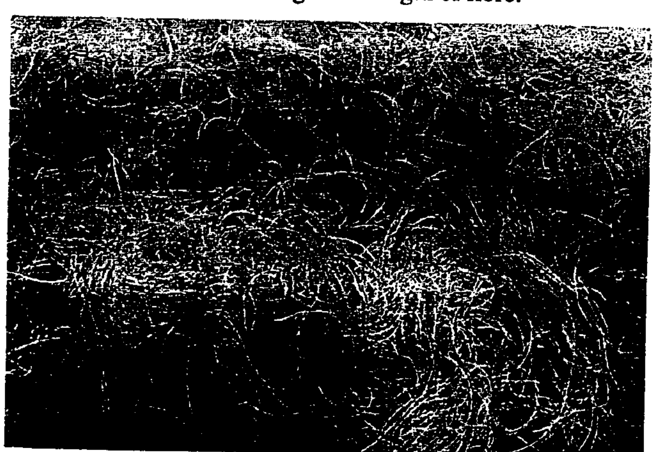
SOFTENING OF COIR

U. S. SARMA Director, Central Coir Research Institute, Alleppey

Introduction

Coir fibre is known for its stubbornness. It can withstand huge amount of weight and rubbing and recovers, as soon as the weight is removed from it. However this property bestows a disadvantage on this fibre not to be amenable easily to make it feel softer. As a matter of fact it falls under the category of wood fibre having lignin content to the extent of 45%. Although the floor coverings made out of coir are very much durable, these have been found to be not useful for the household purposes as one can not walk over it barefooted, whereas the matting produced out of jute, sisal provide comparatively softer feel. CCRI has initiated systematic studies on the softening of coir, which may lead to the development of a few products of better feel without affecting the strength of fibre.



Properties of coir fibre

The physical properties of coir fibres are given below: -

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.sq)	200.00
6.	Modulus of Torsional Rigidity ($X10^{10}$ dynes/sq.cm)	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

The chemical composition (in percentage) of coir fibres is as follows: -

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

A comparative statement on the properties of a few natural fibres, is given below: -

Table: Comparative Properties of a few Natural Fibres

Property	Jute	Banana	Sisal	Pineapple	Coir
Width or Diameter (m m)	-	80-250	50-200	20-80	100-450
Density (gms./cc)	1.3	1.35	1.45	1.44	1.40
Micro-Fibrillar Angle (degree)	8.1	11	10-22	14-18	30-49
Cellulose/Lignin Content (%)	61 /12	65 /5	67 /12	81 /12	43 /45
Elastic Modulus (GN/m^2)	-	8-20	9-16	34-82	4-6
Tenacity (MN/m^2)	440-533	529-754	568-640	413-1627	131-175
Elongation (%)	1-1.2	1.0-3.5	3-7	0.8-1.6	15-40
Aspect Ratio (L/D)(mm)	152-365	-	-	-	35

Coir fibres are devoid of any meshy structure unlike the soft fibres like jute. The surface of the coir fibres is rather smooth with little adhering segments. The wall of each cell in fibres is made up of several layers of cellulose microfibrils laid in spirals about the common cell axis. One particular shell, commonly known as the S_2 layer of the secondary wall, makes up most of the cell substance. The average spiral angle of the microfibrils of this layer dominates over the combined effect of the others. As a result, this angle is known as the spiral angle of the particular fibre cell. The extensibility and tensile modulus of the ultimate cells of coir fibres (and hence largely of the fibres themselves) are related to the spiral angle of the microfibrillar structure. It can be seen that this angle is very large for coir due to which it is not having the pliability but it can be extended up to the extent of 40% which is advantageous to blend it with the extensible protein fibres like wool and silk if it is suitably softened. The extension at break is far greater for coir in comparison to the other fibres. Therefore, coir is able to withstand sudden loading better than other hard fibres. Coir has low density due to its porosity; about a third of the fibres is filled by air to give it the property of springiness (resilience). Further lightness and porosity make it more buoyant when immersed in water, resisting its penetration for a long time. Evidently, coir being heavily lignified compared to the bast fibres like jute is a better moisture repellent. When soaked in water for some time, the filaments swell in lateral directions. There is little or no longitudinal swelling. Thus properties of coir are less affected under moist or wet conditions than the other bast and hard fibres giving it a rough feel. It can be seen from the table that coir has a very low Aspect Ratio, which also makes difficult to soften it to a great extent.

History of softening of natural fibres

During the year 1844 John Mercer while filtering concentrated caustic soda solution in a cotton cloth noticed lateral swelling and longitudinal contraction of cotton cloth. When this experiment was carried out by keeping cotton fabric under tension it was found that the cotton fabric acquired lustre and better properties in terms of more substantivity towards dyestuffs. The process became famous as Mercerisation and mercerised cotton fabrics are still in great demand. Later on it has been found that cellulose swells in concentrated solutions of some neutral salts like Lithium iodide, Lithium, Potassium and Calcium thiocyanates, and Ammoniacal solution of copper oxide (Cuprammonium solution).

While jute, banana and pineapple have considerable softness, there is a need to soften the coir fibres as per the methods described for the softening of cotton by suitable variations in the treatment. Softening of natural fibres like jute (which is a lignocellulosic fibre) was contemplated during the 1930s and it was found that the jute fibre swelled on treatment with 20% of caustic soda solution to yield a crimped fibre which was used for blending with wool fibres to prepare blankets etc.

Later on in 70s studies were also undertaken to soften the jute yarn (6 lb, 2 ply) to produce woollenised yarn which was very much resembling to the woollen yarn, however, the crimp imparted by caustic soda solution was temporary and could not withstand even a few stretchings of the fibre. Besides the loss in strength was of the order of 60%. The effluent treatment was another problem due to very high alkalinity for which standing bath method was utilised although the colour of the fibres deteriorated beginning from the second treatment itself leading to higher utilisation of bleaching chemicals making the process further non economical. The fibre shedding was also increased considerably due to alkali treatment. Therefore attempts were made to stabilise the crimp and to stop fibre shedding by the application of different resins. It was found that epoxy resins could improve the properties of woollenised yarn substantially in terms of stability of crimp and stopping the fibre shedding. However the process did not find much use because of the cost factor involved in the treatment of resin.

During the late 80s IJIRA, Kolkata, had developed a process of softening of jute fibres based on the application of sulphonated castor oil and urea, which was found to yield a better quality of yarn with increased production due to lesser breakage of yarn during spinning process. However this yarn was nowhere near the softness to the alkali treated yarn in terms of feel and crimp.

Coir softening was earlier contemplated by the use of concentrated caustic soda solution, which was found to be quite effective in producing the crimp on the fibre although the colour of the fibre was changed into deep brown, which could be removed on bleaching. There was also a loss in tensile strength of the fibre to the extent of 40%. The effluent treatment was another big problem to tackle as the residual alkali needed to be neutralised with huge quantities of inorganic acids making the process hazardous and uneconomical.

Experiments on treatment of coir for softening

Although caustic soda treatment could produce the best crimp and softening effect on coir, it was rejected by the coir industry due to its hazardous nature. CCRI undertook the research work from a different angle of approach by using the shampoo-based materials known as Cationic softeners. It was found that the cationic softeners based on quaternary ammonium salts produced the desired results but the treatment was found to be of temporary nature as it could not withstand dry and wet rubbing.

Therefore attempts were made to explore the possibilities of finding out new types of cationic softeners, which could provide permanent soft and silky feel on the surface of the coir fibre without affecting its strength.

On carrying out thorough literature survey it was found that the amino silicone softeners were the most appropriate to be applied on coir for providing the desired effect of soft and supple feel. Studies were therefore carried out on the application of various combinations of amino silicone softeners and it was found that the combination of two amino silicone softeners produced the best effect.

An experiment on softening was also carried out at CCRI by the use of a vegetable oil emulsion and urea combination on the coir fibres to produce a soft feel on coir yarn, which was later on demonstrated at Poothota Co-operative society on large scale.

Attempts have also been made to soften the coir fibres by the use of biological agents like COIRRET (a bacterial cocktail) with a limited success. It has been found that the treatment confers limited softness on the green husk fibres so as to make them comparable to the retted fibres in appearance and feel.

Experiments and Methods

Up till now Kawabata system is the best system for objective evaluation of feel and handle, appearance and tailorability of textiles in terms of measuring low stress mechanical and surface properties by the use of 6 instruments costing about Rs. 2 crores. The instruments are:

- FB-1: Tensile and Shear Tester
- FB-2: Bending Property Tester
- FB-3: Compressibility Tester
- FB-4: Surface roughness and Friction Tester
- FB-5: Tensile and Shear Fatigue tester
- FB-6: Thermo Labo-II Tester

(This task can be partly achieved by electronic tensile testers equipped with low stress load cells.)

16 basic parameters are measured in KES-FB system:

Tensile	Elongation, Linearity, Tensile Energy & Resilience
Shear	Shear Stiffness & Hysteresis
Bending	Bending Rigidity & Hysteresis
Compression	Linearity, Compressional Energy, Resilience &Thickness at 0.5 gf/sq. cm.
Surface	Friction & Roughness

In addition, weight per sq. m. is also determined.

Influence of measured parameters on Primary Hand Values of Fabric

Smoothness	Surface, Compression and Shear
Stiffness	Bending Rigidity, Weight, Thickness, Shear & Surface
Fullness & Softness	Compression, Surface, Thickness and Shear
Crispness	Surface, Bending and Tensile
Antidrape/ Spread	Shear, Surface and Bending

The Primary Hand Values (PHV) can be easily computed from the above 16 parameters with a computer programme, which are depicted on 1 to 10 scale. From PHV, Total Hand Value (THV) and Total Appearance Value (TAV) are computed depending on the end use of the fabric. These THV and TAV are on 1 to 5 scale, 5 being the best while 1 the worst hand (or appearance) value.

For objective evaluation of the softness of coir fibres, a Flexural Rigidity Metre instrument has been developed at CCRI under the guidance of Dr. A. K. Mukherjee, National Consultant Chemist, FAO. The instrument measures the deformation of coir fibre loops (prepared by wrapping around a thick glass tube and keeping it for 24 hours at 65% humidity and 25^{0}C) under the weight of a rider so as to quantify the softness. The softer the fibre, the greater is the deformation of the loop.

$$\text{Flexural rigidity} = 0.0047\ mg\ (2\Pi r)^2 \cos\theta / \tan\theta$$

Where mg = weight of the rider

r = radius of the ring

d = deformation of lower end of ring

θ = 493 d / 2Π r

Pads stuffed with softened coir fibres were subjected to Flexing by about 2 lakh strokes to assess the suppleness of softened fibres. The indentation hardness was then measured to assess the deformation of the pads

Spinning trials on the softened coir fibres were conducted on the motorised ratts to assess the imparting of softness on coir yarn.

Toxicological studies on the softened fibres were conducted through Sriram Institute for Industrial Research.

Results and discussion

Studies on the toxicity of softened coir fibres revealed that the treated fibres were safe to handle, as there was no adverse effect on the skin on contact with the alkali treated as well amino silicone treated fibres.

Alkali treated fibres were found to be dull in colour and crimpy due to shortening of length and lateral swelling, while the amino silicone treated fibres were lustrous, soft and supple in feel. To obtain the best results of softening a mixture of two amino silicone softeners was applied on coir fibres and the results were found to be excellent. However the treated fibres required a heat treatment at about 110^{0}C for 3-5 minutes. The fibres when subjected to indentation hardness test it was found that the fibres were not crammed and retained their suppleness. Stuffing these fibres in the conventional way through a local Pillow and Rubberised coir manufacturer a few pillows were made and it was found that the pillows were intact in softness and suppleness even after their use for nearly one year. The cost of a pillow was about 20% cheaper than the pillows made from rubberised coir.

These softened fibres were also subjected to spinning trials on the motorised ratts to produce two ply coir yarn but the yarn produced did not have the soft feel of coir fibres due to its inherent structure of crest and troughs. Further the yarn was found to be more hairy due to the suppleness reducing cohesiveness among the fibres. Therefore the effect of softening was not perceptible. The treated fibre were also utilised for making fibre mats but the effect of softening was not felt due to compactness of the fibre mats. Spraying of the amino silicones on the mats and mattings also did not produce the desired soft feel.

Spinning of jute yarn is carried out by the application of oil-in-water emulsion along with other ingredients like cationic softeners, urea etc. on the fibres followed by piling it for a period of 24-36 hours depending on the hardness of the fibres. After piling the fibres become soft to be processed into cardings and drawings finally to yield the jute yarn. The similar technology was applied on coir fibres to soften it by the use of a vegetable oil-in-water emulsion along with urea (veg. oil:water:ultravon JU:urea::40:204:12:48) for a period of 44 hours. A control was maintained by applying 1000 ml of water on 12 kg of coir fibres. The experiments were carried out on lab scale to standardise the application and bulk trials were also carried out at Poothota Co-operative society. The following observations were made out of these studies: -

1. There was an increase in the output of yarn over the control.
2. There were less number of spinning defects and breakages during spinning.
3. There was an improvement of 30% in texture and pliability over the control.
4. The spinners felt it easy to draw and soft to touch while releasing the fibres and regulating the feeding.
5. The yarn strength was comparable/better than the control.
6. The process is eco-friendly without any effluent.

The above process may be of great use in the preparation of a finer single ply coir yarn on a fully automatic spinning machine based on the concept of jute spinning which may be utilised for making diversified products like upholsteries, decorative bags etc.

Conclusion

From the above studies it is apparent that the softening of coir fibre and 2 ply coir yarn do not coincide because of their inherent structural difference. Possibilities are needed to be explored to find out more end uses for the amino silicon softened coir fibres like blending with fibres like wool, silk etc. The cost factor should also be kept in mind in view of the high cost of these softeners, which adds up to double the cost of coir fibres.

To produce a softer yarn the process already in vogue in the jute industry may be of great use by the application of suitable chemicals (of course, environment friendly) combined with piling and processing on the jute machinery with suitable modifications.

A collaborative project is envisaged to be taken up with National Institute of Research on Jute and Allied Fibres Technology (NIRJAFT), Kolkata, to develop a spinning machine for coir, based on the principles of jute processing. Another collaborative study is proposed to be taken up with the Dept. of Textile Technology, PSG Polytechnic, Coimbatore, to develop a contrivance for the production of a uniform sliver of coir.

Biological softening is another unexplored area where possibility is being explored to collaborate with the Regional Research Laboratory, Thiruvananthapuram.

Acknowledgement

Grateful acknowledgements are due to Shri. Christy Fernandez, IAS, Chairman, Coir Board for his keen interest and continuous encouragement to work on the aspect of softening of coir. Thanks are due to Mr. P. K. Ravi, Senior Scientific Officer (Polymer Tech.) and Ms. I.R. Anto, Lab. Assistant, for carrying out the studies on coir softening.

References

1. Studies on imparting softness to coir fibre/yarn, I. R. Anto, P. K. Ravi, and U. S. Sarma, Proceedings of the International Workshop on Wet Processing of Coir, 7-8 Dec., 1997, Alleppey, Kerala, India.
2. F.T. Peirce, J. Text. Institute, 21,T 377(1930).
3. P. N. Carlene, J. Text. Institute, 41, T 159(1950).
4. End of Assignment Report, (Nov., 01, 1997- Dec., 31, 1997), FAO/CFC Project, Dr. A. K. Mukherjee, National Consultant Chemist.
5. Objective evaluation of feel and handle, appearance and tailorability of fabrics, Part II: The KES-FB system of Kawabata, A. D. Sule and M. K. Bardhan, Colourage, Dec., 1999, 23-35.

Physical properties of some hard fibres used in cordage industry, A. C. Chakravarty, National Institute of Research on Jute and Allied Fibres Technology, I.C.A.R., Kolkata, Jute Bulletin, March, 1968.