Chapter 13
Bio-processing of Coir—A Natural Fibre for Diversified End Use

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13.1 Introduction

Man has been dependent on plant fibres in the form of structural and building materials, utilised in various industries such as paper, textiles, packaging, furniture, etc. The coconut palm, found by Megasthenes, the ambassador of Seleucus Nicator in Sri Lanka as far back as 300 B.C., is one of the most remarkable renewable bioresources. The early Arabs knew of coir, and the coconut palm has been a source of wealth for centuries (Mukherjee 1996).

The coconut fruit is unique, as nature has used its utmost skills to design it in such a way that despite being very heavy, it is buoyant and has a water repellent surface, which enables it to float for long distances. The reason of this buoyancy is the packing material inside the fruit which has been designed to protect its seed that is the nut. The cushions provided around the nut comprise of fibre and pith which are designed to be light but strong reinforcement material and the outer coating is a poly-phenolic substance known as lignin, which is hydrophobic in nature. The lightness of the fruit is due to these fibres and pith which are perforated to the extent of 40%, thereby lowering the specific gravity to the minimum.

In India, about 75% of the coir produced in terms of value is consumed in the Indian domestic market itself, while the remaining 25% of coir is exported (Table 13.1). Countries in Europe and America together consume about 90% of coir exports from India. Coir is marketed in different forms such as fibre, yarn, mat, matting, rug, carpet, geo-textile, curled coir and rubberised coir. The factors that contribute to the increase in export opportunities for coir are the rising cost of synthetic substitutes, a shift in tastes and preferences in favour of natural materials due to greater appreciation of the environmental implications. The 100% biodegradable nature of coir floor coverings has resulted in a steady increase in demand for them as compared with the synthetic materials which create problems of recycling, fire/health hazards and biodegradability. Another development of interest to the coir

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Table 13.1 Export of coir products from India March 2012–April 2013. (Source: Coir Board Agenda Notes 2014)

Item	Qty. (tons)	Value (Rs. Lakhs)
Coir fibre	140,692.93	20,707.66
Coir yarn	4202.31	2387.22
Coir mats	61,441.38	56,386.16
Coir matting	1418.31	1702.76
Coir rugs and carpets	94.83	133.37
Coir rope	419.62	282.41
Rubberised coir	321.47	495.01
Curled coir	8883.14	2112.46
Coir geotextiles	3597.3	2628.74
Coir other sorts	30.37	39.32
Coir pith	208,399.28	24,727.61
Total	*429,500.94*	*111,602.72*

industry is the growth of the market in Europe and America with consumers demanding materials that can be used to prevent soil erosion and promote re-vegetation (Coir Board Report 1996).

13.2 Coir Fibre

Coir fibre is lignocellulosic in nature, with lignins and hemicelluloses forming the cementing materials of the fibre cells. The source of coir fibre is coconut husk obtained after taking the nut. Husk is embedded in the matrix of coir pith where coir pith is present to the extent of 70 % and fibre up to 30 %.The physical characteristics of coir fibre such as length, fineness, strength and elongation determine its utility. Coir has a high extensibility (about 37 %) and high lignin content of 40 % which distinguishes it from other cellulosic fibres. The high extensibility of the coir fibre is primarily because of the microfibrils in the cell wall which lie in perfect helical spirals, extension of the fibre being related to the changes of the spiral angle, that is, the angle which a microfibril element makes with the fibre axis. Coir is in great demand on account of its natural resilience, durability, resistance to dampness and eco-friendliness. Physical and chemical characteristics of coir fibre are presented in Table 13.2 and Table 13.3, respectively.

Table 13.2 Physical properties of the coir fibre. (Source: Ravindranath 1999)

1.	Ultimates	
	Length in mm	0.6
	Diameter/width (microns)	16
2.	Single fibre	
	Length in inches	6–8
	Density (gm/cc)	1.40
	Tenacity (gm/tex)	10.0
	Breaking elongation %	30
	Moisture regain at (65 % R.H. (%))	10.5
	Swelling in water (dia)	5 %

Table 13.3 Chemical composition of coir fibre. (Source: Ravindranath 1999)

Water solubles	5.25 %
Pectin and related compounds	3.00 %
Hemicellulose	0.25 %
Lignin	45.84 %
Cellulose	43.44 %
Ash	2.22 %
	100.00 %

13.3 Natural Retting of Coconut Husk

The coir fibre can be extracted by the retting process by steeping the husks in the backwaters for 10 months. During this period, the husks become soft by microbial activity following which the husks are taken out of the water and beaten gently to release the fibre and pith. The natural coconut husk retting process has been studied by various scientists to understand the involvement of microorganisms and the biochemical changes occurring during the process.

The problems associated with the natural retting process have been a concern of the environmentalists. Besides, the low availability of the fibre as compared to the demand has been a point of focus of the coir industrialists. An established fact known to cause the delay in the retting of coconut husks is the presence of the high percentage of polyphenols (Jayasankar and Bhat 1966; Pandalai et al. 1956; Varrier and Moudgil 1947). Polyphenols from the coconut husks get constantly leached out into the surrounding steep liquors and significantly influence the retting process, thereby resulting in a delay in extraction of the fibre (Jayasankar and Bhat 1966). Retting is also a cause of environmental pollution (Aziz and Nair 1978) as the pH of the environmental waters in a retting zone is lowered from neutral to the acidic range, indicating the release of acidic substances. The biochemical oxygen demand

(BOD) levels increase considerably leading to the deterioration in the quality of the backwaters which is detrimental to the aquatic life. Recommendations have been made for adopting fibre pretreatments by improved retting and biobleaching (Sarma and Ravindranath 2005a; Van Dam 1999). It is therefore imperative to develop ecofriendly methods for coir extraction from coconut husks. Alternative measures, like the development of Coirret, have limitations such as insufficient production capacity to meet the requirement of all coconut-growing regions and its high cost. Therefore, a process which could overcome these shortcomings would be useful for economic utilisation of the husk potential in any coconut-growing region. Bacteria are the most versatile organisms dissimilating an array of aromatic compounds with catechol as the key intermediate involved in the oxidative cleavage of the aromatic ring (Evans and Fuchs 1988). Some important degradative bacteria that occur in water and soil environments belong to the genera such as *Acinetobacter, Aeromonas, Agrobacterium, Alcaligenes, Azotobacter, Bacillus, Enterobacter, Escherichia, Flavobacterium, Methylomonas, Methylococcus, Moraxella, Proteus, Pseudomonas, Rhizobium, Serratia* and *Xanthomonas* (Cork and Krueger 1991). Growth of specific types of microorganisms and their physiological activities are a response to the physicochemical environment. The steeping of coconut husks for retting leads to the establishment of such a unique ecosystem for proliferation of specific microorganisms degrading polyphenols (Dwyver et al. 1986). The biological retting of coconut husks differs from that of other fibrous materials in that it is not confined to pectin decomposition alone but extends also to the disintegration of the phenolic cement binding the fibres together (Jayasankar and Menon 1966b).

The present studies have hence been carried out with a view to explore the possibility of developing a consortium that can survive and proliferate on the leachates from coconut husk which are rich in phenolic compounds in a confined environment. An advantage of such a consortium would be that, it can be developed at any site where coconut husk retting needs to be carried out. It would lead to increasing the supply of raw material from India and establish coir industry, without high investments in states where natural facilities for retting do not exist. This would generate employment opportunities and increase the economy of the region. An attempt is also made in this work to reduce the period of retting of husks for coir extraction, increase the utilisation of the husk potential in coconut-growing regions and address the environmental problems arising during retting.

13.4 Microbiological Studies on Retting of Coconut Husk

Retting of coconut husks involves biodegradation mainly of polyphenols and pectins which bind the fibre in the husk (Bhat and Nambudiri 1971). The efficiency of this process, therefore, depends on the rate and extent of degradation of these binding components. During the retting process, these polyphenols from the coconut husks leach out into the steep liquors, in significantly high concentrations, resulting in the delay of the retting process due to their toxicity. Inoculation of

selected strains of phenol and pectin degrading bacterial cultures have resulted in improving "retting" in a poor retting areas where dull-coloured fibre is produced after 10 months of retting and reducing the retting period to two and a half months (Ravindranath 1991).

Since retting of coconut husk for extraction of coir also leads to the release of phenolic compounds into the retting environment, it was envisaged that inoculation of microorganisms which can degrade the components in the husk leachate would accelerate the retting process. Studies were undertaken to develop a consortium of indigenous bacteria from coconut husks and estuarine water capable of growing on husk leachate, isolate and characterize bacteria growing on phenolic compounds from consortium and to study the effect of seeding of consortium for the coir extaction process in the laboratory system (Ravindranath and Bhosle 1999a, b).

13.4.1 Development of the Consortium, Isolation and Identification of the Bacterial Cultures

One husk was steeped in 1.5 L of estuarine water of salinity 6 ppt in a 5 L beaker. To this, 1.5 L of sterile distilled water was added and the salinity adjusted to 6 ppt with sodium chloride. The mixture was allowed to stand for 30 days. During this period, the phenolic compounds leaching out from the husk would act as a carbon source for the indigenous organisms present in the husk and estuarine water. These organisms would get enriched and proliferate utilising the carbon sources leached out and multiply to give the growth in substantial numbers.

1.5 L of the first enriched culture with the husk was transferred to another beaker and was supplemented with 1.5 L of distilled water with salinity adjusted to 6 ppt and kept for 30 days to yield the second enriched culture. This second enriched culture was also subjected to the above treatment to give a third enriched culture of the consortium growing on husk leachate. The viable count in all the enriched cultures were studied on nutrient agar (Hi Media) and 0.05 % resorcinol mineral medium (RMM). The bacterial isolates were purified on nutrient agar and RMM and the cultural and biochemical characteristics of the bacterial isolates were studied using standard methods.

Interestingly, an increase in the total count as c.f.u./ml was observed on both nutrient and resorcinol media during the transfers. On nutrient agar, the counts changed from 23×10^2 to $85 \times 10^2$and 120×10^3 whereas on resorcinol agar they changed from 43×10^2 to 73×10^2 and 141×10^2. Plating of the consortium on nutrient agar showed different types of colony morphology and out of the nine isolates, four were Gram-positive and five were Gram-negative. On the basis of their biochemical characteristics, the organisms were tentatively identified as belonging to the genera of *Actinomycetes*, *Azotobacter, Bacillus, Micrococcus,* and *Pseudomonas*. Interestingly, on plating the consortium on 0.05 % RMM, only one type of pinnate colonies were observed. When streaked on nutrient agar, the colonies were observed to be bigger in size with a translucent blue sheen formed in 24 h which

disappeared on further incubation after 24 h. This culture, which was isolated from both the subcultures and the final consortium was Gram-negative coccobacilli, oxidase positive, catalase positive and motile. On the basis of the biochemical tests, this isolate was identified as *Pseudomonas* (Ravindranath and Bhosle 1999a, b).

13.4.2 Retting of Husks in Tanks Using Bacterial Consortium

13.4.2.1 Preparation of Inoculum

One surface-sterilised husk was taken in each of the four round bottom flasks (5 L capacity). To this, 2 L of sterile mineral medium was added and allowed to stand for 48 h. During this period, the leachate containing phenolic and other compounds would comprise the nutrient medium for the proliferation of the consortium. The medium was decanted aseptically into sterile flasks and was inoculated with 5% (v/v) of the consortium prepared in nutrient broth and incubated at room temperature for 24 h. This was used as inoculum for the laboratory scale retting experiment.

13.4.2.2 Retting of Husks in Tanks

Mature coconut husks from 11-month-old nuts, which are normally utilised for coir extraction, were used for the laboratory scale study. Three tanks A, B and C were set up with ten husks immersed in tap water. After 24 h of soaking, tanks A and B were inoculated with the consortium in concentrations of 5 and 10%, respectively. Tank C was maintained as the untreated control. In all the three sets, the final husk: liquor ratio was maintained at 1:5. A periodic flushing of the water in all the three tanks was carried out by removal of the steep liquor and refilling with tap water at fortnight intervals. This was done to simulate the flushing action in the environment which gives a brightening effect on the fibre and also exerts a beneficial influence in retting. In order to supplement the loss of organisms due to flushing, tanks A and B were reinoculated with the consortium in the concentration of 5 and 10%, respectively after 1 month of the first inoculation.

Water samples drawn out from the three retting tanks at intervals of 30 days were plated on nutrient medium and mineral salt medium with 0.05% resorcinol. The water sample collected after 60 days of retting was also plated on mineral medium with 0.05% pectin. The initial count in the tanks inoculated with the consortium was observed to increase from 83×10^5 and 300×10^4 to 5×10^7 and 21×10^5 in tanks A and B, respectively, as cfu/ml, whereas the count in the control tank was observed to decrease from 196×10^5 to 120×10^4 cfu/mL in a period of 30 days. There was growth on 0.05% RMM in samples from the two inoculated tanks in 30 days. A sample from the control tank C during the same period showed no growth and colonies appeared only after 90 days of incubation. Plating of the 60-day water samples on 0.05% pectin mineral medium showed the emergence of 43 cfu/mL and

55 cfu/mL from tanks A and B, respectively. However, no pectin degraders could be isolated from the control tank. These pectin degraders comprising of four different types of colonies were purified isolated and identified as *Micrococcus, Alcaligenes, Arthrobacter* and *Escherichia* on the basis of biochemical characteristics.

13.4.2.3 Analysis of Ret Water in Lab-Scale Retting

The phenolic compounds leached out from the coconut husks steeped for retting into the ret water in the lab-scale retting tanks were analysed using the high-performance liquid chromatograph (HPLC). The mobile phase consisted of an isocratic solvent system of acetonitrile/water (20:80), and the flow rate was set at 0.5 mL/min. In the first 2 months, the peaks were found to be similar to the retention time (RT) ranging from 2.7 to 2.8, 3.4 to 3.5 and 4.3 to 4.8 min. The RT of standards used such as catechol, resorcinol and pyrogallic acid indicated that the first peak represents pyrogallic acid and the third represents resorcinol. The second peak however could not be identified. During the third month, these peaks were not present, however there were other peaks with RT 0.68, 5.07 and 6.41. The peak at 5.07 corresponded to catechol when used as standard.

13.4.2.4 Analysis of the Retted Husks

Three husks were drawn out from each of the three tanks at periodic intervals of 1 month (30 days) to monitor the progress in retting. The parameters analysed by standard methods (Nazareth and Mavinkurve 1987; Ravindranath 1991; Ravindranath and Bhosle 1999a, b) were as follows:

A. Pectin and polyphenol content in the husk samples
B. The change in the texture of the husk by physical touch and feel method
C. The lignin content, lightfastness rating and the degree of softness by Xenotest of the fibre from the husks

Interestingly, significant changes were observed in the polyphenol content of the husk which decreased in the inoculated as well as the control tanks. The decrease in the inoculated tanks ranged from 90% to almost less than 10%, whereas in the control tanks, the polyphenol content remained at 30% after 3 months. The pectin content was lowered from 7% to less than 1% in all the three tanks in 30 days and to negligible thereafter. The husks drawn out from the inoculated tanks were softer and the exocarp could be peeled off easily, indicating completion of retting after 90 days. A significant difference was observed with the husks drawn out from the control (untreated tank) which exhibited a hard nature and the exocarp would not peel off easily indicating incomplete retting.

The fibre extracted from tanks A and B exhibited less pith content as compared to the fibre from tank C which was comparatively inferior having a dull colour. Further, the Xenotest rated the fibre from consortium-treated tanks as grade II, whereas

the fibre from the untreated husk showed a rating of grade I. The flexural rigidity of the fibre extracted from tanks A, B and C tested for the degree of softness were found to be 1.19, 1.13 and 2.00 g/cm^2, respectively. The lignin content in the fibre from the consortia treated husk was 38%.

The principal change brought about in the plant tissue during retting is the breakdown of pectic substances which form the chief constituent of the middle lamellae between the fibre cells and the cementing material (Bhat and Nambudiri 1971). The consortium degrading the husk leachates is therefore postulated to contain bacteria belonging to different physiological groups, particularly, metabolizers of phenolic compounds and pectin degraders. The growth of colonies on resorcinol and pectin could substantiate the presence of such bacteria which are involved in coconut husk retting. Preliminary evidence of bacterial growth on resorcinol suggests the presence of bacteria that are able to use the husk leachates as a carbon source.

The study could thus establish the fact that retting of coconut husks could be carried out in tanks by inoculating the consortium to yield fibre in 3 months. This fibre is comparable in quality with that obtained by natural retting in 9–11 months (Ravindranath and Sarma 1998). The potentials of the consortium in biosoftening of the coir could therefore be established. This method eliminates the environmental pollution caused by retting and also provides an alternate method for tapping the husk potential available in all coconut-growing regions for setting up of coir industries (Ravindranath and Bhosle 1999a, b; Ravindranath 2001).

Today, the fibre and pith from the retted husk can be mechanically extracted in a matter of just 10 s using a mobile coir fibre extraction machine known as "Swarna" (Fig. 13.1). The fibre treatment has now been upgraded to a new retting process using a biochem spray (Fig. 13.2) which results in a soft coir fibre which can be used to manufacture good quality traditional products (Fig. 13.3).

The Coir Board has been successful in developing a fully automatic versatile coir spinning machine (Fig. 13.4) which can spin a wide variety of yarn such as sisal-blended yarn (Fig. 13.5) with a productivity of at least 50 kg of single yarn per 8 h and is convenient to be operated by the women workers (Ravindranath and

Fig. 13.1 Mobile coir fibre extraction machine

Fig. 13.2 Biochem spray on coir fibre

Fig. 13.3 Coir floor covering products

Fig. 13.4 Automatic coir spinning machine

Fig. 13.5 Coir sisal-blended yarn

Chitralekha 2010). Coir fibre on blending with jute, sisal, cotton and silk in 80:20 ratio produces fibre yarn of runnage up to 1300 m/kg. Such yarn is used to weave fabrics to make diversified products such as umbrellas, winter jackets, conference bags, acupressure footwear, curtains, lampshades and novel gift articles.

13.5 Coir Pith

Coir pith (Fig. 13.6) which is present to the extent of 70% in the coconut husk is the byproduct of the coir industry and accumulates in the form of hillocks in various places in the country wherever the coir fibre extraction activity takes place. It is one of nature's major lignocellulosic byproducts and its direct application on soil results in reduction in the soil microbial population, soil bio-polysacchases, soil dehydrogenases and soil respiration. Further, coir pith contains 8–12% soluble tannin related phenolics which apparently inhibit plant and microbial growth and also immobilize nutrient nitrogen in the soil during polymerization. Since 1995, Tamil Nadu in South India has started exporting this product and during the last year its export has exceeded 140,000 MT for a value of approximate Rs. 200 crores. (Coir Board Export Data 2014).

Coir Board has carried out research on coir pith for the synthesis of nanocellulose (Subha and Ravindranath 2012) and to convert into compost using Pithplus, an edible mushroom spawn to establish its utility as a potential organic manure (Babu et al. 2008).

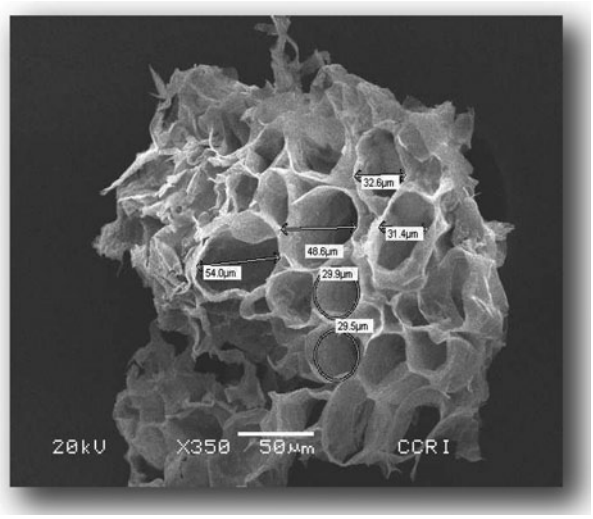

Fig. 13.6 SEM image of a single coir pith particle. (Shubha and Ravindranath 2012)

Pithplus, an edible mushroom spawn speeds up the composting process of coir pith and leads to 42% reduction in volume. This mushroom belongs to the fungal group Basidiomycetes, capable of detoxifying phenolics and producing lignolytic enzymes. Cellulosic compounds present in coir pith support the initial growth of this fungus and act as cosubstances for lignin degradation. The fungal mycelia spread to the surface of the coir pith particles and degrade the lignocellulosic content. In addition, the growth of nitrogen-fixing bacteria is also known to enhance the biodegradation process (Reghuvaran and Ravindranath 2011, 2013a, b).

The standard method of composting of coir pith is to select an area of 5 × 3 m in a sheltered place followed by spreading uniformly 100 kg of coir pith on the marked area. A total of 400 g of fungus, Pithplus on the coir pith is further spread and this layer is covered with another 100 kg of coir pith over which 1 kg urea is applied. This process of sandwiching the Pithplus and urea alternatively with 100 kg coir pith is repeated so that the heap reaches a height of 1 m. To compost one ton of coir pith, 2 kg Pithplus and 5 kg urea are required which can also be replaced by Azolla and soya hulls (Radhakrishnan et al. 2011, 2012). Water is sprinkled on the heap for sufficient moisture and allowed to decompose for 25 days, following which the coir pith is transformed into coir pith organic manure with the nutrient status as detailed in Table 13.4. The composted coir pith obtained is 100% organic manure, with increased nutrient status, reduced C:N ratio, pH and electrical conductivity, most suitable for rooting and plant growth (Ravindranath 2008; Reghuvaran and Ravindranath 2011, 2013a, 2014; Reghuvaran et al. 2008).

Coir in the form of pith, has gained ground as an ideal potting and growth medium for horticulture applications. Coir pith has readily available nutrients like nitrogen, phosphorous and potassium suitable for plant growth. The organic matter content of soil/substrate is an indicator to its fertility and nutrient availability and coir pith has a higher organic matter content as compared to peat moss (Ghosh et al.

Table 13.4 Nutrient status of composted coir pith. (Source: Reghuvaran and Ravindranath 2014)

Lignin	4.8%
Cellulose	10.20
Organic carbon	24.4%
Nitrogen	1.26%
Phosphorous	0.06%
Potassium	1.20%
C:N ratio	19:1
Volume	0.58 cu m
Calcium	0.50%
Magnesium	0.48%
Iron (ppm)	0.09
Manganese (ppm)	25.00
Zinc (ppm)	15.80
Copper (ppm)	6.20
Cation Exchange Capacity	40–90 meq/100 g of sample
Electrical conductivity	>0.25 millimhos/cm

2007). This leads to improvement in plant growth and production when the coir pith is added to the soil. Today, coir pith is an internationally acclaimed medium for horticulture and floriculture and widely exhibited at the world's largest Horti Fair the annual event held at Amsterdam, The Netherlands.

13.6 Tender Coconut Husk

A large proportion of the coconuts produced in India are prematurely plucked for utilisation as a nutritious refreshing drink sold along national highways and kiosks in all coconut-growing states of India. The residue husk forms a bulky agrowaste which is a source of environmental pollution. It is estimated that out of total production of coconuts in the country, 10% are plucked as tender coconuts (CDB Project Report 2010). In West Bengal, 60% of the coconuts are plucked at a very early stage of growth. Studies were conducted by Coir Board (Fig. 13.7), and the overall assessment revealed that suitable machinery & equipment can be used to chop the residue tender husk into chips. The biodegradation of the chips using Pithplus, urea, and a consortium of microorganisms could bestow it with properties for use as a plant nutrient source. A significant increase in the nitrogen, phosphorus and potassium (NPK) content was observed after biodegradation and the potential of microbial decomposition of tender coconut husk into valuable compost could be confirmed. Adoption of this finding in outlets selling tender coconuts would solve the problem of accumulation of tender coconut husk creating environment pollution and composting the husk would give it value addition for use as green manure.

Fig. 13.7 Composting of tender coconut husk

Considerable research effort was also made trying to utilise the tender coconut husk fibre with other agrowaste biomass from agricultural and forestry residues (Sarma and Ravindranath 2005a; 2006a, b). The fibre from the husk of tender nuts is inferior in quality and unsuitable for spinning into coir yarn. In this context, an environmental friendly organosolv process was developed based on the use of organic solvents for delignification, where it is possible to break up the lignocellulosic biomass to obtain cellulose fibre for paper making, high-quality hemicelluloses and other lignin degradation products (Fig. 13.8). This process also avoids emissions and effluents making it an ecofriendly one. Organosolv pulping of tender coconut fibre (cooking liquor to material ratio 10:1) at 121 °C for 60 min could yield a good pulp for the preparation of handmade paper after bleaching. High-quality lignin

Fig. 13.8 Tender coconut fibre after organosolv pulping and bleaching. (Sarma and Ravindranath 2006a, b)

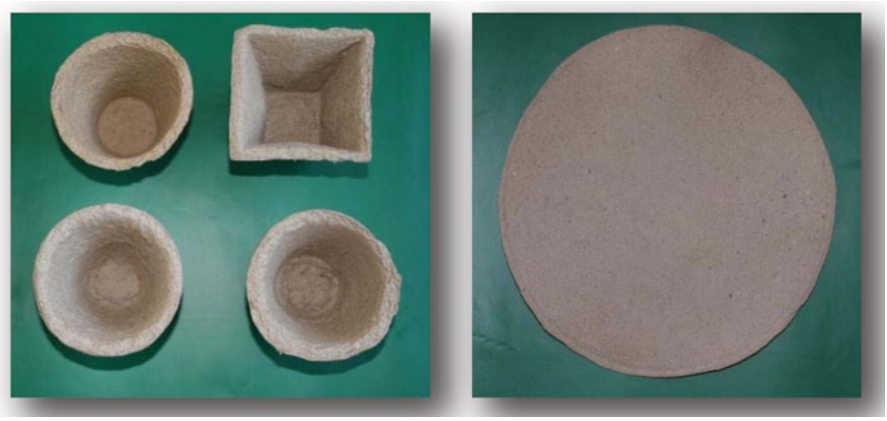

Fig. 13.9 Garden articles and handmade paper from tender husk fibre. (Sarma and Ravindranath 2006a, b)

from the spent black liquor was also extracted thereby opening up new possibilities for alternative uses for lignin. The unbleached organosolv pulp could be moulded into various products like disposable egg cartons, paper plates, garden articles like paper pots (Fig. 13.9). Blending bleached organosolv pulp with paper waste long-fibred pulp in suitable proportions improves strength and surface smoothness of the handmade paper. The results obtained indicate the promising potential of the organosolv process for the pulping of tender coconut fibre to produce high-quality pulp and value-added products for industrial end use.

13.7 Conclusions and Future Prospects

The husk of the coconut is an abundantly available renewable bioresource from which fibre and pith is derived. The coir fibre and pith are lignocellulosic substrates which have great potential for the development of cost effective ecofriendly products to substitute nonbiodegradable ones. Tender coconut husks which accumulate causing environmental pollution can be tapped as raw material for the development of products for human benefit. These lignocelluloses can also be harnessed as substrates for biofuel production in all coconut-growing regions of the world.

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