brigades, refractor and engineering plants. If required the jute fabric may be given water and oil repellent treatments. In these applications jute partly replaces kevlar. Table 2.27 depicts the performance of jute blended protective garments.[49]

Studies[50] conducted by IJIRA reveal that multi-component jute yarns can be successfully used for the manufacture of technical fabrics such as canvas (for tents and tarpaulins) and fire-retardant (FR) fabrics of international quality standards using friction spinning systems. Since the cost of high-performance fibres used in the manufacture of technical yarns is very high, the use of jute fibre as a blend is cost effective. The quality characteristics of high tenacity multi-component yarns for FR protective fabrics are given in Table 2.28.

Table 2.27 Comparison of the fire protection performance of jute/kevlar blend protective garment and garments made from chemically treated conventional fabrics

Criteria	Protective garments made from jute/kevlar blend	Protective garments made from chemically treated conventional fabrics
Flame retardancy	Permanent	Not permanent, lost on repeated washing in detergents
Emission of toxic gases on ignition	Nil	Emits toxic gases that may endanger life
Cost performance evaluation	Cheaper than 100% kevlar fabrics, performance at par with 100% kevlar fabrics	Inferior

Source: Bardham, M. K., 'Jute eco-friendly fibre for technical application and eco-friendly recycling of non-degradable polyester bottle waste'. *Proceedings of the 24th Technological Conference*, January 2002, p. 100. Courtesy: IJIRA, Kolkata.

Table 2.28 High-tenacity jute blended multi-component yarns for protective fabrics

Parameters	A	B
Yarn count (tex)	59	59
Yarn composition		
A. Sheath fibre used (%)		
(i) Jute	40	30
(ii) F.R. Viscose (1.7 D × 40 mm)	–	35
(iii) Kevlar (1.7 D, S.B)	30	
B. Core (%)	30	35
(i) Kevlar (1.7 D, S.B.)		
Yarn properties		
Tenacity (cN/tex)	36.2	36.7
Quality ratio	277	281
Strength (CV%)	7.0	8.0
Elongation (%)	3.7	3.9
Irregularity (%)	18.0	16.7
Hairiness (3 mm, hair/m)	32.5	45.4

Source: Khauta, D. P., Ray, D. K., Sankar, D., Neogi, S. K. and Bhattacharya, B. K., 'Dref spun jute blended multi-component technical yarns and fabrics'. *Proceedings of Jute India Conference*, New Delhi, October 1997. Courtesy: IJIRA, Kolkata.

Jute fibre for use in composite materials for the automobile industry

Interior trim panels in automobiles, such as door panels, dash boards and head liners are manufactured from composite products which increasingly use bast and leaf textile fibres, including jute, as reinforcement (see Appendix D and Chapter 10). The jute felts are either thermoset with polyester or polypropylene resin or may be reinforced on low-cost plastic sheets. In this case heavier jute felts of 1000 g/m^2 weight are used. The rigid panels are then covered with PVC/polyester cloth and installed with the other interior fittings in the cars. These composites are also used in brake linings replacing asbestos fibre which, as it is carcinogenic, is a health hazard.

Jute-based auto trims have the following advantages:

- lighter weight of the vehicle, leading to fuel savings
- low thermal conductivity of the jute fibre which therefore acts as a good heat barrier
- equivalent performance as compared to composites made with synthetics.

Jayachandran *et al.*[61] evaluated non-woven jute fabrics as seat backings, carpet underlays and fibre reinforced structure punching, where it is environmentally friendly compared to powder phenolic resin which is non-recyclable and non-biodegradable.

Car body panels developed by IJIRA[62] by resin transfer moulding using jute/polyester composites have the following advantages over glass/polyester composites:

- substantially cheaper than glass
- offer real weight savings
- allow easier recycling of moulded parts
- are not as abrasive as glass fibres and therefore give less tool wear.

Thermoplastic composites from jute/polypropylene[63] show better quality characteristics over polypropylene composites (see Table 2.39 in Appendix D, where jute composite materials are further discussed).

2.6 Dyeing and finishing: modern developments in chemical finishing

2.6.1 Dyeing

Patro[69] has described the general techniques employed in the dyeing of jute with basic, acid, direct and sulphur dyestuffs. According to the author, most of the requirements of the jute dyer can be met with dyestuffs of the basic, acid and direct classes, and being a highly lignified fibre, jute shows very good affinity for basic dyes and requires no prior mordanting. However, acid and direct dyes have relatively low affinity for jute.[70] Dye-stuffs with higher tinctorial values on jute generally show poor light fastness but it is possible to select dyes which give better light fastness, together with reasonable tinctorial values. For jute, however, light fast dyeing is difficult to achieve, particularly in pale shades, owing to the yellowing of the substrate fabric itself by the action of light. In order to obtain reasonably fast tinctorial effects the fabric must be subjected to some method of light fast bleaching prior to dyeing.

2.6.2 Bleaching

A process developed in the USA has been described in which jute can be bleached to a good white shade, reversion to its natural colour on exposure to light being inhibited.[72] The jute fabric is first bleached by the conventional hydrogen peroxide method; the bleached fabric is then treated with an aqueous solution of potassium permanganate (8–12% of weight of jute) under mineral acid, which is usually sulphuric acid (8–12% of weight of jute). Subsequently, the reduced permanganate is cleared by rinsing the fabric in an aqueous solution of sodium bi-sulphite or sodium sulphoxylate formaldehyde at pH 3.0 to 3.5.

The development of this process has increased jute's possibilities in decorative and furnishing fabrics. Highly regular and patterned grey fabrics with blended fibres and yarns have also been developed in order to impart special properties and optical effects to the texture of such decorative jute products. Market research conducted in specific areas of the USA has revealed a substantial potential demand for decorative jute fabrics. This process also effectively removes the surface hairs of jute fabrics so as to present a smooth handle.

Another process has been developed in the USA for the production of light-fast jute.[73] The process consists of bleaching the jute fabric at a pH below 3.0 at temperatures in the range 15–43 °C in an aqueous solution of potassium permanganate and phosphoric acid in amounts such that the ratio of potassium permanganate to phosphoric acid ranges between 1 : 0.7 and 1 : 1.1. The bleached fabric is then scavenged with an aqueous solution of an inorganic reducing agent such as sodium bi-sulphite at a pH below 4.0. After this step, the fabric is scoured with hot water or steam. It is claimed that by means of this process it is possible to produce bleached jute fabric having a colour fastness of not less than 25 Standard Fastness Hours (SFH).

The BTRA[74] has developed a cold bleaching process for jute fabrics using hydrogen peroxide, special polymeric finishes that can be given to jute and jute/cellulosic union fabrics and also eco-friendly dyeing and finishing processes.

2.6.3 Crease resistance

Das[71] has described the results of the treatment of jute fabrics with formaldehyde in order to impart crease resistant properties by means of a pad-dry-cure method. With a 3% formaldehyde solution a dry crease recovery of 186° and a wet crease recovery of 267° was obtained, but this was associated with a loss of tensile strength of about 16%. By treating the jute fabric under partially swollen conditions (i.e., using a controlled water system containing a non-swelling agent) with aqueous formaldehyde containing an acid catalyst, both wet and dry crease recovery were found to increase substantially. Fairly high wet crease recovery in the range of 242–253° can be achieved by treating alkali-swollen jute fabrics with formaldehyde at room temperature. The loss in tensile strength in this case was not very high, being of the order of 21–32%. With increasing formaldehyde concentration both wet crease recovery and loss in strength increased. Similar effects were observed with an increase in the catalyst concentration and period of treatment. However, wet treatment with formaldehyde under room temperature conditions effected an improvement in wet crease recovery only, without any noticeable effect on dry crease recovery.

2.6.4 Rot-proofing

A process has been developed for rot-proofing jute fabrics by means of copper compounds added to the batching emulsion at the preparatory stage before the fibres are spun. The process is equally effective, and at the same time is more economical than the conventional process of proofing finished fabrics by wet treatment. It also requires a lower percentage of copper than the conventional process for effective protection against micro-organisms.

2.6.5 Woollenisation

When jute fibre is treated with strong alkali profound changes occur in its physical structure. Lateral swelling occurs, together with considerable shrinkage in length; the fibres are softened to the touch and develop a high degree of crimp or waviness. The crimp gives a wool-like appearance to the fibre. This process is known as woollenisation. On stretching the fibres break, the crimp is straightened and this increases the extensibility of the fibre.[66] The effect is small at alkali concentrations up to about 10% but the extensibility increases rapidly at concentrations of 15% upwards and may reach 8 or 9%. At the same time, however, the tensile strength of the fibre decreases with increasing alkali concentration. It is interesting to note that the product of extensibility and tensile strength, the breaking energy, appears to pass through a maximum at 15–20% concentration.[67] This has a beneficial effect on spinning because the carded fibre has a longer average length than normal and this results in a more uniform yarn.

The optimum temperature for crimp formation is about 2 ºC and at higher temperatures the crimp parameters are reduced, becoming zero at 40 ºC. An immersion time of at least 30 minutes is necessary for the crimp to be formed. The physical effects of the woollenisation process are different when the jute fabrics are kept under tension. Research[68] has shown that shrinkage is greatly reduced by tension, falling from 11 to 12% when slack to 1.5 to 2.5% under 3 kg tension. The appearance and handling of jute fabrics are greatly improved by the woollenising process, and bleached and dyed fabrics have good commercial possibilities.

2.6.6 Enzyme treatments of fabrics to improve their softness and smoothness

Chattopadhyay *et al.*[75] have found that a temperature of 55 ºC at a pH level of 5, a 1 : 10 material to liquor ratio and 4% enzyme concentration for a duration of 120 min. produces optimum weight loss for enzyme treated jute fabric. Chattopadhyay *et al.*[76] observed a substantial loss in jute fabric weight after enzyme treatment. Due to an increase in pore and consequently an increase in the exposure of lignin surface the crease recovery angle increased by about 25% whereas moisture regain, abrasion resistance and tensile strength decreased after resin treatment.

2.7 Economic and cost considerations

2.7.1 Manufacturing efficiency

In its traditional end-use, packaging, jute is now more costly than some of the competitive synthetic materials that are on the market. This is due to the higher labour intensiveness, and therefore higher labour cost, of jute production and manufacture when compared to synthetic packaging and although the skills involved are moderate, due to socio-economic conditions, the cost of labour is likely to continue to rise. The key to the solution of this problem lies in a rapid increase of labour and machine productivity. It is therefore appropriate to refer to some of the productivity norms that have been developed.[78] Achievable efficiency in the various stages of spinning and of weaving are shown in Tables 2.29–2.32.

Table 2.29 Achievable efficiency at the carding stage

Quality	Hessian/sacking warp		Sacking weft	
Processing stage	Breaker card	Finisher card	Breaker card	Finisher card
Achievable efficiency (%)	84.0	85.0	80.0	82.0

Courtesy: IJIRA, Kolkata.

Table 2.30 Achievable efficiency at the drawing stage

Processing stage	First drawing	Second drawing	Finisher drawing
Achievable efficiency (%)	71.0	72.0	72.0

Courtesy: NIRJAFT, Kolkata.

Table 2.31 Spinning frame efficiencies for different qualities of jute yarns

Quality	Hessian warp		Hessian weft		Sacking warp		Sacking weft
Count range (lb.)	7.0 to 8.5	8.5 to 10.5	7.0 to 8.5	8.5 to 10.5	9.5 to 12.0	Above 12.0	26–32
Achievable efficiency (%)	81.0	81.0	81.0	80.0	78.0	77.0	75.0

Table 2.32 Weaving hessian and sacking efficiencies*

Sl no.	Quality	Machine efficiency (%)
1.	Hessian	65.0
2.	DWT	70.0
3.	B. twill	75.0
4.	A. twill	75.0

* Hessian and DWT fabrics are woven on looms of 46.5″ reed space and A-twill and B-twill fabrics are woven on looms of 37.5″ reed space.
A-twill: around 550 g/m^2 B-twill: around 475 g/m^2

2.7.2 Jute exports

The jute industries grew differently in India and in Bangladesh; in India, the world's largest producer of jute and jute products, production of jute goods averaged about 1.5 million tonnes per year for the last five years. This level is about three times the average production of about 0.5 million tonnes per year in Bangladesh. In India, about 88% of the total jute products are consumed in the domestic market and hence the industry is governed largely by conditions in the domestic markets. On the other hand, 80% of the jute goods produced by countries like Bangladesh are exported and the industry is more exposed to world market conditions, facing competition. Table 2.33 gives details of the exports of the principal countries concerned.[79] [*Editor's note*: Of course, the exports of those countries that do not themselves produce jute fibre export either jute manufactured or semi-manufactured products made from imported fibre, yarn or fabric. In some cases, for example, the UK, Germany and the Netherlands these 're-exports' may well include substantial quantities of fibre as they will include the activities of international merchanting companies based in those countries that trade in textile raw materials.]

About 85% of the jute industry in India is mainly in the private sector, compared to 40% in Bangladesh. The technology used is similar in both countries, although the equipment is much older in India. Despite this the Bangladeshi mills run at lower efficiencies than the Indian mills: 70% compared

Table 2.33 World exports of products of jute, kenaf and allied fabrics

Country	Export in 1000 tonnes	Country	Export in 1000 tonnes
Developing countries		**Developed countries**	
Africa	1.4	USA	2.1
Guatemala	0.2	EC	50.4
Mexico	0.3	Belgium–Lux	26.6
Egypt	0.1	France	3.7
Syria	0.3	Germany	5.4
Turkey	0.3	Netherlands	6.5
Bangladesh	408.5	UK	5.1
China	6.5	Australia	0.2
India	176.5	Japan	0.6
Nepal	10.0		
Thailand	6.9		
Total	**616.1**	**Total**	**65.1**

Source: *http://www.fao.org/es/esc/common/ecg/28807.enBULLJune2003.pdf* Courtesy: Food and Agriculture Organization of the United Nations.

to 80% and incur substantial financial losses whilst the jute mills in India make a reasonable profit, estimated at about 7% of their sales revenue.[2] The poor financial results of the Bangladeshi mills are due not only to their lower productivity but also to the fact that, as stated above, they face greater competition on world markets than do the Indian mills on their home market. In China, the productivity is high and machine maintenance and quality aspects are good. There is great interest in diversifying the jute products that they produce. The existence of excess labour in the jute mill sector, particularly in Bangladesh is a major problem in the jute industry. This effect of excess labour is reflected in the very low labour productivity of the mills. On average, labour productivity in Bangladesh is about half of that in India.[2]

There is a need for 'skills' training both when recruiting new workers and also for the retraining of existing personnel in order to improve labour productivity. The International Jute Organisation (IJO) in Dhaka[2] has suggested essential strategies for the long-term survival of the industry, both in India and in Bangladesh. Their important conclusions are that:

1. There is a need to set up a framework which would enable information and advice to be freely exchanged between companies on such subjects as product diversification, for example.
2. There is a need to reduce costs by
   (a) ensuring stable prices of raw material
   (b) achieving higher manufacturing efficiencies and actively involving workers in improving productivity
   (c) producing lighter weight products

   (d) utilising waste
   (e) conserving energy
   (f) reducing the variety of products manufactured.
3. There is a need to balance, modernise and replace machinery.
4. There is a need for product quality standards and their maintenance by
   (a) adhering to optimal product norms
   (b) quality control
   (c) staff and management training.
5. Developing and implementing appropriate sales and marketing policies is essential.

IJO has also identified the following as thrust areas essential for jute product development in the future.

Traditional jute products

- variety reduction
- improvement in product brightness (lustre)
- improvement in the quality of carding
- reduction of fibre shedding
- odour improvement
- greater use of shuttleless looms for weaving so as to achieve improvements in manufacturing efficiency, product quality and the development of new products.

Diversified (new) jute products

- jute for use in paper pulp
- jute geo-textiles
- carpets
- consumer items – jute and jute blends (luggage, etc.)
- decoratives (furnishing fabrics).

2.8 Market development

Jute used to be regarded as an export-orientated commodity that enjoyed a world-wide monopoly market. However, this was to be challenged by the advent of synthetic fibres in the early 1960s. By the late 1970s high-density polyethylene and polypropylene began to take a share of the packaging market and similarly, synthetic carpet backing cloths attacked that particular market, in which jute was paramount at the time. From the point of view of jute the situation has continued to deteriorate, as is shown by the fact that the international market for jute goods (world exports of jute and allied fibres +

goods made from these fibres) which was of the order of 1.3 million tonnes at the beginning of the 1980s has come down to about 1 million tonnes at present.

In this situation any marketing strategy adopted by Bangladesh, India or China should have the objective of arresting further erosion of these international markets. This would require aiming at new classes of consumer with newer jute products and would entail producing these ranges of new, diversified, jute items. This also implies a transformation in the role and utilisation of jute fibres from packaging to the production of a wider selection of textiles, from geo-textiles to finer fabrics for a variety of end-uses, some of which have been touched on above.

2.8.1 Textile development possibilities of jute fibres

As we have seen in previous sections of this chapter it is now possible to spin fine and regular yarns of up to 4 lb. (or 138 tex). These yarns and fabrics made from them can now be subjected to all types of dyeing, printing and finishes. Jute can be blended with viscose staple fibre, polypropylene, wool, ramie, pineapple fibres, etc. These blends normally have jute as the predominant fibre. Generally 6 denier 100 mm or longer fibres are used to ensure a satisfactory blend. Dyeing is satisfactory and reaches a light fastness of 5+ and washing fastness of 4+. All shades including pastels can be dyed and the fabrics can be shrink-resisted, crease resisted, flame retarded, stiffened, softened, woollenised, etc.

Jute has a number of desirable properties; high breaking and tear strength, good sheen and lustre, inelasticity and dimensional stability, thermal insulation, bulk and a unique texture. It has a raw and natural look, which is appreciated by western consumers. After blending and in union with fabrics some of these properties are further highlighted. It is a common notion that jute is not washable. It is true that the wet strength of jute is lower than its dry strength but in no textile application is jute used when wet and even when being washed and the fibres subjected to pressure and linear and shear stress the strength of the fabric is fully adequate. It should also be noted that jute has superior washability to that of wool or silk.

Union fabrics of jute/cotton with cotton yarn in warp and jute in weft form an important item in the area of jute diversified products. It is also possible to produce union and blend fabrics having cotton in warp and jute/viscose or jute/PP in the weft.

Decorative jute is traditionally used as a wall covering fabric. Correctly finished jute blended fabrics will make excellent furnishing fabrics for use in upholstery and for curtains, screens, etc. For some furnishing end-uses such as upholstery a small proportion of nylon staple fibre (about 5%) is sometimes added to the blend to further increase abrasion resistance. Buckram or interlining fabric is also another recognised end use. Properly finished and printed fabrics can also be used as dress material and for other apparel uses in colder climates.

Jute/pp fabrics can also be converted into attractive blankets after proper finishing and especially raising. Jute fabrics of appropriate construction can also provide an excellent substrate for PVC and other coatings.

Blended yarns of jute/PP after woollenisation have an appearance similar to wool and they have equally good, if not better, thermal insulation properties. They can be made very soft and dyed to fast and attractive colours. It should also be possible to spin these blended yarns to finer counts than 100% jute. Such yarns would be better than 100% wool in many respects, for example, in washability and durability. Also they would be relatively inexpensive. Jute/PP yarns should also have considerable abrasion resistance and even some resilience and as carpet face yarns they could find a substantial outlet. They can also be used for the manufacture of superior quality blankets.[94] Such yarns could also be a good substitute for wool for knitting purposes. They would be better than 100% synthetic products such as acrylic yarns, which have very little weight and natural feel. However, the development of suitable yarns would require a considerable technical effort in order to produce knitting quality knotless yarns suitable for use high production knitting machines so as to allow for mass production, which would be their obvious market as the yarns would be competitive in price with other yarns used in the knitting industry.

Jute/viscose yarns will also enable the production of finer yarns. Viscose is a versatile fibre with good sheen and softness and blending with jute results in a good quality yarn, comparable to raw silk in sheen and look. These yarns can be dyed to fast colours and be subjected to all types of chemical processing such as heat setting, mercerising, fire retardancy, water proofing, etc. These yarns could also be knitted and would produce attractive hand- or machine-woven fabrics which would increase the size of the market open to jute as they would be less expensive than jute-cotton blends because cotton prices in eastern regions of India are increasing. In this respect jute would also have the advantage of being produced locally which would also reduce its total cost to spinners.

Hand and power looms are able to produce jute and jute blended fabrics in a variety of designs and in small lots according to consumers' preferences, which is a major marketing advantage when compared with most other textile producers throughout the world and should provide major export opportunities.

2.8.2 Potential markets for jute products

South America

South American countries are large producers of coffee and other agricultural commodities, a high proportion of which are exported. These need to be protected from damage whilst being transported and close woven, odourless jute bags of the required sizes are well placed to supply this requirement at an economical cost. South America also has a large carpet industry for which there may be some scope for jute carpet backing cloth (CBC).

Decorative jute fabrics and their end products such as wall coverings, shopping bags, wall hangings, etc., should enjoy good demand in these countries. There should also be scope to sell blankets, dhurries, postbags, brattice cloth etc. The substrate for PVC leather cloth, linoleum and other coated products should also form an attractive area for export in these countries.

Africa

Like South America, some countries, Kenya and Uganda for example, are exporters of agricultural commodities and could use considerable quantities of jute sacking. The continent should also offer a substantial market for jute decoratives as furnishing fabrics and also for its end-products such as different types of shopping bag, school bags, etc. There also should be good market for jute and jute blended blankets, dhurries, seed bags, postbags, etc. Bags for packing of industrial products such as cement, sugar and certain chemicals should also create a demand from the industrial units in some of the countries in the region.

Middle East – Iran, Egypt, Sudan, Pakistan, etc.

These countries have a large and increasing requirement for jute bags and other products for packing agricultural and industrial products. Special bags made from laminated jute fabrics, lighter bags, and union bags should also help to increase the size of this market.

Japan and Eastern Asia

Japan is a big user of jute goods and has an increasing demand for a number of jute products. It imports large quantities of rice bags manufactured to its own specifications. It is also one of the biggest buyers of jute yarns. Blended yarns of jute and other bast fibres should offer very good scope in this market. With adequate market development jute decoratives and other end products should meet with considerable success. Wall coverings in particular should quickly become popular with consumers in most of the region and particularly in Korea, Hong Kong, Singapore, Malaysia, and Taiwan, etc. Japan also imports large quantities of CBC.

Australia and New Zealand

Australia and New Zealand are already consumers of jute. Decorative products, jute yarns and CBC in particular are well established but there is, however, still a good deal of scope to increase the usage of jute goods in these countries by offering better designed products for specific end uses. Australia could also be a good market for jute soil savers, mattings, decoratives and their end products such as shopping bags, wall coverings and also for brattice cloths and substrates for PVC and other coatings.

Europe and the USA

Europe and the USA offer tremendous scope for value added products in the areas of decoratives, wall coverings, small finished products (shopping bags, luggage, etc.). Blended fabrics and yarns could be another potential product base in these countries, particularly as carpet face yarn and in the manufacture of furnishing fabrics. The use of jute yarn as carpet weft, fuse yarn, cable yarn and for the weaving of decorative fabrics also has a large potential. Linoleum backing, substrates for PVC leather cloth webbing and mattings, etc., are also markets capable of being developed. Soil savers are already attracting extensive enquiries. Final products made from blended yarns and fabrics could also open up a large market for value added merchandise. All these items require a good deal of promotional effort and a sound product base.

The will and determination of jute and textile entrepreneurs to bring out the advantages of fine jute yarns, blended yarns, speciality jute fabrics, and the many other final and intermediate products mentioned above in areas hitherto not tested by many consumers from all over the world could make jute a real international fibre and an integral part of the world's textile industry. Jute should be projected[64] as a genuine member of the textile family as it has now become finer and is available in blends capable of meeting the exacting requirements of the global textile industry's consumers.

2.8.3 Market promotion

In India, an organisation known as the Jute Manufacturers Development Council (JMDC) assists in the marketing of jute products. Some of their important activities include

- the participation in and organisation of specialised trade fairs, buyer-seller meetings, workshops and seminars
- sponsoring delegations and commissioning market surveys and commodity studies
- providing commercial information and market intelligence surveys to the jute industry and trade
- the identification of new and diverse uses of jute and the encouragement of their manufacture and sale
- the implementation of internal market assistance and external market assistance schemes
- running the jute show rooms.

Another agency, the National Centre for Jute Diversification (NCJD) acts as the nodal agency for entrepreneurship and development in the Indian jute sectors. One of its main objectives is to develop need-based programmes for the popularisation and adoption of jute diversified products. The NCJD also encourages weavers and craft workers living in rural areas and who work in the unorganised sectors to adopt diversified jute products.

An important scheme operated by the NCJD, the Jute Entrepreneurs Assistance Scheme (JEAS) aims at exploring new application areas for jute products and spreading the production base of jute diversified products.[80] According to available information,[81] in India there are about 90 manufacturing units involved in jute diversification projects assisted by the NCJD. This organisation's financial contribution to these projects totals nearly Rs.190 million ($US4 million), which has, in its turn, generated capital investment of over Rs.1,000 million ($20.8 million). The range of the jute diversified products manufactured in these assisted units include

- jute fine yarns
- jute decorative fabrics
- laminated particle board for knock-down furniture
- jute composite board for automobiles and industrial clutches and brake linings
- shopping bags and laminated teabags
- jute non-woven fabrics
- jute cotton blended dhurries
- jute stick particle board
- jute composites and roof ceiling
- jute yarn based moulded items
- hand made paper and allied products
- jute thermoplastic composite board
- soft luggage and briefcases
- fashion garments and accessories.

Another scheme, the Technology Upgradation Fund Scheme (TUFS), is operated by the Ministry of Textiles (Jute) and its aims are to assist the introduction of state-of-the-art[82] or near state-of-the-art technology into the jute mill sector.

2.9 Environmental considerations

Jute, as a biodegradable natural product, is environmentally friendly. It does not pollute the environment either during agricultural cultivation, conversion to jute goods in the industry, transport and usage of jute products or in their ultimate disposal after use. Jute bags and sacks are reusable which not only makes them environmentally friendly but also cheaper than disposable packaging. Jute consumes less energy both during cultivation and conversion to final products than many other textiles, and particularly cotton and synthetics. Jute is annually replaceable. Jute geo-textiles have also proved to be superior in soil erosion control.[83]

Jute geo-textiles also have potential for newer applications other than soil erosion and in some cases are already being used for these purposes, for example, as

- reinforcement in temporary hull (unpaved) roads, rural roads, landscaping, etc.
- reinforcement fabric during the construction of highways
- vertical wick drains to accelerate drainage of water in soils.

The Motz Group[84] has developed a combined synthetic/jute natural turf for athletics fields. The jute in the fabric backing retains moisture and promotes the growth of natural grass, and decomposes over a known period. Geo-jute materials[85] retain moisture up to five times their own weight and are used for soil protection under conditions of heavy rainfall. United Bonded Fabric Pvt. Ltd. of Australia[86] have developed and patented jute geo-textiles to promote soil stabilisation and protection from rainfall erosion by infiltration of water into the soil beneath the fabric.

A joint study conducted by IJIRA and the Dept of Forestry, Govt of West Bengal[87] revealed that open mesh jute woven fabric (geo-textile) could be used for the protection of forests in coastal areas where sand erosion occurs due to high winds and rain.

2.10 Health and safety considerations

Jute fibres are pre-treated with hydrocarbon-based Jute Batching Oil (JBO) to improve spinning performance. The migration of these hydrocarbons from JBO processed jute sack fabrics into the contents of the sacks contaminate them. A study has been made by Mustafizur Rahman,[88] that in a 1 kg jute sack made from fibre pre-treated with 5% JBO, 3.7 g of the JBO residue is transferred to its contents in constant contact with the sack surface. If the mass of the contents is 50 kg then the level of the contamination would be 74 ppm.

The International Jute Organisation (IJO) has adopted a standard for the manufacture of jute bags used in the transport of certain food materials (cocoa beans, coffee beans and shelled nuts). This standard, IJO standard 98/01[95] came into effect from October 1999 and provides a universally acceptable specification. Rice Bran Oil (RBO) technology developed by IJIRA[89] is an eco-friendly cost-effective process for the production of jute sacks suitable for packing foodstuffs. RBO-treated jute is free from hydrocarbons and complies with international eco standards.

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2.12 Appendices

Appendix A: jute's allied fibres – kenaf (*Hibiscus cannabinus*), roselle (*Hibiscus sabdariffa*) and urena (*Urena lobata*)

General

The fibres from these three plants are taken together because the extraction of their fibres, their textile processing and the articles which are made from them are, to all intents and purposes, the same as jute's – even to the extent that the United Nations Food and Agriculture Organisation (FAO) groups their statistics under one heading: 'Jute-like fibres'. They are all members of the mallow (*Malvaceae*) plant family. These plants have many different names, amongst the most common are in India where kenaf and roselle are also known as mesta or bumli. In different countries of Africa urena is called 'congo-jute' or rama-rama and in Central and South America guaxima, uassima and carillo. Kenaf is also sometimes called guinea hemp.

The three species are tropical crops and when cultivated grow to about three metres. Kenaf and roselle are annuals and whilst urena is a perennial it may also be cultivated as an annual. The principal differences between the three species and between them and jute are that kenaf and roselle are less demanding in their soil and climatic conditions. As long as the soil is well drained kenaf will grow in drier and poorer soils than jute and roselle can survive even drier condition than kenaf. Urena requires more moisture than both and a richer soil.[3,96] The cell structures of roselle and kenaf are almost identical. Some of the physical and chemical properties, and a description of the morphology of these fibres can be found in Tables 1.8a, 1.8b and 1.10 in the appendix to Chapter 1.

Early processing

These three fibres, when produced on smallholdings, are usually decorticated in ways similar to jute, but when cultivated on large estates mechanical ribboners of differing complexity may be used. Two of these are illustrated in Figs 2.10 and 2.11.

Figure 2.10 Hand ribboning kenaf stems using bicycle wheel hub. Source: C. Jarman, *Plant fibre and processing: A handbook*. Courtesy: Intermediate Technology Publications, UK.

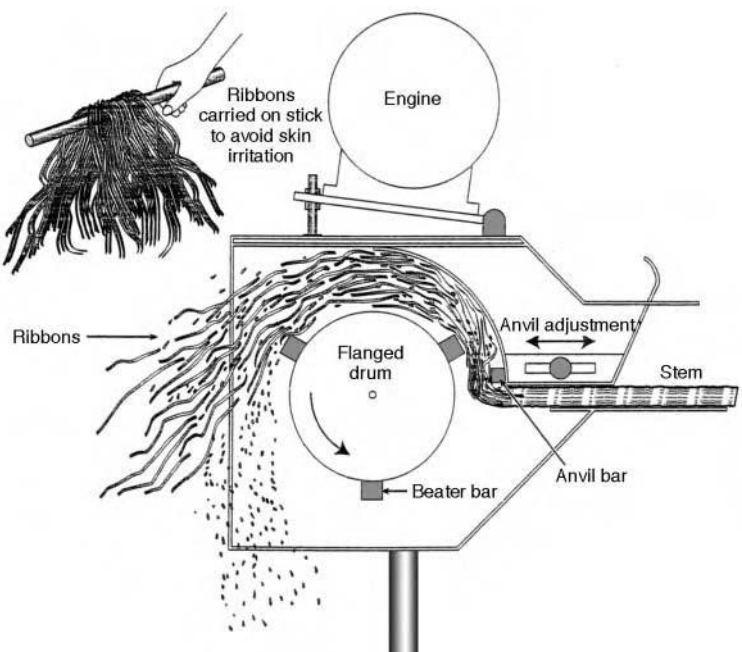

Figure 2.11 Alvan blanch ribboner. Source: C. Jarman, *Plant fibre and processing: A handbook*. Courtesy: Intermediate Technology Publications, UK.

Production statistics

As can be seen from Table 2.34 the production of these three fibres is fairly well spread over the world's tropical countries. As can also be seen from the table the main producing countries are China, India, Thailand and Russia.

Table 2.35 shows that annual production from 1998 to 2002 has been steady at around 400,000 tonnes but that production has decreased by 50% or more since the 1970s and 1980s. If we compare this drop in production with the production of jute over the same period (Table 2.36) we see that the production of jute has remained reasonably constant. It would seem, therefore, that it is the jute-like fibres that have borne the brunt of the competition provided by synthetic fibres, principally polypropylene and polyethylene, that started penetrating many of jute's markets at about that time.

Table 2.34 Production of jute-like fibres by country (2003) (kenaf, roselle and urena)

Jute-like fibres production (tonnes)	2003
Angola	1,000
Bangladesh	1,000
Brazil	9,349
Central African Republic	88
Chile	10,000
China	75,000
Congo, Demoractic Republic of	5,866
Cuba	10,000
El Salvador	3,000
Ethiopia	750
Guatemala	400
India	196,470
Indonesia	7,500
Madagascar	600
Mali	1,300
Mozambique	3,300
Myanmar	30
Nigeria	900
Pakistan	2,200
Russian Federation	48,000
South Africa	1,100
Spain	0
Thailand	57,000
World	434,853

Source: FAOstat.
Courtesy: Food and Agriculture Organization of the United Nations.

Table 2.35 World production of jute, kenaf and allied fibres 1998–2002 ('000 tonnes)

	1998/99	1999/2000	2000/01	2001/02
Jute fibre				
World	**2,212.4**	**2,105.0**	**2,185.0**	**2,501.0**
Developing countries	**2,212.4**	**2,105.0**	**2,185.0**	**2,501.0**
Far East	2,212.4	2,105.0	2,185.0	2,501.0
Bangladesh	851.9	731.5	820.0	876.6
India	1,311.8	1,331.8	1,422.0	1,580.0
Myanmar	33.5	26.5	27.8	28.0
Nepal	15.2	15.2	15.2	16.4
Kenaf and allied fibres				
World	**553.6**	**459.8**	**420.0**	**450.3**
Developing countries	**546.3**	**452.8**	**413.0**	**443.3**
Far East	501.2	410.0	371.7	403.5
China	248.0	164.0	126.0	136.0
India	182.2	198.2	198.0	220.0
Cambodia	2.0	2.0	2.0	2.0
Indonesia	7.2	7.0	7.0	7.0
Thailand	47.2	29.7	29.6	29.5
Vietnam	14.6	9.1	9.1	9.0
Latin America	27.1	25.4	25.7	25.0
Brazil	8.6	7.9	8.2	8.0
Cuba	10.0	10.0	10.0	10.0
Africa	13.8	13.7	12.0	11.5
Near East	4.2	3.7	3.6	3.3
Developed countries	7.3	7.0	7.0	7.0
Total jute, kenaf and allied fibres				
World	**2,766.0**	**2,564.8**	**2,604.9**	**2,950.7**
Developing countries	**2,758.7**	**2,557.8**	**2,597.9**	**2,943.7**
Far East	2,713.6	2,515.0	2,556.6	2,903.9
Bangladesh	851.9	731.5	720.0	876.6
China	248.0	164.0	126.0	136.0
India	1,494.0	1,530.0	1,620.0	1,800.0
Cambodia	2.0	2.0	2.0	2.0
Indonesia	7.2	7.0	7.0	7.0
Myanmar	33.5	26.5	27.8	28.0
Nepal	15.2	15.2	15.2	16.4
Thailand	47.2	29.7	29.6	29.5
Vietnam	14.6	9.1	9.1	9.0
Latin America	27.1	25.4	25.7	25.0
Africa	13.8	13.7	12.0	11.5
Near East	4.2	3.7	3.6	3.3
Developed countries	**7.3**	**7.0**	**7.0**	**7.0**

Source: FAOstat.
Courtesy: Food and Agriculture Organization of the United Nations.

Table 2.36 World production of jute 1964–2003 (tonnes)

Year	Production	Year	Production
1964	2,281,496	1995	2,414,476
1969	2,608,222	1996	2,985,778
1974	1,900,496	1996	2,201,705
1979	2,681,216	1997	2,201,705
1984	2,610,283	1998	2,634,317
1989	2,597,949	1999	2,592,293
1994	2,696,826	2000	2.657,000
		2001	2,923,740
		2002	2,784,740

Source: *www.fao.org* Courtesy: Food and Agriculture Organization of the United Nations.

It is not possible, from the available FAO data, to determine the actual production of each of these three fibres, kenaf, roselle and urena. However, by assuming that the African and American countries produce mainly urena and the Asian countries kenaf or roselle we can establish that the annual world production of arena is approximately 40.000 tonnes, leaving, again approximately, 400,000 tonnes for the other two fibres.

Appendix B: jute world fibre production

Table 2.37 Production of jute by country (2003)

Jute production (m.t)	2003
Bangladesh	800,000
Bhutan	350
Brazil	1,567
Cambodia	650
Cameroon	100
China	90,000
Egypt	2,200
India	1,789,000
Iran, Islamic Republic of	0
Japan	0
Myanmar	41,887
Nepal	17,500
Pakistan	22
Peru	200
Sudan	3,350
Thailand	5,000
Uzbekistan	20,000
Vietnam	21,000
World	2,792,826

Source: *www.fao.org* Courtesy: Food and Agriculture Organization of the United Nations.

[*Editor's note*: Compared to many of the other fibres covered in this book jute has kept up its production reasonably well over the past 40 years, although with a few years with below 'normal' quantities (1974, 1996 and 1997). But this is not the full story because the production of the 'allied fibres' (kenaf, roselle and urena) decreased considerably and they are part of this particular part of the textile market. It would seem that the reason why jute did not suffer from the overall decrease in the market for these fibres was that India is not only, by far, the largest producer (see Table 2.37) but that most of India's production is consumed within the country which was, at least to some extent and during this period, a sheltered economy. This, perhaps, sheltered Indian jute from the competitive factors affecting other countries, such as Bangladesh. These export a greater part of their production to 'developed' markets where they would have had to face severe price competition, not only from jute producers in other countries, but also from synthetic fibres such as polypropylene, polyethylene and to some extent, nylon.]

Appendix C: Recent developments in retting methods

The Central Research Institute for Jute and Allied Fibres (CRIJAF), the Jute Technological Research Laboratory (JTRL), known at present as the National Institute for Research on Jute & Allied Fibre Technology (NIRJAFT)[12,15] and the Indian Jute Industries' Research Association (IJIRA)[7,14] have developed various methods whose objectives are to improve the quality of fibres obtained by biological (bacterial) retting.

The CRIJAF[16] technique

This depends on retting the machine decorticated jute ribbons in normal water, with the object of attaining complete retting of the stalks in a limited supply of water. But because of the damage done to the fibre during decortication and the high cost of decortication by machine the process is not considered to be viable in its present state of development.

The JTRL technique

Scientists at JTRL have sought to improve fibre quality by applying separate treatments at both pre- and post-retting stages. The pre-retting treatment of stems, which has undergone several years of field trials, consists of preparing an inoculum of bacteria which is claimed to accelerate retting. A dilute suspension of this bacterial culture, to which a solution of urea has been added, is then sprayed over the whole body of the green stems.

The process is as follows: the inoculum culture is prepared in the field where the jute bundles are stacked after harvesting. Small cut pieces of green stems are placed in a large receptacle into which a solution of nutrients in water has previously been poured. These nutrients could be sulphides and nitrides of potassium, calcium and magnesium. The inoculum, previously prepared in the laboratory, is mixed with the jute stem nutrient mixture in the receptacle and allowed to multiply for some days, utilising the jute stems as a carbon source. A dilute solution (4–5%) of urea in water is prepared and mixed with the bacterial suspension obtained from the green stem culture in the field. The dilute culture-urea mixture is then applied by garden spray to the bundles of jute stems spread in thin layers on the field. The mixture is applied more profusely to the butt ends of the stems. The bundles are then steeped in water for normal retting. This process produces a marginal improvement in the quality of treated fibres compared to control fibres also retted in the same tank. No tangible reduction of under-retted barky root ends is possible by this JTRL method.

A post-retting treatment has also been developed at this Institute to upgrade lower qualities of jute fibre produced by the ribbon retting route and freshly extracted from the retting tank. The wet fibres are spread on the ground and sprayed with a dilute solution of urea and ammonium dihydrogen phosphate. This is followed by spraying with a fungal culture powder. In actual practice the fungal culture mixed with kaolin is distributed among the farmers in 500 g polyethylene packets. After treatment, the fibre stack is covered with a big plastic sheet to prevent the loss of water by evaporation for a couple of days or thereabouts to complete the retting process. The fibre is washed again in 'clean' water to remove the barks, etc., and dried. This fungal treatment of fibre at the post-retting stage followed by stacking for a further duration and rewashing in clear water is claimed to be effective in improving the quality of the fibre treated. However, considering the cost and overall effort involved in this treatment, the extra costs of labour for washing the fibre for the second time and of the chemicals and fungal spores (excluding the attendant cost of a culture plant for producing the spores), the unavoidable lengthening of the overall period of retting and the possibility of pilferage of fibre stacked on the ground, the process cannot be considered applicable on a large scale in the field.

The Ministry of Agriculture suggestion

To facilitate the process of retting the insertion of three or four sticks of leguminous plants such as 'sun hemp' or 'Dhaincha' in each jute bundle is suggested by the Directorate of Jute Development, Ministry of Agriculture, and the Government of India.[16] Also, to attain uniform retting, it is suggested that the two to three feet basal portion of the bundles be kept under water for two to three days, prior to conventional retting. While the presence of stems of leguminous plants certainly exerts a benign influence on the retting of jute stems, the effort of giving extra retting to the root ends of stems by standing them for two to three days in knee-deep water is not always effective. Mud sticking to the root portions is often found to destroy the lustre and colour of the retted fibre. Also water of the required depth is not always available.

The IJIRA technique

IJIRA's improved retting technique is based on mildly crushing the basal portion of stems to produce a little cracking of the bark and then steeping the root portion only in a 4–5% solution of urea. This not only ensures complete elimination of any under-retted barky roots but improves the quality of the resultant fibre by one to two grades, especially in areas where water is scarce. This also reduces the total period of retting by three to four days in the case of jute and five to six days in the case of mesta.

The rationale of the method is that biological retting of jute involves a complex array of micro-organisms that occur abundantly in the retting ponds and that creation of conditions which facilitate their entry into the stems and particularly into their roots will naturally lead to uniform retting and consequent improvement in the quality of the fibre. Since biological retting, in nature, is not the handiwork of any single species of bacteria the effect of adding an inoculum of any single micro-organism is not likely to be felt amongst the multitude of adventitious bacteria already present. On the other hand, the growth-stimulating influence of urea added in the process is felt not only at the root end of the stem, but also through its entire length as the exposed xylem tissue of the roots will ensure that the chemical is carried up the stem during the steeping of the root-malleted plants in its solution. In this way a very small quantity of urea simply applied to the root side of stems is an effective method of increasing the rate and uniformity of retting and therefore of improving the quality of the fibre.

IJIRA's pre-retting process[7] is simple. The green stems of jute plants are mildly thrashed with wooden hand mallets at their root end so that only the outer bark is crushed at several points, whilst the central woody core remains intact. Several stems are seized by the worker in his left hand with the root ends held over a hard object such as a piece of log or brick. Some 25–30 cm of the bottom portions of the stems are beaten in three to four places by a wooden or bamboo mallet wielded by the right hand of the worker. The stems are then turned over by a twist of the left hand for malleting their undersurface as before. It is preferable to carry out this mild crushing of the stems by using a hand-driven mechanical device, such as those that are available from the various Indian jute institutes as the operation then take less time and costs less. After crushing, the stems are tied into bundles as usual, these are then held vertically for 3–4 minutes in a large drum containing a 4–5% solution of commercial grade urea at ambient temperature so that the crushed portions of the stems are completely immersed in the urea solution. They are then stacked on the field for transportation to the retting tanks.

The urea acts in two ways: first, as a swelling agent to the barky tissues which develop numerous tiny fissures after swelling, thus further improving the access of the retting bacteria to the cambium layer of the stalk, and secondly, as a nutrient to the retting microbes, which are thus stimulated to bring the whole process of retting to completion in a shorter time than would otherwise be the case. IJIRA[14] have also established that jute ribbons can be retted by using proprietary enzyme preparations rich in pectinase for 48 hours. Pectinex Ultra Spl and Flaxzyme from Novo Industry A/S, containing predominantly high pectinolytic activity, were used in this study. Fibres obtained from enzyme retted ribbons have higher strength than those produced by conventional or ribbon retting. In the presence of a citrate phosphate buffer or ethylene diamine tetra acetic acid (Na-salt) enzyme mediated retting is improved This enzyme based retting process, however, is only of academic interest and cannot be a practical proposition because of the prohibitively high cost of the enzymes.

In conclusion, it is the authors' view that conventional biological retting of jute and mesta in abundant, clean water preceded by the IJIRA's malleting/urea treatment of the root portion of stems is the best available method for improving the quality of jute fibres. If the farmers are given a proper price for the higher quality grades of fibre obtained by following this simple technique the extra cost involved would be fully covered as it amounts to only 25% of the potential price gain.

Appendix D: non-textile uses of jute

Jute-based paper pulp

Jute has been identified as a useful raw material for paper manufacture. However, the prices at which jute is available in major jute-growing countries in comparison with the prices of other raw materials such as bamboo, straw, baggage, wood pulp, etc., are a stumbling block for the paper industry in adopting jute as a raw material. Although there are advantages, from the point of view of quality, of using jute for the manufacture of paper this improvement is not at present accepted by the industry as sufficient to justify the use of jute on a substantial scale.

Jute sticks are used for the manufacture of paper pulp. However, there is a need to devise cost-effective ways[2] of collecting, handling, transporting and storing the sticks as well as of establishing a regular distribution network of the resultant product. The use of jute/mesta stalks (whole plant) for papermaking has been experimented with in India by the paper industry and present production is around 18,000 tonnes, or about 1.3% of the average annual raw jute production of 1.3 million tonnes. Bangladesh has set up a jute-based paper plant and is also taking further steps to establish further jute-based pulp and paper production.

The technology for jute-based paper is available but, apparently, the economy lies in captive plantations of jute to provide assured and adequate quantities of raw material for large-scale paper plants. With deforestation being discouraged as an environment-protection measure the prospects for jute-based paper are at least feasible in the long term but specific market-orientated products are yet to make a commercial breakthrough. In the manufacture of certain speciality tissue papers and in the manufacture of newsprint, jute-based paper pulp has been successfully used in blends with normal paper pulp and perhaps such blends would be a necessary intermediate step, paving the way for the eventual use of 100% jute pulp.

Use of jute in pulp and paper

For making pulp,[65] jute and allied fibres are used in several forms, for example as:

- a whole jute plant
- jute sticks
- bast fibre
- mill wastes having virgin fibres (yarn waste, gunny cuttings, caddies, etc.)
- recycled fibres such as old gunny wastes, etc.

Jute is an excellent long fibred raw material[12] for the paper industry. It has certain advantages:

- It is an annual renewable resource whereas the cycle is much longer for hard wood or bamboo.
- It is biodegradable and eco-friendly.
- Unlike bamboo or wood, it does not need a chipping operation (but may need a breaking operation).
- Jute has less lignin content compared to bamboo or wood and is easier to cook.
- The yield of jute is higher at 60–62% compared to 40–45% for bamboo, 42–45% for wood, 28–30% for straw or 13–15% for bagasse.
- It is less bulky to handle and store.
- Jute has long fibres and therefore gives better machine runnability.

Jute structural composites

Composite materials are increasingly replacing metals and wood (as they may be lighter and less expensive). Although plastics on their own are also used for these purposes, they are not very effective in performance. Asbestos is carcinogenic. Generally among composites, glass fibre/resin composite is popular but expensive, though it is very effective in performance. The physical properties of laminated and non-laminated jute stick particle board are given in

Table 2.38 Physical properties of paper from jute pulp

Weight (g/m^2)	Average tensile strength (kg)	Tensile index (Nm/g)	Average burst strength (kg/cm)	Burst index ($kPam^2/g$)	Density (g/cc)
134.89	4.5	21.82	3.33	2.42	0.29
144.78	6.25	28.23	3.73	2.52	0.31
168.22	5.5	21.38	3.47	2.02	0.35
168.44	5.65	21.93	3.73	2.17	0.33
174.33	5.4	20.26	3.4	1.91	0.26
251.67	9.33	24.24	4.5	1.75	0.61
275.89	11.47	27.19	6.0	2.13	0.64
277.78	8.47	19.94	4.13	1.45	0.65
287.22	13.6	30.96	7.0	2.38	0.59
303.11	10.23	22.07	4.9	1.58	0.72

Source: Mitra, B. C., *Data book on jute*, January 1999. Courtesy: National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata.

Table 2.39. Particle boards produced from jute sticks have excellent sound-absorption properties. The composites can absorb about 80% of sound at a frequency of 4000 Hz. The properties of jute composites (Table 2.40) developed by IJIRA[13] are comparable to those of medium density fibre boards.

Substantial amounts of research have been reported in the field of jute composites.[51–59] These cover the use different resins and manufacturing techniques and the quality characteristics of the resulting composites. The potential market for jute-reinforced plastics[60] is based on the specific properties of jute. These are high strength, high modulus and low cost. Jute in the form of fibre, sliver, twine or non-woven fabric is mixed with a binder system (epoxy resins, polyesters or polypropylene) to form the composites for various uses as listed below:

- Architecture: for false ceilings, panelling, partitions, doors and windows, furniture and pre-fabricated shelters.

Table 2.39 Physical properties of laminated and non-laminated jute stick particle board

Sample	Impact strength (kgf/cm)	Flexural strength (MPa)	Tensile strength (MPa)
(a) Particle board	2.1	11.16	4.8
(b) Laminated (polyester) particle board	10.0	16.2	8.24

Source: Mitra, B. C., *Data book on jute*, January 1999. Courtesy: National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata.

Table 2.40 Comparative properties of jute composites and medium-density fibre boards

Property	MDF Exterior grade	MDF Interior grade	Jute composites
(i) Bulk density (kg/m^3)	500–900	500–900	953
(ii) Moisture content (%)	5–15	5–15	3.04
(iii) Water absorption (%) max.			
(a) 2 h soaking	6	9	5–10
(b) 24 h soaking	12	18	12–33
(iv) Linear expansion (swelling in water %, max.)			
(a) Due to general absorption after 24 h soaking			
1. Thickness	4	7	3–18
2. Length	0.3	0.4	0.26
3. Width	0.3	0.4	0.2
(b) Due to surface absorption	4	5	2–14
(v) Modulus of rupture (min.) (N/mm^2)	28	28	43.66
(vi) Tensile strength perpendicular to surface (min.) (N/mm^2)			
(a) Fresh	0.8	0.7	1.2
(b) After cyclic test	0.4	–	0.99
(c) After accelerated water resistance test	0.25	–	0.26
(vii) Screw withdrawal test (min.)			
(a) Face	1,500	1,500	Not applicable (thickness of sheet is less)
(b) Edge	1,250	1,250	

Courtesy: IJIRA, Kolkata.

Table 2.41 Some quality characteristics of jute/polypropylene and polypropylene composites

Properties	Type of composites: Polypropylene	Jute/polypropylene: With adhesive	Jute/polypropylene: Without adhesive
Density (g/cc)	0.90	1.02–1.17	1.02–1.17
Flexural strength (MPa)	41.00	72.92–112.20	56.48–28.83
Flexural modulus (GPa)	1.40	4.50–9.50	4.50–10.50
Tensile strength (MPa)	33.00	49.55–72.87	36.01–33.65
Izod impact strength (J/m) (notched)	24.00	28.00–33.73	26.90–32.19
Water absorption (%)			
2 h boiling	0.10	0.77–2.22	0.93–3.06
24 h cold soak	0.02	0.44–0.91	0.56–1.86

Source: Private communication. Courtesy: IJIRA, Kolkata.

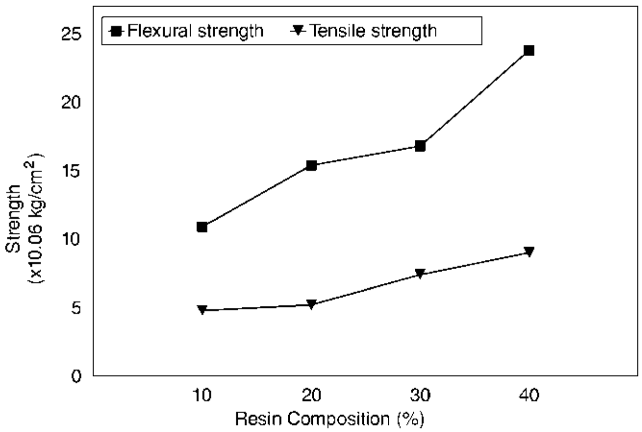

Figure 2.12 Physical properties of jute stick particle board. Source: Mitra, B. C., *Data book on jute*, January 1999. Courtesy: National Institute of Research on Jute and Allied Fibre Technology (NIRJAFT), Kolkata.

- Transport: for bus or railway coaches, auto trims, ship interiors, dashboard panels, etc.
- Engineering components, brake linings, moulding materials, etc.
- Other applications such as packing boxes, signboards, letter boxes, etc.

Jute has also been reported as being used for building materials such as fibre reinforced concrete and roofing tiles, and bituminised runway coverings. Studies by NIRJAFT[12] revealed that flexural strength, tensile strength and impact strength improves with increase of resin component in jute stick particle board (Fig. 2.12) used for interior decoration.

Appendix E: jute testing instruments developed by SITRA

The South India Textile Research Association (SITRA) at Coimbatore has developed several electronic instruments[77] for measuring the compressibility, roughness, dimensional stability and extensibility of jute fabrics.

Testing for handle

Compression

Fabric softness is one of the most frequently used terms in comfort performance by consumers. Fabric compressibility, i.e., the difference in fabric thickness at different loads, gives an objective measurement of the softness or fullness of the fabric. The compression tester developed by SITRA is based on this principle.

Roughness

Fabric roughness is a measure which is generally felt subjectively. The nearest characteristic of a jute fabric to roughness which can be measured objectively is fabric friction. The Fabric Roughness Tester developed by SITRA works on force measurement during the slow movement of fabric against fabric.

Dimensional stability

Low extensibility of fabrics can lead to difficulties in producing over-feed seams; problems in moulding and seam pucker. High extensibility, on the other hand, can lead to a fabric being stretched during laying up, causing the cut panels to shrink when they are removed from the cutting table. Fabrics exhibiting these characteristics are likely to lead to severe problems during the manufacture of sewn articles and to the production of faulty merchandise. SITRA has developed an instrument to measure fabric extension (Fig. 2.15) at 5, 20 and 100 g/cm and bias extension at 5 g/cm.

It is important that the fabric used for a particular purpose retain its dimensions after washing or when subject to other processes. Hence, it is essential to measure properties such as relaxation shrinkage and hygral expansion. Relaxation shrinkage is the irreversible change in the fabric dimension associated with the release of extensional or compressional strains within a fabric that were not permanently set during finishing. Both excessive and insufficient values of relaxation shrinkage can create problems. These dimensional changes occur when the fabric is exposed to high relative humidity, steam or water. Hygral expansion is the reversible change in fabric dimension associated with the absorption or desorption of water. The basic procedure adopted in the Fabric Dimensional Stability Tester developed by SITRA is the measurement of length and width benchmarks before and after a selected finishing process.

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2.14 References

See Appendix II on page 380.

2.15 Glossary of terms

Bark Outer covering of stems.

Brattice cloth A coarse cloth of Jute used for screens, ventilators etc. especially in mines, it is often coated.

Buckram Stiff, coarse linen cloth used in linings and for binding books.

Burlap Coarser cloth of jute.

Count An alternative to 'grist'.

Cuttings The root ends of a reed, with bark adhering to it, that are cut off and processed separately.

Decortication Mechanical extraction of bast fibres.

Dhurries Heavy carpet fabrics.

Entities Jute fibres produced at the first carding stage

Felt A jute fabric characterised by the entangled condition of many or all of its component fibres. The technology used for manufacturing the jute felts is needle punching.

Gunny A strong coarse material made commonly from jute, especially for bagging.

Grist The mass in pounds (lb) of a spyndle of yarn.

Head A large bundle of reeds.

Hessian A plain cloth made from single yarns of approximately the same linear density in warp and weft, usually made from bast fibres, particularly jute.

Juck Stack of harvested jute reeds.

Kutcha bale A loosely packed bale of fibre for local use.

Long jute The length of reed remaining after the removal of cuttings.

Muslin Lightweight plain or leno weave fabric.

Niwar Narrow width fabrics manufactured on tape looms.

Padding Impregnation of a substrate of a liquor or a paste followed by squeezing.

Porter A term originally used as a measure of the spacing of wires in the loom reed. The porter measure of a loom reed is the number of splits (space between wires) in a red length of 37 inches divided by 20. Thus a 10-porter reed contains 200 splits in a length of 37 inches. In jute weaving, each split normally carries more than one thread, and sometimes the spacing of the warp ends in the woven fabric is given in porter measure. To avoid confusion, thread-spacing in fabric should always be expressed as threads per unit length.

Pucca bale A densely packed bale of fibre for export.

Quality ratio The single-thread breaking load of a yarn in pound force (lbf) expressed as a percentage of the grist, or count.

Reed The bundle of fibres extracted from a single plant stem.

Retting Subjection of crop to biological or chemical treatment to make fibre bundles more easily separable from the woody part of the stem.

Sack Coarse fabrics made out of jute yarns for making bags.

Shots The weft threads inserted on the loom.

Spyndle A length of 14,400 yards. Jute system of yarn counts: no. of lengths of 14,400 yds that weigh 1 pound. (1 yard = 19.5 cm, 1 pound (lb) = 454 g)

Stack Arrangement of jute stems in a bundle form.

Twine Twisted threads of jute, hemp, etc., used for package tying.

Ultimate cell The basic plant cell from which the fibres are constructed.

Union Fabric with cotton yarn in the warp and jute yarn in the weft.