7
Coir

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7.1 Introduction and history

7.1.1 Introduction

Kerala, the land of 'Kera' (which means coconut tree) is a small state in the southern part of India and the state is, in fact, named after its coconut trees which grow in abundance all over the state. Coir, one of the industrial hard fibres, enjoys a unique position. Kerala is the main producer and supplier of coir to the world market and 'Coir' from Kerala is known for its quality and exquisiteness all over the world.

7.1.2 History

Coir is the fibre extracted from the fibrous outer covering of the fruit of the coconut palm, botanically known as *Cocos nucifera* (Linn) and is a native of the tropics. Botanists are of varying opinions regarding the origin of this tree. Whilst this crop is considered to be of pre-historic origin in the Philippine Islands, its known cultivation dates back to 300 BC in Sri Lanka and available evidence also confirms its existence in India 3,000 years ago. Coconut is one of the most important sources of vegetable oil in the world as its kernel contains up to 60% oil.

The spinning of coir yarn from coir fibre was practised several centuries ago but the industrial manufacture of coir products developed in the middle of the 19th century. James Darrah, an Irish-born American entrepreneur who came to India in 1850, set up a factory in Alleppey in 1859 and this marked the beginning of the organised world coir industry. This factory grew to become a very large firm under the name Darrah Smail & Co. and was of considerable renown in Alleppey. Within fifteen to twenty years of Darrah Smail & Co.'s establishment more than a dozen other such factories were set up in the town, most of these managed and owned by Europeans. After India gained independence in 1947 most of the coir factories were either closed down or handed over to Indian nationals. From the centralised production system that

prevailed up to that time production began slowly to migrate to the suburbs and grow as a cottage industry. Thousands of small-scale coir product manufacturing units were gradually set up within a few kilometres of the town of Alleppey. The products manufactured by these small units were bought in semi-finished condition by exporters, were further processed under their supervision and then exported after value addition. Recently some exporters have begun to set up large-scale manufacturing units of their own as centralised production has been found to help ensure better-quality products.

7.2 Chemical and physical fibre structure

7.2.1 Chemical structure

The tables in the Appendix to Chapter 1 compare the physical and chemical characteristics of coir to those of other fibres. Natural fibres can be grouped mainly into three groups

1. vegetable fibres (cellulosic or lignocellulosic)
2. animal fibres (protein fibres)
3. mineral fibres.

Cellulosic fibres are formed by the polymerisation of glucopyranosyl units and protein fibres are formed by the polymerisation of amino acids. Lignocellulosic fibres are formed by the incrustation of three basic polymers cellulose, hemicellulose and lignin.

The building unit for a cellulose molecule is glucose. A cellulose molecule is formed by the polymerisation of glucose units by glucopyranosyl linkages. This polymeric molecule, containing around 1,500 glucose units, forms the primary structure of cellulose. For fibre formation these long chain molecules lie side by side in bundles held together by hydrogen bonds between the numerous neighbouring hydroxyl groups. Whilst forming the hydrogen bonds, the bundles are twisted to form rope-like structures which join together and deposit to form the fibres. In a similar way, the polymerisation of mainly xylose (a pentose of sugar) forms a xylan chain. Xylan chains along with some other molecules are commonly known as hemicellulose. Lignin is a polymer of a set of aromatic compounds.

During the formation of lignocellulosic fibres, the cellulose bundles, before twisting together, are embedded in lignin, which cements them to each other, producing a structure that can be compared to a composite product or reinforced concrete, of which the cellulose and hemicellulose chains are integral parts. Because lignin plays an important role in the physical characteristics of the fibres and because these fibres are formed by the mechanism described above they are relatively harder and stiffer than pure cellulosic fibres such as cotton and also harder and stiffer than other lignocellulosic fibres such as pineapple, ramie and sisal. The chemical composition of coir is given in Table 7.1.

Table 7.1 Chemical composition of coir fibre

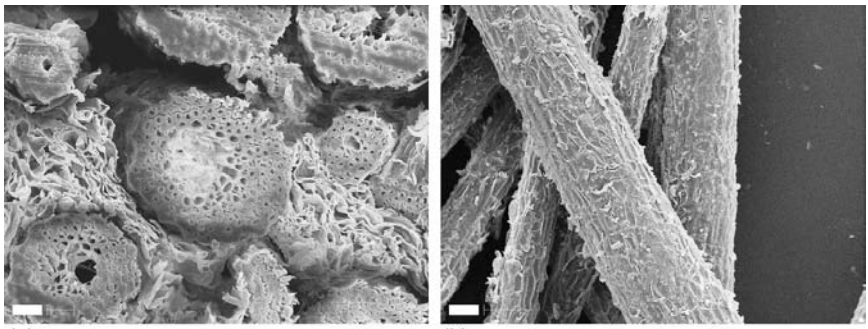
1.	Water soluble	5.25%
2.	Pectin and related compounds	3.00%
3.	Hemicellulose	0.25%
4.	Lignin	45.84%
5.	Cellulose	43.44%
6.	Ash	2.22%

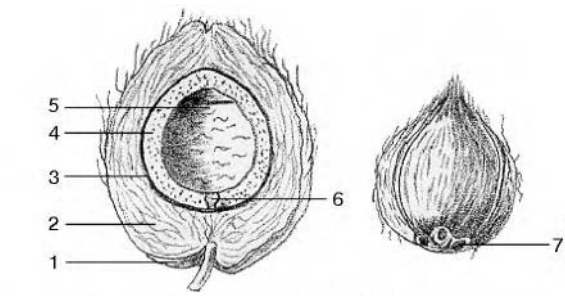
The Appendix to Chapter 1 of this book also provides largely similar figures for the composition of coir fibres (Table 1.9). Jarman, interestingly, also provides figures for both young and old nuts (see Appendix B on page 305).

7.2.2 Physical structure

The individual textile fibres of all hard fibres are made up of a number of minute cells and these cells have distinguishing features that help in their identification. Like the fibre bundles themselves some cells of similar shape and dimensions occur in all the hard fibres but the averages and extreme values differ appreciably. The wall of each cell is made up of several layers of cellulose micro-fibrils laid in spirals about a common axis. One particular cell layer, commonly known as the S2 layer of the secondary wall, makes up most of the cell substance and the average spiral angle of the micro-fibrils of this layer dominates the combined effects of the other layers. As a result this angle is known as the spiral angle of that particular fibre cell (see Table 7.5 on page 295).

A cross-sectional outline shows that the cells of coir fibre have an oval shape. They have small air cavities near the centre of the filaments and roughly one-third of the bulk of the fibres is filled by air. This entrapped air gives rise to the pronounced springiness (resilience) of the fibres, their buoyancy in water and increases the time water takes to penetrate them. When soaked in water for some time the filaments swell laterally, but there is little or no longitudinal swelling. After 24 hours of immersion in water coir swells less in comparison to other hard fibres. Thus the properties of coir are less affected under wet conditions than are other hard fibres, and coir is particularly resistant to the effects of bacteria and salt water. Average values of the physical properties of coir fibre are given in Table 7.2. The enlarged views of the cross-sections of coir cells are given in Fig. 7.1(a) and longitudinal section through a coconut in Fig. 7.1(b). Other, sometimes slightly different, results for the physical characteristics of coir fibres are given in tables in the appendix to the Introduction of this book. The colour of coir fibre varies from golden yellow to dark brown depending on the method of fibre extraction.





1. thin, yellow-brown, watertight outer skin (exocarp)
2. thick, fibrous middle layer (coconut fibre, coir, mesocarp)
3. hard inner layer, the stone (endocarp)
4. white, oily copra layer, 1–2 cm thick (solid endosperm)
5. cavity filled with coconut milk (liquid endosperm)
6. embryo

(c) 7. 'eyes' (3 germ pores set in pits)

Figure 7.1 (a) and (b) Photomicrographs of coir stalk cross and longitudinal sections. Source: DeMontfort University, 2004; (c) longitudinal section through a coconut (left) and plan view of stone (right). Source: Gesamtverband der Deutschen Versicherungswirtschaft. Courtesy: www.tis-gdv.de.

7.3 Fibre production and early processing

Coir fibre can be extracted from the fibrous coconut husks either after natural retting or without retting.

7.3.1 Natural retting and fibre extraction

The ripe coconut is dehusked for the removal of the nut. This is done by impaling the coconut on a sharp iron spike (Fig. 7.2). The removal of the husk is a skilful operation as it requires both cutting and twisting the coconut as it is impaled.[1]

1. Textile Consultant, 228 Ballylesson Rd, Drumbo, Lisburn, UK.

Table 7.2 Properties of coir fibre

Physical properties of coir fibre		
1. Gravimetric fineness (tex)		40.00
2. Breaking load (kg)		0.45
3. Tenacity (g/tex)		10.00
4. Extension at break (%)		29.13
5. Flexural rigidity (dynes/cm^2)		200.00
6. Modulus of torsional rigidity ($\times 10^{10}$ dynes/cm^2)		1.89
7. Density (g/cc)		1.40
8. Porosity (%)		40.00
9. Moisture regain at 65%R.H (%)		10.50
10. Transverse swelling in water (%)		5.00
Dimensions and other physical characteristics of ultimate cells of coir fibres:		
1. Length (mm)	Average	0.60
	Maximum	1.00
	Minimum	0.30
2. Width (micron)	Average	259.00
	Maximum	277.00
	Minimum	229.00
3. Cell shape	Oval	
4. Lumen shape and size	Elliptic, large to medium	
5. Wall thickness	Medium to thin	

In natural retting the husks are immersed in water soon after dehusking. Husks that are exposed to the sun or allowed to dry become brittle and do not yield superior quality fibre because some of the water-extractable components such as tannin are decomposed by air and sunlight into insoluble compounds.

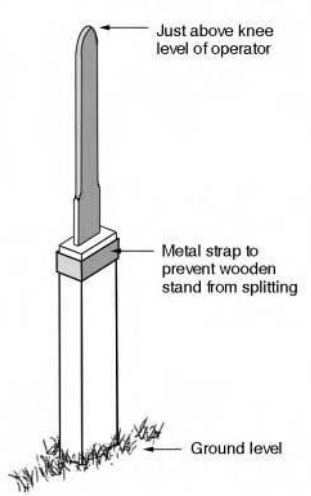


Figure 7.2 Coconut dehusking spike. Source: C. Jarman, *Plant fibre and processing: A handbook*. Courtesy: ITDG Publishing, UK.

Traditionally, retting is done by immersing the husk in water, preferably brackish, for six to nine months. The husks are placed in coir nets or dumped into pits near lagoons or by the side of backwaters where the water flows in and out with the rise and fall of the tide. During retting the pith binding the fibres together decays and the water soluble tannic substances are washed away. Retting improves the tenacity, flexibility and extensionability of the fibre and helps to obtain a whitish golden colour. Retting is decisive to the final quality of the fibre. Modern research has helped to reduce retting time by crushing the husks before retting and the Coir Board has also developed an effective bacterial culture (trade name 'Coirret') which both reduces retting time to as little as three months and improves fibre quality.

When retted the husks are taken out of the water and their outer skins, the exocarp, are peeled off. Traditionally, they are then placed on wooden blocks and beaten manually with wooden mallets in order to separate the fibres but now this is also done mechanically by using beater drums. The fibre is then cleaned by using a 'willowing' machine. The fibres are then dried under shade and bundled for further use. This fibre is called retted fibre and is mainly used for spinning coir yarn. It is also used for the manufacture of fibre mats.

7.3.2 Mechanical fibre extraction

There are two methods adopted in the coir industry for the non-retted mechanical extraction of fibre. The first method uses decorticators and the second method uses combing drums.

Fibre extraction by decorticator

The husk is first crushed with spiked or fluted rollers in order to break the exocarp and to let water enter the husk. After crushing the husks are soaked for different periods, up to a maximum of two weeks, depending on whether the husks are green or dry. The soaked husks are then fed into the beater (decorticator) by hand.

The beater is a set of 25–40 one foot (30.5 cm) long steel beater arms fitted on the periphery of a shaft in a helical path and rotated at about 300 rpm with 30–40 HP motors. The beater mechanism is contained in a grilled circular casing of sifter rods which is generally 5/6 ft (1.52/1.83 m) long and 2.5 ft (76 cm) in diameter. The husks are fed through a hole on one side of the beater, and beaten. This process also partially sifts the fibres which then come out at the other end. At this stage the fibres are not completely opened and they are fed into a turbo cleaner, (which is a mini-beater) to complete the opening operation. They are then fed into a sifter to remove dust, pith, etc., and dried in the shade and bundled. The main defect of extraction of fibre by decorticator is that the mattress (shorter) and bristle (longer) fibres are mixed.

Fibre extraction by combing machines

In this method the husks are also first crushed and soaked before being fed into the combing machine. This machine is equipped with two picker drums which comb alternate halves of the husks as they are moved past them by the rims of two eccentric revolving wheels or a conveyor belt system. Combing removes the shorter fibres and pith from the husk and separates the longer fibres. After combing the shorter fibres and pith are taken on to a revolving screener, drop through the screener and are discharged at the other end of the machine. Fibres from the screener are then further cleaned in a turbo cleaner. If the fibre is to be used for spinning the longer and shorter fibres have to be mixed and that is done at this stage. If the bristle and mattress fibres are not to be mixed, the fibres are then dried and bundled separately.

The fibres obtained in this way from unretted husks are lower in quality than retted fibres in that the colour is not as good, and their tenacity, extension, flexibility and yield are also inferior. This is because greater force is required to extract unretted fibres and therefore they suffer greater damage during processing. Coirret, developed by the Coir Board, mentioned above, does improve the quality of unretted fibres to that of retted fibres and to obtain this result the fibre is treated in tanks for 72 hours. However it should also be noted that of the two types of fibre, unretted fibre has better resilience which makes it more suitable for use in the manufacture of rubberised coir (see below section 7.7.10).

7.4 Yarn production and machinery

7.4.1 Yarn production – traditional method

Coir yarn production is perhaps the only field of the coir industry in which mechanisation has hardly penetrated. Spinning coir is mainly done by the traditional method of using manually rotated wheels called ratts. The conventional ratt is a set of two wheels, one fitted to a stationary stand and the other to a movable stand. In a simple unit the stationary stand contains two spindles connected to the wheel by a belt and the movable ratt contains one spindle. The wheels are fitted with handles so that they can be rotated. A minimum of three people is required to operate the unit, one for rotating the stationary ratt (the 'rotator') and the other two to draw the two single strands which make up the two-ply yarn. The number of people required to operate the unit may increase to four depending on the variety of yarn spun, number of spindles available, etc. The wheel on the stationary ratt is rotated in an anti-clockwise direction by one of the workers whilst the other two feed the fibre onto the rotating spindle and move backward drawing the single strands to the required thickness. When the required length of single strand is attained, the free ends of the strands are joined together and hooked onto the spindle on the movable ratt. A triangular yarn guide is then held between the two strands so as

to control the evenness of twist by one worker whilst the third worker rotates the movable ratt in a clockwise direction along with the rotation of the stationary ratt in an anti-clockwise direction. While rotating the movable ratt, the worker will also push it forward in order to adjust for the loss of length while doubling the yarn. The speed of rotation of the wheels, the movement of the yarn guide and the forward movement of the movable ratt have to be regulated in the desired manner to obtain different varieties of yarn. Although fibre quality is important the main factor that will control yarn quality is the regularity of twist levels in the single and doubled yarns. The count of the yarn is decided by the quantity of fibre used when spinning the single strands.

Nowadays the above method of yarn production has been mechanised to a certain extent by incorporating a motor to rotate the stationary ratt in place of the rotator. This type of ratt is called a 'Motorised Traditional Ratt'. This method also helps to improve the quality of yarn as the motor provides an even speed of rotation. Also this method improves productivity since the rotator is substituted by a motor. It is also worth mentioning in this context that a portion of some varieties of coir yarns such as Quilandy yarn, Beach yarn, etc., are still hand spun. These yarns are of uniform thickness and have a smooth texture without any hairiness, but production costs are higher.

7.4.2 Mechanical spinning

Up to now the efforts of different organisations aimed at developing effective spinning machinery for coir have not been fully successful, mainly due to the non-mesh-forming and lack of cohesiveness characteristics of the fibres which cause problems during drafting, although another mechanism called the 'Motorised Ratt' has been developed. In these, twisting, doubling, etc., are mechanised but the feeding of the fibre is manual and yarn quality still depends on the expertise of the worker. Also their production capacity is limited.

7.4.3 Automatic spinning

Automatic spinning machines are also available. These have been developed following research by the Coir Board of India, and they continue to be improved by further R & D. They are based on the principle of DREF III core spinning, the core yarns used are generally fine cotton or nylon. There are no statistics available which would indicate the quantity of coir yarn which is machine spun but it is probably less than 10% of total yarn production.

7.4.4 Specifications of coir yarns

The Bureau of Indian Standards has approved 23 varieties of coir yarn spun from retted fibre and three varieties spun from unretted brown fibre but the number of

Table 7.3 Specifications of important varieties of coir yarn

S. no.	Variety	Type of fibre	Colour (natural)	Twisting and spinning	Approx. runnage	General characteristics
1.	Anjengo	Long and medium stapled well cleaned fibre from well retted husks.	Bright golden, reddish brown to bluish grey	Wheel-spun hard twisted and hard spun	180/360	Less hairy and smooth texture
2.	Alapat	Long and medium stapled combed fibre from retted or under-retted husks spun	Bright golden to bright brown or grey	Hand or wheel spun soft twisted soft or medium spun	170/230	Less hairy smooth texture and regular in spinning
3.	Aratory	Long and medium stapled, less combed fibre from retted husks	Reddish brown to bluish grey	Wheel-spun soft twisted and hard spun	200/260	Hairy, less regular in spinning and slightly pithy
4.	Vycome	Medium and short stapled combed* fibre lumpy with pith from retted husks	Bright cream reddish brown to dark grey	Hand or wheel spun, soft twisted and soft spun	200/300	Hairy, less regular in spinning and rough texture
5.	Beach	Medium and short stapled uncombed fibre from under-retted husks	Reddish brown	Hand spun very soft twisted and soft spun	240/260	Less hairy, smooth texture, regular in spinning and very pithy

6.	Quilandy	Medium stapled, less combed fibre from well retted husks	Bright golden to greyish	Hand spun, medium twisted and medium spun	110/130	Slightly hairy regular in spinning and with little pith
7.	Roping	Medium and short stapled uncombed fibre from under-retted husks.	Brown to grey	Hand spun, soft twisted and soft spun	50/60	Extraordinarily thick, unclean in appearance, very less hairy and pithy
8.	Beypore	Medium and short stapled less combed fibre from under-retted husks	Bluish-brown	Hand spun soft twisted and soft spun	70/90	Very thick, less hairy, containing a little pith
9.	3-ply	Medium and short stapled, less combed fibre from under-retted husks	Brown to grey	Wheel spun in 3-ply hard twisted and hard spun	55	Extraordinarily thick, hairy with varying amounts of pith, hard and rough texture
10.	Parur	Long and medium staple clean fibre from well retted husks	Golden, reddish brown to bluish grey	Wheel spun, very hard twisted and very hard spun	85/115	Fairly hairy and rought texture with little pith

* In this context 'combing' does not denote the normal textile process but is a manual cleaning operation carried out as the fibres are removed from the retted husks. Wheel spinning is spinning using traditinal hand ratts. Hand spinning is spinning by hand without the use of ratts. This produces soft twisted and level yarns but production is much lower. 'Hard spun' applies to single yarns. 'Hard twist' applies to plied yarns.

yarns actually produced at present is lower and are listed in Table 7.3. The important varieties of coir yarn spun from retted fibre have been named after the places where they were traditionally spun. Thus the best yarn, called Anjengo, is spun in the Anjengo area of the Trivandrum District of Kerala State. Aratory yarn, Vycome, Parur, etc., are similar names derived from the names of the places connected with the production of these yarns. They can broadly be classified into three types, hard twisted, medium twisted and soft twisted. Among the important varieties of yarn, Anjengo and Aratory are hard twisted, Alapat and Quilandy are medium twisted and Vycome and Beach are soft twisted. The hard twisted yarns are mainly used for the production of coir matting and carpets, and soft twisted yarns for the production of coir mats as these produce good brush (pile). Generally soft twist yarns are used only for the brush of mats whilst for other end-uses hard twisted yarns are usually preferred. In Table 7.3 'hand spinning' indicates that no equipment is used, wheel spinning that traditional ratts are used. Hand spinning produces soft twist yarns of uniform thickness but, of course, production is much lower than spinning with ratts.

7.4.5 Yarn thickness measurement systems

The fineness of coir yarn is denoted by the term 'scorage' which is 1/20th of the number of windings of coir yarn which could be wound close to each other without overlapping in a span of 36 inches (91.5 cm). In other words, the term scorage represents the number of strings or yarns that could be held close to each other without overlapping, in a span of 1.8 inches (4.57 cm).

Runnage is another term which is generally accepted by the trade to denote the fineness of coir yarn. The runnage of a yarn is the length in metres of one kilogram of that yarn. For example, if one kilogramme weight of a particular yarn measures 240 metres, the runnage of that yarn is expressed as 240 m/kg. Table 7.3 shows specifications of some of the important varieties of coir yarn.

7.5 Bleaching, dyeing, printing and finishing

The changing tastes of consumers have also affected the coir industry. For example, it has become essential to make increasingly ornate products. Dyeing has been used in the industry for quite a long time in order to impart design into products, but in recent years bleaching has also been developed as a means of ornamentation.

7.5.1 Bleaching

It is estimated that about 20% of coir fibre and yarn used for the manufacture of various coir products is now bleached. Due to the bulky nature of the products

they are not easy to bleach and therefore this is generally done at the yarn stage. Various bleaching agents are used for bleaching textile materials. This is effected either by oxidation or reduction under appropriate conditions. Bleaching may include oxidation by hypochlorites, chlorites, peroxides or eracids and reducing agents such as sulphites, bisulphites, borohydrides, etc. The quality of water used in bleaching plays a very important role and it is therefore useful to incorporate water softening agents such as Calgon, zeolites, ETDA, etc., in the bleaching recipes. The coir industry generally uses hydrogen peroxide, and the process may be either hot or cold.

In cold processing the bleaching is done in cement tanks constructed for the purpose. The material to be bleached is kept in the solution having a material to liquor ratio of 1:10 for yarn and 1:12 for fibre with a treatment time of 16 hours at room temperature. In hot processing the material and liquor are kept at 80–90 ºC for one hour in a stainless steel tank with frequent agitation. In both processes the material is taken out after bleaching, washed in cold water and dried under shade. The following materials are used for bleaching coir.

1. Hydrogen peroxide
2. Sodium silicate
3. Soda ash
4. Lisapol D
5. Trisodium phosphate
6. Calidon – L1
7. Bleaching powder
8. Alum
9. Caustic soda

Typical bleaching recipes are as follows:

Hot bleaching. Hydrogen peroxide, 35%-10cc per litre of water or 7 to 8% by weight, sodium silicate 6% by weight.

Cold bleaching. Hydrogen peroxide, 10% by weight, sodium silicate, 7% by weight, wetting agent or soap solution, 1% by weight.

Hot bleaching is more expensive than cold bleaching as heat is required but fewer chemicals are needed, productivity is higher and quality is improved.

7.5.2 Dyeing

Applying different colours to products so as to make them attractive from the point of view of the consumer is a basic principle adopted in many industries and coir is no exception to this worldwide phenomenon. Although a wide range of dyes capable of yielding bright shades of good to excellent fastness is used in textiles, quite a large number of these are not suitable for dyeing coir, mainly for two reasons. Some of them require special pre-treatments of the material which

are not practical for coir due to its bulky nature whilst others are too expensive from the point of view of the coir industry.

The evenness of dyeing depends upon the power of absorption of the coir fibre, the nature of the dyestuff and the dyeing conditions. Taking into account such aspects as penetration, brilliance of shade, fastness properties, costs, etc., dyestuffs belonging to the basic, acid and direct classes are generally used. In order to achieve better results dye bath assistants such as acetic acid, sulphuric acid, formic acid, common salt, etc., are also used under appropriate conditions of temperature and for specified periods depending on the dyestuff being used.

Basic dyes have high tinctorial value and affinity to coir but are susceptible to light and rubbing. Acid dyes have better fastness to light but are not as bright as basic dyes. Direct dyes could produce shades having better fastness properties than acid dyes but they produce dull shades and require longer processing times. The coir industry also uses azo-free dyes as well as natural dyes.

7.5.3 Printing

Due to the uneven surface of coir products stencil printing has to be used. The designs are first cut out on galvanised iron sheets, the number of sheets required for printing a particular design depending on the number of colours present in the design. The dyes used are mainly basic, though selected acid and direct dyes are also sometimes used. After printing the materials are dried in the air at room temperature. Usual after-treatments, such as steaming, which form an essential part of processing printed apparel textiles are impractical for coir because of the bulky nature of the products, and therefore printing with these categories of dyes produces colours with practically no fastness to water or rubbing. As an alternative to these dyes plastic emulsions, synthetic enamel paints and reactive dyestuffs are used to achieve prints of better light fastness and deeper penetration.

For printing, the ready mixed paint or dyestuff solution is sprayed onto the coir mats or matting manually, using a compressor and spray guns. Experiments show that products printed with plastic emulsion or paint, when tested (by xenotest) for light fastness, show a slight initial dulling after six to eight hours of exposure followed by no further change in the colour tone. Regarding the behaviour of products under service conditions synthetic enamel paints abrade or wear off slowly from the surface resulting in the loss of the gloss or lustre of the film. With plastic emulsion paint the colour is rather subdued, but offers greater resistance to abrasion or wear. Both types of paint show excellent fastness to water.

In the case of reactive dyes the penetration is deeper, coupled with brilliant hues. It has been reported that 10% fading occurred when subjecting mats dyed with this class of dye to direct sunlight for 15 days.

7.5.4 Bleaching and dyeing machinery

Two methods are used to bleach and dye coir: manual and mechanised.

Manual bleaching and dyeing

This is the most popularly used method for dyeing and bleaching coir. The material to be dyed is placed in the dye solution in copper or stainless steel tubs and heated from below. The material is manually stirred regularly for specified periods. After dyeing is complete the products are washed with clean water and dried under shade.

Mechanised dyeing

The mechanised system of dyeing consists of a forced circulation of liquor in both directions through uniformly arranged materials. The temperature is controlled as required by regulating the flow of the heating system. After dyeing, hydro-extractors are used to remove the major part of the mechanically held water and finally these materials are dried on an endless conveyer drier. This system helps to improve penetration, shade consistency and levelness by the action of temperature, efficient and forced circulation of dye liquor and the period of processing. It also enables the processing of large quantities of material at a time. This method of dyeing and bleaching has been adopted by the major exporters of the coir industry. The machinery is manufactured in India.

7.6 Fabric production

Fabric production in the coir industry can be broadly classified as woven and non-woven. The greater part of India's exports of coir consists of woven products. Although non-woven products, mainly tufted products, are mainly manufactured in Europe their production is increasing in India. Details of the various methods of fabric production are set out below.

7.6.1 Woven production

The major portion of woven coir products are manufactured by using the simple method of the interlacement of warp and weft. The woven products are broadly classified into three groups: mats, matting and carpets.

Mats

Coir mats are mainly classified into two categories, brush mats and non-brush mats. In brush mats, warp and weft are interlaced with simple weaving

Table 7.4 Standard mat sizes

Size number	Dimensions in mm
0	550 × 330
1	600 × 350
2	700 × 400
3	750 × 450
4	850 × 500
5	900 × 550
6	1000 × 600
7	1050 × 650
8	1150 × 700
9	1200 × 750

techniques, using two to three shafts, to form the base fabric into which the brush is interlaced using various suitable techniques and in this way producing different types of mats. The brush may be cut or uncut yarns or fibre. Brush mats are manufactured usually up to six feet (183 cm) in width, in required lengths. If the brush is yarn, this is interlaced with the lease fabric and cut on the loom by inserting a knife through a grooved iron rod over which the warp passes. The rod is then removed and the weft beaten up to the fell by the slay to secure the cut pile yarns. If the brush is fibre, small bunches (tufts) are inserted by hand on alternate warp yarns. After completing a row of tufts across the warp a pick of weft will be passed and pushed by the reed against the fell of the cloth, thus anchoring the tufts onto the warp yarns. The top portions of the tufts are then cut with scissors to the required height of the pile. The standard sizes for mats are set out in Table 7.4. Mats are also produced to required sizes.

In non-brush mats only warp and weft interlacement is used. These are comparatively thinner when compared to brush mats and are generally manufactured in small sizes for use as doormats only. Patterns can be woven into these mats by using different coloured yarns or fibres. Details of the different types of coir mats and their end uses are described in the section on matting below.

Machinery

Coir mats are generally manufactured on traditional wooden or iron hand looms. The weaving technique is also very simple. The only exception to hand-weaving is one particular variety of mats, creel mats, which are also manufactured on power looms, but the quantity produced in this way is very small. For hand weaving on these looms the weft is hand wound onto flat wooden pieces specially made for the purpose. Non-brush mats are manufactured on various types of wooden frame. In the case of the most important variety, called corridor

mats, a number of iron rods equal to the number of warp ends required are arranged on the frame. The weft yarn is then wound over and under alternate rods. After winding the required number of weft yarns the rods bearing the weft yarns are removed from the frame, placed in a hand press and pressed to the required width of the mat. The rods are then pulled out, one by one, and the warp yarn inserted with the help of an iron rod similar to a needle. The rods are about 60 cm long.

Matting

Coir matting is brushless and is produced by using simple two- to four-shaft weaves as well as more complicated designs. In the simple weaves the variety of designs produced are bicoloured, striped, checked and other designs. These mattings are reversible. Three-shaft weaves are used in order to get sturdier mattings than ordinary two-shaft weaves but this also enables the production of twills, herringbones (known as VV designs) and other weaves. The main defect in using a three-shaft weave is that the matting is not reversible.

Four-shaft weaves are another common type of weave used in coir industry. These produce a more compact fabric than does the use of two- or three-treadle weaves mentioned above. Design effects produced include twills, herringbones, diamonds, stripes, solid colours and others; these mattings are beautiful and reversible. Only relatively simple designs can be produced by using the above weaves. If more complicated designs are to be produced Jacquard weaving mechanisms are required. Coir matting is produced in rolls of different widths ranging from 30 cm up to 5 m and in lengths from 25–50 m per roll.

Machinery

The machinery used for manufacturing matting is mainly of two types, traditional handlooms and power looms. For handloom weaving yarn preparation includes sorting, splicing, spooling, warping and beaming. Sectional warping is used because single-beam warping is not practical due to the bulky nature of the fibre. All this preparation is done on wooden equipment. If the yarn is to be woven on 'improved' handlooms, called bobbin looms, the warp yarns are not wound onto a weaving beam but onto bobbins, using bobbin winders. These are then arranged on a creel which holds as many bobbins as the number of warp ends required to weave the particular matting to be produced. The yarns are then drawn between tension beams fitted with emery fillet and fed through the heddle frames. This system avoids warping.

In handloom weaving production per worker per shift of eight hours is around 12 to 15 sq. yards (10 to 12.5 m^2). The number of workers working on a handloom will be in proportion to the width of the loom, one weaver controlling up to one metre in width. To a certain extent power looms are also used to weave

matting of 1–5 m width. In these looms the yarns are drawn directly from creels as in the case of bobbin handlooms. In this case the weft yarn is wound onto cops by cop winders. One weaver is required per machine to replace empty cops and to attend to yarn breakages.

The Coir Board of India has developed a semi-automatic loom for manufacturing coir matting. In this loom the picking is manual but all other operations are done mechanically. The main benefit of this loom is that it produces material of more consistent quality than that produced on handlooms. However, handlooms require much less investment than power looms, but their production is lower.

In ordinary power and semi-automatic looms only simple weaving techniques using two-, three- and four-shaft mechanisms are used and therefore the designs formed on these will be of limited complexity. For more complicated designs dobby and jacquard mechanisms are used.

Carpets

Coir carpets, also known as Mourzouk Carpets, are one of the most attractive coir products. A particular type of weave known as Mourzouk weave is used and the peculiarity of this product is that the weft is predominant and the designs are formed by using different coloured weft threads. To produce the design weft threads are individually dyed and woven into the warp in the appropriate order to make up the design. The warp threads are concealed. In ordinary coir matting the warp is equally or more predominant than the weft and the designs are formed by both warp and weft. By using the Mourzouk weave any type of intricate and attractive design of regular or irregular shape can be manufactured. This product is available in rug sizes.

Machinery

Mourzouk carpets are manufactured on slightly modified traditional handlooms only.

7.6.2 Non-woven products

Coir non-woven products are manufactured using bonding and needling techniques with easily curable products, for example polyvinyl chloride (PVC), or rubber. These are used as bonding agents in standard curing processes. Coir pile fabrics, apart from brush mats, are generally made in this way. On the other hand, in the production of needle-punched non-wovens, simple needling is sufficient; no bonding agent is required and other fibres, such as jute or wool for example, can be mixed with coir to form the final product. When producing blended non-wovens the fibres may either be mixed or used as

separate layers in the fabric. Non-woven fabrics are mostly produced in roll form.

Another important non-woven product is rubberised coir. The coir fibre, extracted from dry coconut husk, is fed into a heavy-duty curling machine which twists the fibre into a fairly thick yarn. Twist continues to be added to the yarn until it curls up on itself into a single-ply rope. This is kept for three to four months so as to set the curl in the fibres. This rope is then de-twisted which, as it is single ply, will free the individual fibres which take the form of small springs. These 'spring' fibres are spread to form thin layers and sprayed with latex (plus suitable chemicals). and passed into a vulcanising chamber. After vulcanisation the sheets will be about 1.25 cm thick and these individual sheets are then pasted again with rubber latex and vulcanised again to form the required thickness of the final product.

Machinery

Unlike most other coir products, coir non-wovens are mainly machine manufactured. The most important coir non-wovens, PVC tufted products, are manufactured on a production line consisting of a creel with a tensioning device which holds the yarn in position, a yarn cutting head, a PVC layer spreader, the tufting mechanism, the curing chamber, a shearer for cutting the brush and arrangements for cutting the rolls to size along with the required conveyor systems. The investment required is considerable, approximately US$220,000, and the productivity of the machinery is high, about 800 m^2 per eight-hour shift. Machinery for tufting into a rubber base as is done with PVC has yet to be developed. However, the manual tufting of coir to a rubber base to make small-sized mats is currently practised These machines are locally manufactured but due to their low productivity are not in large-scale use.

In the case of rubberised coir a series of machines is also required. They are the machine for de-twisting the curled coir, a sheet-forming machine with arrangements to spray rubber latex on both sides of the sheet, a vulcanising chamber, cutting machines and arrangements for stitching the cotton cover. The most important of these is the sheet-forming machine. This machinery is made indigenously.

7.7 Products and applications

As already mentioned, Coir gives a variety of eco-friendly products suitable for industrial, commercial and domestic uses. The main items are coir fibre, yarn, mats, matting, geotextiles, garden articles, coir ropes, and fenders. These products and their main applications are described below.

7.7.1 Coir fibre

Coir fibre is the basic raw material for spinning coir yarn. Over and above this basic use it is the main constituent of a recently developed wood substitute. Fibre is also used in the manufacture of certain varieties of mats. Baby fibre (fibre cut into small pieces) is used as pot filling material in horticulture; it is also a good packaging material. Coir fibre is also used, at present only to a small extent, in the manufacture of composite panels for the interior trim of automobiles.

7.7.2 Coir yarn

Coir yarn is the main product used for manufacturing other coir products such as mats, matting, ropes, etc. It also has several other uses. It has been, and still is, the main binding material used in the construction of wooden ships. As these yarns give good grip to climbing plants and are eco-friendly they are widely used in the cultivation of hops. Due to its resistance to slippage it also is used as a good binding (tying) material. Coir yarn is also used in greenhouses as an 'air-cooler. For this, the sides of the greenhouses are covered by strings of two-ply yarn hanging close to each other. These are then soaked with water. When air penetrates into the greenhouse through these wet strings, the water evaporates and by doing so cools the air inside the greenhouse. The specifications of the important varieties of yarn used for the above purposes are given in Table 7.3 above.

7.7.3 Coir mats

There are a number of Coir mats manufactured as described in section 7.6.1. They are required for different occasions and uses. Details are described below. Indian quality codes and specifications of important varieties of these mats and mattings are set out in Appendix F.

Fibre mats

This is the most important variety of coir brush mats. The presence of individual fibres in the brush provides a good brushing effect and hence they serve as very effective doormats. These mats are very good examples of fine craftsmanship and a wide variety of designs can be woven into them using dyed or bleached fibre. As stated above in section 7.6 very attractive and complicated designs can also be printed onto the mats on natural or bleached grounds, using dyestuffs or enamel paints. These mats are excellent examples of 'fitness for purpose' and in addition are aesthetically attractive. In some areas coir fibre mats are used for polishing glass bangles. The quality code of the most common item is FM2.

Creel mats

This variety is a brush mat with warp cut pile. This is comparatively cheaper with less pile height, woven both on hand looms and power looms. Beach creel mats, made from cheaper beach yarn, are cheaper than vycome creel mats, made out of vycome yarn. Both are available in natural or bleached colour or with printed designs. Their main use is as doormats for short-term uses. The quality codes are BC, VC, etc.

Rod mats

This is a type of brush mat with higher pile height. This is also manufactured with beach and vycome yarns and generally exported in natural colour. This variety is used for doormats and dumping mats, for example. The cheapest quality, with thin pile, is also used as a medium for seed germination as coir has good water-holding capacity which provides sustained moisture during growth. The quality codes are BR, VR, etc.

Gymnasium mats

This is a special type of mat used in gymnasia. They are available in different thicknesses starting from 6 cm. They can be manufactured with cordage handles for easy handling and are available in different sizes, the standard size being 6×6 ft (183×183 cm). Cheaper varieties are used as dumping mats. The quality codes are BG, VG, etc.

Non-brush mats

Coir mats without brush are generally manufactured on frames. Corridor mats which are the most important non-brush mats are also known as Hollander or Dutch mats. Other types are Sinnet mats (also known as chain mats or braid mats), Mesh mats, Rope mats (also known as lovers' knot mats). They are generally used as doormats. Rope mats, made out of coir rope, are sturdier in construction and are also suitable for outdoor uses. The way in which these are made is described in Appendix D.

7.7.4 Coir matting

Coir matting manufactured as described in section 7.6.1 is put to many uses; for example wall-to-wall floor covering, wall panelling, echo controlling. Coir matting, cut to required rug sizes with four sides stitched and with or without different types of webbing serve as good decorative items for living rooms. Since coir has an inherent ability to control excess heat and cold it serves as an excellent floor covering, especially under cold conditions. The echo-controlling

quality of coir makes it a good material for furnishing large auditoriums, for both floor and wall coverings. Its capacity to resist dampness makes it a good rug for temporary uses on lawns and other open areas.

Coir matting mats

Coir matting cut to small mat sizes in different dimensions and with rubber backing and edging serves as very good doormats in the cheaper price ranges. This matting is also made into square tiles with rubber backing and edging for floor coverings and into moulded car mats.

7.7.5 Coir carpets

Coir carpets, also known as Mourzouk Carpets, are a beautiful range of furnishing materials in rug sizes. With the possibility of incorporating any complicated design by weaving, this variety is extensively used as decorative floor coverings for domestic and commercial use, especially where they may be subjected to heavy use.

7.7.6 PVC-backed coir mats

Manufactured as described in section 7.6.2, PVC-backed coir mats are a kind of pile mat. This item is easily cut to any size and shape and used without any further finishing. They are widely used as doormats, runners, carpets, different shaped products such as show pieces etc. They are available in different pile heights starting from 14 mm.

7.7.7 Coir geotextiles

In the present world scenario, given the great importance of preserving nature, geotextiles are becoming increasingly important. Coir finds a major place in this market as it is 100% natural, can be completely absorbed by the soil within a period ranging from several months to several years, as required, and is an excellent replacement for synthetic fibres which are extensively used at present. Due to its long-lasting qualities, coir provides better performance when compared to other natural geotextile materials such as jute; in soil erosion control, soil stabilisation and river embankment protection, for example. The different coir geotextile items are described below.

Coir mesh matting

Woven mesh coir matting is the most important coir geotextile. Mesh matting is made with different varieties of coir yarn in fairly open constructions with

Table 7.5 Specifications of popularly used coir mesh matting

Designation code (1)	Type of warp yarn (2)	Approximate scorage of warp yarn (3)	Ends per dm (4)	Type of weft yarn (5)	Picks per dm (6)	Mass kg/m^2 (7)
MMA3 (H2M8)	Anjengo	12	11	Aratory	7	0.700
MMA4 (H2M9)	Anjengo	11	13	Aratory	7	0.900
MMV1 (H2M5)	Vycome	13	9	Vycome	8	0.740
MMV2 (H2M6)	Vycome	12	4.6	Vycome	4	0.400

dm: decimetre (10 cm).

varying strengths and mesh sizes. The item required for a particular use is selected on the basis of several criteria; the slope of the ground, the type of soil, climatic conditions and possibly others. The specifications of the most popularly used coir mesh matting are described in Table 7.5. Although these are open fabrics their construction remains stable during handling because the roughness of the fibres and yarns provide sufficient friction to prevent yarn slippage.

These mesh mattings are also available in the form of loop fabric, where loops of coir yarn are formed on the surface of the matting by using rods during weaving. These loops give extra grip for the plants growing through the mesh and thus give added strength to the combination of matting and plants.

Coir (coco) logs

Coir log is manufactured by filling tubular nets made out of coir (or if necessary synthetic) twine with coir fibre or coir needle felt. The resulting shape is that of wooden logs. These logs are used for controlling soil erosion on river banks and other places subject to heavy water flow and when fixed in position they allow the water to drain away whilst retaining the soil. In order to help the easy growth of vegetation around the logs, layers of wood charcoal are also placed in the nets with the coir to serve as manure for the plants. These logs are available in a range of sizes, but the most used are 12–18 ins diameter and 10–20 ft. long (30–45 cm diameter and 3–6 m long).

Coir bed

Coir bed is manufactured by filling bags made from mesh matting with coir fibre. These can also be used to control soil erosion. Beds with portions cut out at specific distances so as to enable the placing of plant saplings are also available on the market. Another use of coir bed is for seed germination in nurseries. After germination, the whole coir bed, with the saplings, is taken to the final site of cultivation.

Coir needled felt blanket

Coir needled felt is manufactured as described in section 7.6.2 and is available in different densities. When applied in blanket form it is a good soil erosion control material and will encourage vegetation growth. It can also be cut to required sizes and shapes and used as basket liners, mulch material, seed germination pots, moulded pots, soil conditioners, coco poles, etc. It is also an excellent packaging material.

7.7.8 Coir rope

Coir rope is spun from coir yarn and available in shroud laid (three-strand) and hawser laid (four-strand) constructions. Due to the peculiarity of the fibre, coir rope has better 'grip' when compared to synthetic ropes and is therefore easier to handle for ordinary uses. Coir rope is available in different thicknesses starting from half to five inch (1.25–12.5 cm) diameter. In addition to its conventional uses coir rope is now being used on a large scale for growing mussels. For this, ropes of approximately one inch diameter in continuous length of 200–250 m are used. European Countries, especially France, are the main users of coir rope for this purpose.

7.7.9 Coir fenders

Coir fenders are manufactured by knotting coir rope in a particular way over an inner core made to the required shape from coir yarn or fibre. They are available in spherical and cylindrical shapes with handles made from coir rope. In addition to their marine use to prevent damage to ships during berthing they are also used as decorative pieces in hotels and other public places.

7.7.10 Coir garden articles

There are a number of garden articles manufactured from coir. These include coir poles used as climbers for creeper type plants (grow sticks). These are made by covering wooden poles with fibre or rubberised sheets and winding coir yarn tightly round the poles. These are generally three feet (approximately 90 cm) long and PVC tubes are sometimes used instead of wood. Other gardening articles include small coir pots used for growing seedlings, larger pots used as inner liners, husk chips and baby fibre used for pot filling, etc. Birdnests made from coir are yet another item; these are made by hand stitching thin varieties of two-ply yarn.

7.7.11 Rubberised coir products

The rubberised coir sector offers a range of products suitable for modern comfortable living. The soft but stiff nature of rubberised mattresses (rubberised

coir sheets covered and stitched with thick cotton fabric) are recognised as providing comfort with good back support and are accepted as being amongst the best products available on this market. Cushions, pillows, bolsters, etc., made from rubberised coir are also available. The bare sheets (without cotton fabric covers) are used as packing material for sophisticated engineering products.

7.8 Handle and wear characteristics

Coming under the group of industrial fibres, coir fibre is well known for its stiffness and resilience. It can withstand large amounts of pressure and abrasion and recovers as soon as the pressure is removed. Coir fibre is categorised as a wood fibre having a lignin content of about 45%. Due to this, the floor coverings made from coir are very much more durable (but not as soft) than jute or wool. Comparative figures of the properties of coir with some other natural fibres are given in Table 7.6.

Unlike the soft vegetable fibres coir is devoid of any mesh structure. Coir's extension at break is far greater than that of these fibres and therefore it is better able to withstand sudden loading. Coir density is low due to its porosity. About one-third of the fibres are filled by air, which imparts its springiness. Efforts are being made to soften coir fibre. Experiments conducted at the Central Coir Research Institute by the Coir Board reveal that softening using a vegetable oil and water emulsion with added urea is effective in softening coir fibres. Further work in this area continues.

7.9 Economic and cost considerations

In the present world of stiff competition, the marketing of products of good quality at reasonable prices is very important. Coir being a natural product manufactured mainly by small 'cottage industry' operations is well placed to benefit from this situation. Coir products should not be compared to similar

Table 7.6 Comparative properties of a few natural fibres

Property	Jute	Sisal	Coir
Width or Diameter (mm)	–	50–200	100–450
Density (g/cc)	1.3	1.45	1.40
Micro-fibrillar angle (degree)	8.1	10.22	30–49
Cellulose/lignin content (%)	61/12	67/12	43/45
Elastic modulus (GN/m^2)	–	9–16	4–6
Tenacity (MN/m^2)	440–533	568–640	131–175
Elongation (%)	1–1.2	3–7	15–40
Aspect ratio (L/D) (mm)	152–365	–	35

Table 7.7 Prices of comparable qualities of floor coverings made from coir, jute and sisal (prices in US$/m^2 FOB)

	Coir	Jute	Sisal
1. Panama matting – natural colour (latex backed)	2.5	3.00	7.00
2. Panama matting – bleached (latex backed)	3.0	3.50	–
3. Boucle matting – natural (latex backed)	3.80	4.25	8.00
4. Boucle matting – bleached (latex backed)	4.6	5.00	–

products made from synthetic fibres as their characteristics are very different; however, they can be compared to products made from jute, sisal and other bast and leaf fibres. The half million artisans engaged in the production of coir throughout India can provide coir at a reasonably low price when compared to jute and sisal products also manufactured in India. Examples of the FOB prices of comparable qualities of coir, jute and sisal products are given as Table 7.7.

Coir is a bulky material when compared to jute and sisal and therefore freight costs will be higher. Hence the delivered cost in distant markets may be comparable to those of jute or sisal. However, coir has specific qualities which give it advantages over other natural fibres, and due to this the world demand for coir is increasing year by year. Some comparative prices are illustrated in Table 7.8.

7.10 Marketing

Marketing occupies an important position in the organisation of a business unit and, in fact, it is the essence of all business. It is the function of a business concerned with the creation of a customer. The creation of a customer entails the identification of customer needs and organising the business to meet these needs. Marketing is also defined as the delivery of customer satisfaction at a profit. Sound marketing is critical for the success of any organisation. Exporters of India's coir industry have always accepted these points.

Table 7.8 Comparison of prices and other characteristics of coir and other fibres

	Coir	Sisal	Jute	Hemp
Price per tonne $US Sept. 2003	600–650	1900–2000	550–600	550–600
Density g/cc	1.4	1.45	1.3	NA
Resilience (modulus)	4.6	9–16	NA	NA

Table 7.9 Import tariffs of major importing countries (May 2003)

1.	USA	0–4.6%
2.	UK	0–10.4%
3.	Australia	0–10.8%
4.	Germany	0–6%
5.	Denmark	0–5.8%
6.	Sweden	Nil
7.	Portugal	4–9.6%
8.	Greece	0–9.6%
9.	Canada	Nil
10.	Pakistan	15–35%

After India's independence in 1947 and the subsequent closure of the European companies the individual exporters maintained existing relations with the broad sales network covering overseas importers and agents.. Exports of coir products from India are now handled by about 250 exporters; these include large, medium and small companies, public and private limited companies, proprietary (single-owner) concerns, government undertakings and workers' co-operative societies; all of which compete fairly with each other. Most of these exporters are capable of supplying all types of product including PVC tufted products, and they export to about 80 countries in the world.

The marketing of coir has a special nature. Coir is generally a buyers' market. Hence the importers and agents, and not the producers, decide on the type, quality, design and other specifications of the product to be marketed in a particular season. Based on these estimated requirements they then place firm orders with the exporters. Generally exporters only manufacture products after receiving firm orders. The lead time from receipt of order to despatch is about one month but this may vary slightly according to circumstances. In exceptional cases exporters will keep a stock of manufactured goods if they are sure to receive specific orders for them. A list of exporters representing all sections mentioned above and of the three exporters associations is given in Appendix E.

Some importing countries levy import duty on coir products. These tariffs vary from product to product and country to country and Table 7.9 gives the range of tariffs levied by some of the major importing countries. These tariffs are liable to be waived or reduced on production of country of origin certificates under the Generalised System of Preferences Scheme. Various agencies in India including the Coir Board are authorised to issue such GSP certificates.

7.11 Production and consumption

7.11.1 Production and exports

Coir is produced in about ten countries. However India and Sri Lanka account for the major portion of world production. Details are given in Table 7.10.

Table 7.10 Estimated production of coir products in India and Sri Lanka (tonnes)

	India		Sri Lanka	
	1999–2000	2000–01	1999	2000
White fibre	120,000	120,000	55,242	55,100
Brown Fibre	236,000	244,000		
Bristle fibre	–	–	4,081	5,103
Mattress fibre	–	–	23,222	28,919
Twisted fibre	–	–	19,512	21,078
Coir yarn	222,300	233,400	–	–
Coir Products	64,900	71,500	–	–
Coir rope	48,900	51,300	–	–
Curled coir	29,800	31,000	–	–
Rubberised coir	46,300	51,000	–	–
TOTAL	768,200	802,200	102,057	110,200

Table 7.11 World exports of coir and coir products (1996–2000) (tonnes)

Country	1996	1997	1998	1999	2000
APCC Countries*	**102,283**	**104,810**	**112,337**	**110,002**	**117,394**
India	*44,660*	*46,223*	*51,139*	*50,697*	*56,046*
Coir yarn	13,631	14,238	17,845	13,095	14,817
Coir matting	7,136	7,392	6,769	6,932	8,288
Coir mats	20,962	21,450	20,560	25,344	28,944
Coir rope	108	87	183	243	298
Rugs & carpets	2,190	1,895	3,183	3,285	2,603
Rubberised coir	209	227	431	650	402
Others	424	934	2,168	1,148	694
Indonesia	*866*	*595*	*30*	*59*	*102*
Malaysia	*110*	*225*	*139*	*65*	*52*
Philippines	*927*	*1,001*	*1,818*	*1,504*	*1,509*
Sri Lanka	*52,402*	*51,973*	*54,106*	*50,787*	*52,430*
Mattress fibre	24,384	26,072	20,083	23,222	24,508
Bristle fibre	5,515	5,696	5,014	4,081	4,325
Coir yarn	849	945	780	486	768
Twisted fibre	18,635	18,086	25,761	19,512	17,863
Coir twine	3,019	1,174	2,468	3,486	4,966
Thailand	*3,318*	*4,793*	*5,105*	*6,890*	*7,255*
Other countries	**300**	**300**	**300**	**300**	**300**
TOTAL	**102,583**	**105,110**	**112,637**	**110,302**	**117,694**

* APCC: Asian and Pacific Coconut Community.

Production of the other countries is nominal. According to the Asian Pacific Coconut Community (APCC), world exports of coir and coir products in 2000 totalled 117,694 tonnes. India accounted for 56,046 tonnes and Sri Lanka for 52,430 tonnes. India having been in the industry for quite a long time, exports more value added products than Sri Lanka, whose main export is still coir mattress fibre. Table 7.11 shows the world exports of coir and coir products during the years 1996 to 2000.

[*Editor's note*: (a) Set out in Appendix C on page 305 are the annual world coir production statistics, by country; for each year between 1999 and 2003, and for every five years between 1964 and 1999. These show that the total production over this period increased by over 50%, the increase starting in the early 1980s. However, during this period Sri Lankan production decreased, as did Malaysia's, whilst India's more than doubled. In percentage terms Thailand increased production by 800%, but from a very low base of 2,500 tonnes and a 120% increase took place in one year, from 2002 to 2003. Also in Appendix C is a graph, prepared by Mr Gordon Mackie[1] which forecasts an encouraging future for coir (see page 306).

(b) There is, of course, in Tables 7.10 and 7.12, what could be called a certain amount of double counting in that fibre is present in these tables as fibre, yarn and products and whilst their totals are interesting as a measure of economic activity, they must not be considered as a total weight of fibre produced or consumed. Production tonnages are clearly set out in Appendix C.]

7.11.2 Domestic consumption (India)

As mentioned above, India and Sri Lanka are the main producers of coir in the world. The majority of India's production, amounting to 80% (by weight), is consumed in the domestic market and only 20% is exported. Table 7.12 gives the details of domestic consumption of various items of coir in India during 1999–2000 and 2000–2001. The domestic consumption of Sri Lanka is negligible.

Table 7.12 Indian domestic consumption of coir (tonnes)

Item	1999–2000	2000–01
Coir fibre	35,800	37,000
Coir yarn	109,000	110,000
Coir products	18,000	24,000
Coir rope	50,700	51,000
Curled coir	1,720	1,900
Rubberised coir	45,600	48,500

Table 7.13 Major importing countries of coir products in 2000 ('000 tonnes)

Country	Coir fibre	Coir yarn	Coir mats, matting & rugs
1. USA	4.1	1.7	13.3
2. UK	6.5	0.1	4.9
3. Netherlands	2.6	2.1	2.9
4. Germany	10.1	1.6	2.6
5. Japan	5.7	–	0.7
6. South Africa	1.7	–	–
7. Australia	0.6	–	1.5
8. France	0.5	1.8	1.3
9. Portugal	1.8	0.4	0.1
10. Belgium	0.3	1.1	2.2
11. Greece	1.3	–	0.2
12. Italy	0.6	3.6	1.2
13. Spain	0.7	0.5	0.9
14. Pakistan	1.2	0.5	–

7.11.3 Imports

The USA is the biggest importer of coir products in the world. In 2000 they imported 19,000 tonnes of coir; the other major importers are Germany, the Netherlands, the UK, Japan, Italy, Belgium, France and Australia. The USA imports mainly coir mats, matting and ropes along with coir fibre whereas Germany, the UK, Japan, etc., import more coir fibre than products. Italy and Netherlands are the main importers of coir yarn. The imports of coir by the major importing countries during 2000 are given in Table 7.13.

7.12 Environmental and health and safety issues

7.12.1 Introduction

Coir, being a 100% natural fibre extracted under natural conditions, has few problems with the environmental, health and safety aspects of its production. Even though it is claimed that the manual extraction of coir fibre after retting is harmful to the labourers engaged, as they sit for hours at a time, this has yet to be scientifically proved. Moreover, with the introduction of the mechanical extraction of fibres, this conventional method is now limited to one or two districts in Kerala State and even in these districts manual fibre extraction is falling and is expected to cease within a short period of time.

7.12.2 Natural retting

Traditionally, coir fibre was extracted from coconut husks after natural retting. In this process the effluents were carried away by tidal waters. These effluents

are 100% natural and highly diluted with a low degree of toxicity and only the foul smell of this natural retting sites invites attention. Apart from this there are no serious pollution problems, and even this pollution is diminishing as the trend, due to economic and social changes, is towards a considerable reduction in the quantity of coir obtained by natural retting. Moreover, the Coir Board has developed a technology by which the retting can be done in concrete tanks and the rett liquor treated so as to neutralise the polluting ingredients.

7.12.3 Dyeing

Among the environmental problems arising from coir production, pollution by the effluents of coir dyeing is important because these contain residual dyestuffs. Even though, to some extent and where continuous dyeing is adopted, these residual dyestuffs will be utilised by the standing-bath method of dyeing, some liquor will inevitably be left at the end of the process. However, modern production practices employ approved non-azo dyestuffs and these are now increasingly used. Also several agencies are now establishing 'Common Facility Centres' for the use of small-scale manufacturers and this will also facilitate pollution control. The Indian Government's Pollution Control Board is extremely strict in implementing non-polluting methods of dyeing.

7.12.4 Sulphur smoking

Coir yarns and products are subjected to sulphur smoking before shipment. This is done both in order to disinfect them and to obtain a brighter colour. Sulphur smoking is done in airtight smoking chambers for about 12 hours. After completion and when the chambers are opened there is a possibility of the sulphur dioxide and other gases escaping. In order to overcome this difficulty the smoking chambers are fitted with the necessary equipment for collection and treatment of the sulphur dioxide gas, which is the main constituent, and which is converted to sulphuric acid. The Pollution Control Department ensures strict observation of these norms.

7.12.5 Accumulation of coir pith

Coir pith is a by-product of coir fibre extraction. In former days the pith was stored in heaps near the fibre extraction units and dust particles would spread over neighbouring areas. The Coir Board of India has developed a mechanism by which the coir pith can be converted into organic manure and used for agricultural purposes. As discussed in Appendix A on page 304 pith is now increasingly used in organic farming and horticulture, and its accumulation is being rapidly reduced.

7.13 Conclusion

Coir provides a livelihood to 500,000 poor people in India alone with low levels of atmospheric pollution. Being an ecofriendly, natural product from renewable sources, coir products serve mankind in several ways as a substitute for many synthetic products which are extensively used but are harmful to nature. Coir wood substitute will help to protect valuable forests. It is the duty of all nature lovers to give maximum encouragement to this industry.

7.14 Appendices

Appendix A: Non-textile coir products

Pith

Coir pith is the binding material which is the main constituent of the coconut husk. For each kilogram of coir fibre extracted about two kilograms of pith are produced. The accumulation of this pith in the coir fibre manufacturing units used to create pollution problems due to dust being blown all over the area by the wind. In addition large areas were required to store it. However, in recent years research by the Coir Board of India has demonstrated that pith has very good applications in various agricultural and horticultural fields. It has excellent moisture-retention capacity of 500–600%, high potassium content and low bulk and particle density. It is also reported that the high cation exchange capacity (CEC) enables it to retain large amounts of nutrients and the adsorption complex has high contents of exchangeable potassium, sodium, calcium and manganese.

Composted coir pith resembles peat and is commercially known as cocopeat. It is used for seed germination, raising seedlings, rooting cuttings and other forms of plant propagation, the hardening of plant tissue and for embryo cultured plants. It is also used in hydroponic systems of plant cultivation, glasshouse cultivation, soil conditioning, lawn making, etc. With the increased emphasis on organic farming and horticulture, coir pith is gaining in importance and relevance all over the world. It is exported in the form of briquettes and blocks; the Netherlands are one of the main importers.

Coir ply

Coir ply is a product developed by the Coir Board of India as a wood substitute. The product is made by bonding coir with phenolic resins, the coir content being approximately 65–70%. Since coir fibre is extracted from the fruit of coconut trees, which grow in abundance in several parts of the world, coir ply could make a material contribution to reducing the consumption of wood and thus save

natural forests. The technology now developed is capable of producing products used, for example, for surfacing, panelling, furniture manufacture, and partitions. Further research is under way to produce coir ply grades suitable for shuttering and similar uses.

Appendix B: Chemical composition of new and old coconut fibres

	Water solubles	Pectins	Hemicellulose	Lignin	Cellulose
Young nut	16.00	2.70	0.15	40.50	32.9
Old nut	0.2	3.00	0.25	45.80	43.30

Source: Philippine Coconut Authority 1978, quoted by Jarman, C. *Plant Fibre Processing*, Intermediate Technology Publications, Rugby, UK, 1998.

Appendix C: World coir production 1964–2003

Table 7.14 World coir production 1964--2003 (tonnes).

	1964	1969	1974	1979	1984	1989
World	393,157	411,818	389,211	395,488	425,422	543,499
Bangladesh	8,057	10,618	7,911	9,188	10,622	10,699
India	187,400	217,700	224,000	209,400	256,800	347,700
Malaysia	41,200	47,500	43,300	43,900	48,000	45,300
Sri Lanka	154,000	135,500	109,000	127,000	103,000	132,000
Thailand	2,500	1,000	5,000	6,000	7,000	7,800
	1994	1999	2000	2001	2002	2003
World	695,800	654,190	682,790	658,390	632,290	636,640
Bangladesh	12,000	11,390	11,390	11,390	11,390	11,390
India	494,100	454,000	468,000	450,000	450,000	450,000
Malaysia	40,700	29,800	29,400	28,000	28,900	28,000
Sri Lanka	140,000	150,000	165,000	155,000	133,000	127,250
Thailand	9,000	9,000	9,000	14,000	9,000	20,000

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

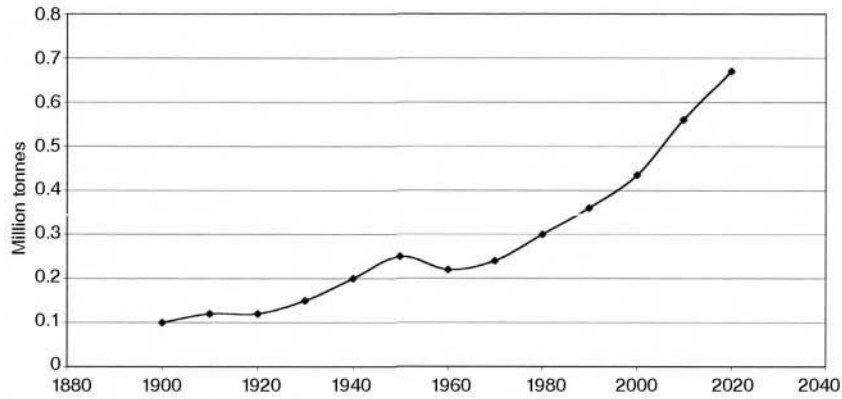


Figure 7.3 World coir production 1900–2003 and forecast to 2020. Courtesy: Gordon Mackie.

Appendix D: The manufacture of coir mats

The manufacture of corridor mats is covered above, in section 7.6.2.

Sinnet mats

A wooden frame is prepared onto which are fixed headless nails according to the design of the mat. Then coir yarn is braided to form flat braids; the number of yarns in the braid is generally 9 or 11, depending on the required quality of the mat. The braid is then guided through the nails in a zigzag path, leaving inner spaces and so producing the pattern; both the placing of the nails and the way in which the braid is guided through them will affect the quality of the mat. This is then followed by stitching, after which the mat is taken out of the frame and final finishing work done to produce the end-product.

Rope mats

A wooden frame is prepared in the same way as for sinnet mats. The coir yarn is plied into ropes of the required thickness and guided through the nails following a particular path. After completing one round, the process is repeated so that a minimum of four layers are formed. The number of layers will depend on the size of the mat. When this has been done the mat will be removed from the frame, the layers will be stitched and both ends of the rope will be merged into the body of the mat so that they are not noticeable

Mesh mats

A wooden rectangular frame is made to the size of the mat. Headless nails are fixed to all four sides of the frame. The warp and weft yarns are guided in between and around the nails along the length and width of the frame so as to be perpendicular to each other. Four layers, two of warp and two of weft, are laid alternately in this way and the mat will be made by tying them together where they intersect with a special knot. The mat is then removed from the frame an finished, using a suitable knotting technique.

Appendix E: Indian coir manufacturers and exporters trade associations

Travancore Coir Mats and Matting Manufacturers Association, Allepey, Kerala
Coir Shippers Council, Cherthala, Allepey, Kerala
Indian Coir Association, Kochi, Kerala.

Indian coir exporters

M/s. D C Mills (P) Ltd.,
P.B. No. 169, Alleppey,
Kerala – 688 001
Telephone: 0477 2251016, 225366, 2865373
Fax: 0477 2251301, 2251201, 2863019
E-mail: konath@md2.vsnl.net.in
Website: http://www.dcmills.com
Contact person: KJ Dennis
Constitution: Limited company

M/s. Foam Mattings (India) Ltd.,
P.B. No.4619,
Alleppey, Kerala – 688 012
Telephone: 91 477 2251172, 2254081, 2264223, 2264216
Fax: 91 477 2251654, 2263948
E-mail: fomil@md3.vsnl.net.in
Website: www.fomil.com/
www.Geotextile.org.
Contact person: P.R. Luis
Year of establishment: 1979
Constitution: Public company

M/s. The Goodwill Coir Manufacturing Co.
P.B. No. 2616, Canal Ward,

Alleppey, Kerala – 688 007
Telephone: 91 477 2246338, 2246340
Fax: 91 477 2244487
E-mail: goodwillcoir@satyam.net.in
Contact person: T.V. Sreedharan
Year of establishment: 1950
Constitution: Partnership firm

M/s. Alleppey Company Ltd.,
P.B. No. 2602, Tac House,
Alleppey, Kerala – 688 007
Telephone: 91-477-2245021, 2242330, 2242835
Fax: 91-477-2243161
E-mail: coir@glasmd01.vsnl.net.in
Website: www.karan-carpet.com
Contact person: N. Venugopal
Year of establishment: 1930
Constitution: Public company

M/s. Cocopalm Products Company,
P.B. No. 3, Vazhichery,
Alleppey, Kerala – 688 001
Telephone: 91 477 2244639, 2243132, 2251382
Fax: 91 477 2243132
Contact person: George Varghese
Year of establishment: 1958
Constitution: Proprietorship firm

M/s. Jos Coir Mills,
P.B. No. 80, Chungom,
Alleppey, Kerala – 688 001
Telephone: 91 477 2259058, 2243592 (RES)
Fax: 91 477 2243021
Contact person: K.A. Joseph
Year of establishment: 1996
Constitution: Proprietory firm

M/s. Madhavan Inc.
Zilla Court Ward,
Alleppey, Kerala – 688 013
Telephone: 91 477 2235900, 2235239, 223682, 223300
Fax: 91 477 2232131
E-mail: madinc@sancharnet.in

anilmad@sify.com
Contact person: Anil Madhavan
Year of establishment: 1993
Constitution: Partnership firm

M/s. Palm Fibres & Yarns Trading Company,
P.B. No. 37, Pathirappally,
Alleppey, Kerala – 688 521
Telephone: 91 477 2258172 (5 lines)
Fax: 91 477 2258171
E-mail: palmfibr@md2.vsnl.netin
palmfibr@sancharnet.in
Website: www.palmfibre.com
Contact person: Jose Paul Mathew
Year of establishment: 1965
Constitution: Limited company

M/s. Shertallai Coir Mats & Matting Co-op. Society Ltd.,
No. 240, P.B. No. 3,
Kalavamkodam P.O.,
Cherthala, Alleppey,
Kerala
Telephone: 91 478 2812520, 2813220, 2864227
Fax: 91 478 2814029
E-mail: shercom@md5.vsnl.net.in
Website: www.cocoscooperative.com
Contact person: T.C. Ranganathan
Year of establishment: 1958
Constitution: Co-op Society

M/s. Travancore Mats & Matting Company,
P.B. No. 5, Cherthala,
Alleppey, Kerala – 688 524
Telephone: 91 478 281 2528, 2217, 2238, 2825
Fax: 91 478 281 2906, 0484 6685
E-mail: tmmc@travancore.com
Contact person: V.R. Prasad
Year of establishment: 1917
Constitution: Partnership firm

Sri Lankan coir exporters

Sancta Maria Coir Products (Pvt) Ltd
Chilaw Rd
Modukatuwa
Maravila
Telephone: (94) 32 54435, 722 83040, 773 83667
Fax: 32 54269
e-mail: salea@sanctamari.com

Rileys Limited
53/6 St Jude's Mawatha'
Mahabage
Telephone: (94) 1 958668 / 959048
Fax: (94) 1 956637
e-mail: rileys@sri.lanka.net

Osni Lanka (Pvt) Ltd
7a Havelock Place
Colombo 5
Telephone: (4) 1 586511
Fax: (4) 1 502460
e-mail: info@osnilanka.com
Contact person: Niranga Hettiarachchi

Toyo Cushion Lanka (Pvt) Ltd
193 Minuwangoda Rd
Kotugoda
Ekla
Telephone: (94) 1 232939, 236635, 232942
Fax: (94) 1 23294, 23765
e-mail: toyo@sri.lanka.net

A more detailed list of Sri-Lankan coir fibre and products exporters can be obtained from the Coconut Development Authority of Sri-Lanka:

Tel: +94 11 250 2501/8730/2503
Fax: +94 11 250 8729
e-mail cdaho@sltnet.lk

Appendix F: Quality codes and specifications of important varieties of coir mats and mattings

Code	Type of yarn					Ends/ dm	Picks/ dm	Pile Height mm	Mass gms/ m^2
	Slack chain	Tight chain	Weft	Pile	Con-struction				
1	2	3	4	5	6	7	8	9	10
Creel mats									
BC1	–	Beach	Beach	Beach	warp cut Pile	9	24	22	4800
BC2	–	Beach	Beach	Beach	do	9	24	25	5400
VC1	–	Vycome	Vycome	Vycome	do	9	25	22	5400
Fibre mats									
FM2	Vycome	Vycome	Vycome	Fibre	Inserted fibre	12	12	28	7800
Corridor mats									
RC3	–	rope yarn	Aratory	–	brushless	5	–	–	3350
WC3	–	do	Vycome	–	do	5	–	–	3050

Coir mattings

Code	Type of warp yarn	Approximate scorage of warp yarn	Ends/ dm	Type of weft yarn	Picks/ dm	Mass kg/m^2
1	2	3	4	5	6	7
2 shaft mattings						
M2A2	Anjengo	14	31	Vycome/Beach	11	1.55
M2R2	Aratory	14	31	Vycome/Beach	11	1.47
2 shaft basket weave mattings						
M2BA1	Anjengo	15	30	Anjengo/Aratory	17	1.72
M2BR2	Aratory	14	28	Aratory	17	1.72
4 shaft mattings						
M4A2	Anjengo	14	31	Vycome	13	1.75
M4R2	Aratory	14	31	Vycome	13	1.68
Mesh mattings (geo textiles) See Table 7.5 on page 295.						

7.15 Glossary of terms

Baby fibre fibre cut into small lengths.
Braid mat another name for sinnet mats.
Brush mat a coir mat which has pile.
Chain mat another name for sinnet mats.
Coco logs coir filled tubular nets (used in erosion control).
Cocos nucifera Latin name for coconut palm.
Coconut pith cork like spongy material embedded to the fibre in the coconut husk.
Coir bed coir filled mesh netting bags (used in erosion control).
Coir braid three or more strings of coir yarn plaited either by hand or by mechanical device with or without inner core.
Coir briquette briquettes made from coir pith/coir pith heat pressed with other ingredients into briquettes.
Coir cordage cords, ropes, etc., made from coir fibre or coir yarn.
Coir fender fender made with coir fibre, yarn or rope for inner core material and coir rope suitably knotted for outer shell in different shapes.
Coir rope a cordage made out of a number of strings of coir yarn first twisted to make strands and then to rope with a diameter of 8 mm and above.
Core yarn the yarn or string placed inside a rope, braid, etc., to give better shape, higher weight, etc.
Corridor mats coir mats, non-brush type, with low rib effect on both sides, manufactured on frames with the aid of iron rods. Both the warp and weft are continuous in the mat throughout.
Creel mats cut pile coir mats made on looms with two or more chains. Pile is formed by cutting the brush chain bend over a grooved iron rod.
Dutch mat another name for corridor mats.
Fibre mats coir mats with brush formed by insertion of tufts of coir fibre on alternate warp strands in the process of weaving.
Hollander mat same as corridor mats.
Latex backing backing given on coir products with rubber latex containing vulcanizing ingredients, non-staining antioxidants and fillers, properly expanded by mixing air.
Lovers' knot mat coir mats made from coir rope guided through nails projected on a wooden surface in a definite order and the starting and finishing ends of rope merged with the adjacent layers. Mats are made in oval, oblong and circular shapes. This mat is also known as rope mat.
Matting a woven fabric from coir yarn generally used as rugs, runners and wall to wall furnishing.
Matting rugs mattings of different weaves cut to rug sizes with ends bound, tucked in or fringed, as required.

Mattress fibre short and resilient fibre mechanically extracted from dry husks of ripe coconuts.

Mesh mats coir mats made on frames with nails projected on it, by laying yarn in criss-cross manner and knotting the intersecting points with coir yarn, producing a mesh effect.

Mesh matting the matting woven by positioning warp and weft relatively at higher distance to form mesh effect.

Non-brush mats coir mats without brush/pile.

Non-reversible mattings coir mattings with differential weave effects on face and reverse sides.

Ratt a manually operated set of wheels for twisting and spinning coir yarn.

Retting the process of keeping the husks immersed in water for a period ranging from six to ten months during the course of which the pith and other matters become loosened, allowing easy extraction of fibre.

Rod mats coir brush mats in which brush is formed by cutting coir yarns folded two, three or more together and wound by hand on a grooved iron rod along with alternate warp strands.

Rope mats mats made with coir rope.

Scorage of yarn a number indicating the fineness or coarseness of coir yarn, which is one twentieth of the number of yarns that could be laid close to each other without overlapping in a length of 0.914 m.

Sulphur smoking treatment before shipping to disinfect coir products and obtain brighter colour.

Sinnet mats coir mat made of coir braid guided between the nails projected on a flat surface as per design with stitches to hold the layers of braid together.

Sorting selection of coir yarn based on colour, twist, runnage, etc.

Spindles an iron or wooden rod shaped into a hook at one end having a stud at the centre to receive a string around from a large wheel for its rotation, used for imparting twist for spinning.

Stationary ratt the spinning wheel fixed on the ground used for making single strands of coir yarn and also for doubling.

Three-ply yarn wheel spun coir yarn in three-ply made from medium and short stapled fibre from retted husk, hard twisted and hard spun, Brown to grey in colour, hairy, hard and tough in texture, containing varying amounts of pith, in the runnage range 40–55 m/kg (scorage: 4–8).

Traditional loom a wooden handloom traditionally in use for weaving coir mats, mattings, carpets, etc.

Two-treadle basket weave a two-treadle weave in which two or more warp threads work together with two or more weft inserted in the same shed for successive picks.

Two-treadle plain weave plain weave in which warp and weft work one up and one down and one under and one over respectively.

Webbing the material in the form of tapes used for fastening the cut ends of coir matting by stitching/pasting or the process of fixing the webbing material at the cut edges of matting.

Yarn guide a wooden block in triangular shape or any other shape with grooves running along the length to receive primary strands, used for doubling process in spinning and rope making.