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RETTING OF COIR - A REVIEW

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ABSTRACT

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The various methods followed locally for biological retting of coconut husk, the microbiology and biochemistry of biological retting and factors effecting retting, chemical retting and biochemical retting are reviewed. Different types of micro-organisms involved in coir retting and their role in the degradation of pectin and polyphenol are discussed. The need to reduce the retting period is brought out.

INTRODUCTION

Coir is an important product of coconut, giving income to the coconut growers and gainful employment to many. In industrial practice the extraction of coir fibre is effected manually or by mechanical means. Depending on the age of husks used in the manufacture of fibre it can be divided into two categories :–

(a) White Fibre – Produced from fresh green husks of 10–11 month old nuts. The husks are allowed to undergo retting and the fibre is extracted manually. This fibre possesses good elasticity and colour.

(b) Brown Fibre – Produced from the dried brown husks of about 12 month old nuts. The husks are soaked for 2–3 weeks and the coir is extracted mechanically. These fibres are more brittle and brownish in colour.

Because of its peculiar properties coir can be used directly or after softening and bleaching treatments in the manufacture of quality products. Coir is used in seats, cushions, mattresses for the manufacture of brushes, brooms, ropes, yarns, mats, mattings, carpets, rugs etc. Presently mattress fibre and short stapled variety of brown fibre, 'O mat' fibre, are also utilised in making rubberised coir for upholstery. A new use of mattress fibre is in air conditioning and sound proofing of buildings. Mattress fibre is also used in laminated plastics (F.A.O Bulletin, 1969). Coir also finds its use as filter points in tube wells. (Prabhu, 1959 a).

Fresh husks used within a few days of the husking of nuts are best suited for retting. Husks which have been exposed to the sun become brittle and do not yield good fibre. Besides, it is easier to beat retted fresh husks for the extraction of fibre.

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BIOLOGICAL RETTING

This is comparatively cheap and an easily manageable biological method based on fermentation. Retting in water causes separation of the leathery exocarp from the fibrous mesocarp. The mesocarp is nothing but an assemblage of individual fibrevascular bundle or coir, with the cork like paranchymatous cells containing the cementing materials dispersed throughout the mass. The strands are composed of a highly lignified form of cellulose, hence their harshness and brittleness. At this stage of maturation maximum lignin and minimum cellulose is found in the husk. (Menon and Pandalai, 1960).

Methods of Biological Retting

In the process of biological retting the husks are submerged in slow running water or stagnant water. Each retting yards usually contains about 1000 husks either tied into a bundle or placed inside coir nets. These are allowed to float in the retting area until they get fully soaked. The soaked husks are either weighed down by piling on their tops mud and slime collected from the bottom of the retting yard, or tied down to bamboos buried in the mud. Alternatively the husks may be soaked in basin shaped pits dug out for the purposes on the coast but within the reach of tidal waves.

In Sri Lanka white fibre production is found mainly in the southern coastal belt. A survey of retting sites in this area reveals that the above methods are practised.

Retting inside coir nets is practised in Koggala Lagoon. The method adopted in Duwamodera - Kosgoda, Rathgama and Dodanduwa Lagoons is retting in enclosures prepared with Kitul or Bamboo stakes. In Ahangama, Madihe (Matara) and Dondra head, retting is done in pits near the sea within the reach of the tidal wave. Retting in channels is practised in a few places like Randombe, Kodolwatte (Balapitiya) and Seenigama.

In any case all these methods essentially consist of brackish water retting. The period required for the completion of the process depends upon several factors though in general it varies from 5–6 months to as many as 9–10 months.

Process of Retting

Two stages can be recognized in the process of retting, viz. physical and biological stages.

In the first or physical stage, the husk absorbs water and the plant tissues swell. Simultaneously a number of substances like Carbohydrates, Glucosides, Tannins, Nitrogen compounds etc., are leached out of the tissue and brought into solution.

During the second stage – the biological stage, a variety of micro-organisms develop at the expense of the extracted substances, thereby creating suitable conditions in the environment, and paving the way for the micro-organisms decomposing the binding material of the tissues, collectively referred to as

pectic substances, to act. These micro-organisms secrete various enzymes which dissolves the binding materials enabling easy separation of fibre. In the early part of the biological stage the liquid becomes cloudy through the development of micro-organisms. These micro-organisms act upon the carbohydrates and nitrogen compounds extracted during the physical stage, producing organic acids and gas. This is followed by a rise in temperature of the husks. The evolution of the gas results in the frothing of the liquor. When the frothing subsides a whitish film of fungi covers the surface of the retting liquor. This is particularly noticeable where the retting is carried out in stagnant water.

During the principal biological stage, the anaerobic pectin decomposers dissolve the pectins in the middle lamella of the parenchymatous tissues and separate the fibre bundles. Markedly offensive odours resembling those of hydrogen sulphide emanate from the retting pits at this stage. The reason for their development is not fully understood, though it is assumed that they are due to secondary microbiological decomposition processes, involving a resolution of the cellulose materials. The odours are particularly noticeable in places where the debris of previous retting has accumulated as in Seenigama.

The turbidity, gas formation, smell and rise of temperature increase from the third to the fifth month but after six months the water becomes clearer, the smell and evolution of gas appearing to diminish. Most of the fibres gets loosened at this stage, but it takes about ten months for the full loosening of the fibres.

Microbiology of Coir Retting

The retting of coconut husk is essentially a micro-biological process. The biology of retting is still only very imperfectly understood. Preliminary work on these aspects of research has shown that different organisms are active at different stages of decomposition (Menon, 1959).

Kluyver and Reksohadiprodijo (1924) were the first to suggest the involvement of micro-organisms in the retting of coir, while Winogradsky and Friebes in 1895 isolated the bacterium associated with the retting of Flax. Fowler and Marsden (1924) and Fowler and Christie (1924) were the first investigators of organisms involved in coir retting. They reported the presence of bacterium closely resembling *Sphaerotilus* together with short bacteria and a mould. Heyn (1951) succeeded in isolating six types of bacteria including *Diplococcus* sp. *Vibrio* sp., *Closteridium* sp., and yeast. One of the *Clostridial* type decomposed pectin in Vitro. Jayasankar and Menon (1961 a) restricted their study to isolation and identification of fungi. They pointed out *Aspergillus*, *Fusarium*, *Trichoderma* and *Mucor* species as those associated in the retting of coconut husks.

Bhat *et al* (1972, 1973, and 1975) made a microbiological study of the retting process and reached the conclusion that by and large the retting process is an anaerobic one and aerobic species of bacteria belonging to the genera *Pseudomonas*, *Escherichia*, *Micrococcus*, *Bacillus*, *Paracolobactrum*, *Alcaligenes*, *Achromobacter*, *Aerobacter* and *Corynebacterium* and several

yeast species such as *Saccharomyces fructuum, Debaryomyces hansenii, D. nicotianae, D. kloeckeri, Cryptococcus diffluens, Rhodotorula flava, R. glutinis* and *Hansenula schneggii* are intimately involved in the process and that most organisms play a vital role in the decomposition of petic substances and polyphenols. The work done in India reveals the relative abundance of the bacterial and yeast genera in the microflora involved in retting. These are shown in table I (Bhat and Nambudiri, 1972).

Source of Retting Organisms

Regarding the source of retting organisms early observations are confusing Fowler and Marsden (1924) in the course of their research on the retting of coconut husks observed that the bacteria responsible for the decomposition of pectin is present in the fresh coconut husk itself.

Table 1. *Incidence of bacterial and yeast Genera in coir rets*

Bacteria	% *abundance*	*Yeast*	% *abundance*
1. *Escherichia*	26	1. *Saccharomyces fructuum*	24
2. *Pseudomonas*	19	2. *Debaryomyces hansenii*	16
3. *Micrococcus*	18	3. *Debaryomyces kloeckeri*	16
4. *Bacillus*	14	4. *Cryptococcus diffluens* ..	14
5. *Paracolobactrum* ..	10	5. *Rhodotorula flava* ..	14
6. *Alcaligenes*	10	6. *Rhodotorula glutinis* ..	09
7. *Achromobacter*	01	7. *Debaryomyces nicotianae*	04
8. *Aerobacter*	01	8. *Hansenula schneggii* ..	02
9. *Corynebacterium* ..	01	9. *Candida*	01

Years later Heyn (1951) isolated three different types of bacteria from the soaked husk. However, experiments carried out by Pandalai *et al* (1957) clearly showed that the retting organisms are present in the water used for retting and not in the husk, as postulated earlier.

Bio-Chemistry of Retting

Analysis of mature husk showed 75-76 gm.Kg $^{-1}$ of polyphenol and 16-17 gm.Kg^{-1} of pectin (Bhat, 1971). Analysis of husks before and after retting showed that there is a fall in pectin, polyphenol and hemicellulose contents. Thus there is clear indications now available to show that these compounds have to be degraded for the release of the fibre. Hence those organisms which can attack pectin and polyphenol only take part in the actual release of the fibres. Of the micro-organisms mentioned, only *Micrococcus varians* involved in the oxidation of phenol (Jayasankar and Bhat, 1964, 1966) as well as pectin (Jayasankar *et al.*, 1967). *Candida* and *Debaryomyces hansenii* exhibit phenolitic activity only (Bhat, 1971), while others are active degraders of pectin only.

Study on succession of microflora suggest that the polyphenols of the husk are degraded first by the micro-organisms and then only they tend to attack pectin. The results clearly established the fact that polyphenols are degraded faster than pectin in the early stages of retting (Bhat and Nambudiri, 1973).

Factors Effecting Retting

Salinity- There are contradictory reports available regarding the effect of salinity. According to Fowler and Marsden (1924) salinity of water is of little or no importance. Pandalai *et al* (1957), showed that retting takes place quickly and efficiently in brackish water. Recent work by Bhat and Nambudiri (1973) indicates that sodium chloride is not necessary for the retting of coconut husks. In fact, the presence of sodium chloride neither hastens the retting process or improves the colour of the resultant fibre. On the contrary salt in the stagnant rets yielded poor fibre. This suggests that setting up of retting yards in inlands, where no sea water or brackish water is available is feasible and renders possible further exploitation of coconut husk for this purpose. However, according to Kertesz (1955) presence of salt is essential for the activity of certain enzymes such as pectinesterase.

Periodic Flushing of the Ret Liquor- The leaching away from the fermentation material of polyphenols by flushing was beneficial from the point of view of hastening of the process as well as improving the quality of the final products. Renewal of ret liquor at 10 day intervals is optimal for efficient retting under laboratory conditions (Bhat and Nambudiri, 1972). Too frequent renewals (3-6 day) are less efficient than stagnant rets. The "ebb and flow" help retting probably by removing toxic substances formed during the process of retting. Depending upon the material-liquor ratios in the retting systems it will become necessary to arrive at the optimal flushing frequency of the ret liquor (Jayasankar, 1977).

Aeration— Aeration of the retting environment facilitated faster proliferation of the microflora in the environment. *Pseudomonas* were found to dominate under such conditions (Bhat *et al.* 1973). Such alteration in the balance of microbial population may effect the rate of retting.

Crushing the Husks prior to Steeping – Crushing the husks prior to steeping resulted in speeding up the degradation of polyphenols and pectin (Bhat and Nambudiri 1972). Retting time is thus reduced by half. This operation provides more surface on accessible areas for the microbes to colonise and attack. However, the quality of the fibre obtained was inferior to that derived from uncrushed husks. The crushing could be done by simple crushing rollers similar to sugar cane crushers. If the husks are removed from the retting pits after one month, crushed and then put back, the retting could be completed in three months. However, this crushing and handling of husks will involve an additional cost which will have to be balanced against the obvious advantage of quicker retting (Padmanabhan, 1959).

In the fibre mills in the "Coconut Triangle" where brown fibre is produced mechanically the soaking time can be reduced considerably by adopting this procedure of crushing before soaking. Unfortunately only few mills are making use of this advantage at the moment.

CHEMICAL RETTING

Although the natural production of fibre is a microbiological process, it can also be treated as chemical process. Experiments aimed at the reduction of the time involved in retting by the use of either chemicals or enzymes were carried out by Barker (1933), Baruah and Baruah (1944, 1945, 1946 & 1949), Baruah *et al.*, (1948) and Watson & Baruah (1946). However, none of these alternate methods has been found useful for application on a commercial scale.

A Reviews by Prabhu (1959 b) and Jayasankar and Menon (1961 b) gives some of the methods using chemicals. In one of the processes called the Naji Process, partially crushed husks are treated with lime, sodium sulphate or sodium carbonate containing traces of aluminium sulphate for a period of 1–2 hours and subjected to a steam pressure.

In "Elod and Thomas Process" (1931) the crushed husks are twice immersed in hot water with the addition of slaked lime or similar substances during the second immersion to avoid discolouration.

In the process due to Rowell (Prabhu 1959 b), fibre is extracted by subjecting the husks to high steam pressure (5.5 - 6.2 N/mm^2) in specially constructed chambers.

Boiling the husks in a weak solution of caustic soda and subsequent squeezing are the features of the "Vander-Jagt Process" described by Robert Krik (1931).

Yet another method is the Hayes-Gratze process (Prabhu 1959 b) in which the split husk is immersed in water, pressed and then boiled with water and passed through an oil emulsion at the boil.

In addition to these Jayasankar and Menon (1961 b) has tried Acid oxalic, Acid Citric, Ammonium Acetate, Ammonium Carbonate, Ammonium Oxalate, Ammonium Phosphate, Ammonium Tartrate, Calcium Hydroxide, Potassium Tartrate as possible retting agents in different concentrations and under different conditions.

BIO-CHEMICAL RETTING

Baruah and Baruah (1944) reported that a mixture of enzymes isolated by them which they named Hiparol reduces the time of retting to a couple of hours. The husks are immersed in water containing Hiparol Powder at pH 5. The period of retting varies from 20 hours for immature husks to 16 hours for mature husks. Laboratory experiments carried out by them indicate that there is possibility of successful application of this method in the industry. Further research in the use of this method will be of great advantage.

MECHANICAL - CHEMICAL RETTING

Besides these chemical methods Messrs. E. W. Downs and Sons (Tropical), Glomsford, Suffolk, England (Builder, 1954) has developed a method using combination of mechanical and chemical treatments. This is based on the principles of disintergration by impact. The first operation

consists in splitting the husks by impact in a specially constructed beater chamber. These splices are then passed through a connecting duct into a sifter for the opening and screening of the fibres. The fibres are obtained at the end of the sifter while the dust and other waste pass through the screen plate situated at the bottom half of the machine. This process is worked in conjunction with a subsequent chemical treatment for the removal of tannins.

EXTRACTION AND YIELD

For the extraction of white fibre, properly retted husks are removed from the rets, washed free of adhering slime, mud and/or sand and exocarp is then easily peeled off with hand. The husks are beaten on wooden logs or stones with wooden mallets to separate the fibres. The fibres are cleaned, spread out in the sun to dry and made into bundles.

For the extraction of bristle fibre the soaked husks are fed on to breaker drums fitted with spikes. The drums are driven at a high speed in opposite directions to effect the separation of the long and short fibres. The bristle fibres passing between the drums are collected and passed through another pair of drums having closer nails for cleaning. Fibres are then washed and dried. Fibre mills in Sri Lanka practise this method.

The yield and quality of coir from husk depends on many factors such as age of husk, variety of husk, season, local conditions and practices and the location of retting yards. A significant factor observed in Sri Lanka is that 1000 husks (full) yield on average about 140 kg of fibre as compared to 90 kg in India. However, a careful study by Nathanael and Tissera (1958) on the recovery of fibre gave the following from 1000 husks (moisture free basis) :—

Bristle Fibre	31.75 kg	13.9%
Mattress Fibre	59.00 kg	25.9%
"Dust"	137.00 kg	60.2%
Total	227.75 kg	100.0%

The general variation in the pith content is from 68 kg to 150 kg per one thousand husks. The fibre to pith ratio is found varying in the majority of the samples from 1:0.8 – 1.5.

COIR INDUSTRY IN SRI LANKA

Coir fibre cannot be regarded as a major product. It is only a by product of the copra and/or desiccated coconut industries. Hence the stage at which the nuts are harvested is such to give maximum production of copra. It has been proved from detailed studies that for optimum copra production, it is necessary to harvest fully mature nuts that have had full 12 months growth (Padmanabhan, 1959). Hence it is not surprising that most of the fibre produced in Sri Lanka is brown fibre. Thus white fibre production is restricted to those areas where the nuts are mainly for culinary purposes and where natural retting facilities are found.

The traditional method of retting and extracting white fibre as practised in Sri Lanka is very tedious, unpleasent and time consuming. Due to extremely long period required for retting the turnover is slow. This also affects the quantities of husk that can be worked. Shortening the retting period will result in rapid turnover of husks and also improve the quality of the fibre which need not have to remain for a long time in muddy water. Therefore, this is a problem that requires experimentation. Experimentation alone is not going to bring benefit to this industry, unless these are put into practise.

REFERENCES

Barker, S. G. J. (1933). Report on the attributes and preparation of coconut fibre, E. M. B. 71, (London), Reviewed in *J Text. Inst.* 24, 288. *Chem. Abst.* 28, 1194

Baruah, P. and Baruah, H. K., (1944) Hiparol *Sci. Cult.* 9, 395.

Baruah, P. and Baruah, H. K., (1945). Retting by hiparol and its commercial application *Sci. Cult.* 10, 201-205.

Baruah, P. and Baruah, H. K. (1946). Retting by hiparol and by bacteria. *Sci. Cult.* 11, 369-373. Abstracted *Chem. Abst.* 40, 7645.

Baruah, P. and Baruah, H. K. (1949). Processing of jute and bacterial pectinases. *Fibres* 10, 55-59, Abstracted *Chem. Abst.* 44, 4682 f.

Baruah, P., Watson, C. M. and Baruah, H. K. (1948). Hiparol and Bacterial Pectinases. Use for fibre extraction and allied purposes. *Fibres* 9, 128-130 Abstracted *Chem. Abst.* 44, 4682 g.

Bhat, J. V. (1971). The coir Fibre. *Coir* 16, (1), 37-41.

Bhat, J. V. and Nambudiri, A.M.D. (1973). Effect of some of the environmental factors on quality of Coir. *Coir* 17 (2), 23-27.

Bhat, J. V. and Nambudiri, A. M. D. (1972). The uniquity of coir retting. *Coir* 16 (4), 17-28.

Bhat, J. V. Nambudiri, A. M. D. and Rao, B. V. (1972). Pattern of bacterial and yeast populations of coir rets. *Coir* 17 (1), 13-15.

Bhat, J. V. Kuntale, K. G. and Prabhu, G. N. (1973). Succession of bacterial species in the experimental rets. *Coir* 17 (3), 21-23.

Bhat, J. V., Prabhu, G. N. and Parimala Vradraj, Kuntala, K. G. and Ambuja, R. (1975). Investigations on 'anaerobic' retting of coconut husks. *Coir* 19, 27-29.

Builder, J. M. (1954). *Fibres* 15, 81. Reported by Prabhu, G. N. (1959) *Coir* 3 (2), 11-12.

Egonelod and Ludwig Thomas, V. S. P. (1831), 740, Nov. 10 C.A. 26, 856.

F. A. O. Commodity Bulletin Series (1969). *Coir-Economic Characteristics Trends and Problems.* Rome 44 pp 64.

Fowler, G. J. and Christie, R. K. (1924). Studies relating to the symbiosis of seeds and bacteria. *J. Indian Inst. Sci.* 7, 253-72. Abstracted *Chem. Abst.* 19, 1442.

Fowler, G. J. and Marsden, P. (1924). Retting of coconut husks for the production of coir. *J. Indian Inst. Sci.* 7, 39-52. Abstracted *Chem. Abst.* 18, 3278.

Heyn, A. N. J. (1951). The microbiological retting process for the preparation of a hard fibre and influence of this process on the fibre properties. *Verhand Komink. Ned. Acad. Wetten, Chap. Afd. Naturk II, Reeks Deel.*, 48, 7-59. Abstracted *Chem. Abst.* 46, 5322.

Jayasankar, N. P. (1977). Perspectives on the biological extraction of coir. *Coir* 22, (1), 6-9.

Jayasankar, N. P., and Bhat, J. Y. (1964). The role of *Micrococcus* sp. in the coir Fermentation. *Curr. Sci.* 33 (12), 369.

Jayasankar, N. P. and Bhat, J. V. (1966). Mode of attack on phenol by a *Micrococcus* sp. isolated from coir rets. *Can. J. Microbiol.* 12, 1031-1039.

Jayasankar, N. P. and Menon, K. P. V. (1961 a). Microbiological flora of a few retting areas. *Coir* 5 (3), 33-36.

Jayasankar, N. P. and Menon, K. P. V. (1961 b). Retting of coconut husk with chemicals, Part I. *Coir* 5 (4), 25-27.

Jayasankar, N. P., Agate, A. D. and Bhat, J. V. (1967). Microbial decompositions of pectic substances, V - Evidence for the role of *Micrococcus* sp. in the retting of sisal and coconut husk. *J. Indian Inst. Sci.* **49**, 10-18.

Kertesz, Z. I. (1955). *Methods in Enzymology, Vol. I,* Edited by Colowick, S. P. and Kaplan, N. C. Academic Press Inc., New York 158-166.

Kluyver, A. J. (1924) Similarities and variations in the metabolism of microbes. *Chem. Weekblad* **21**, 266-277. Abstracted *Chem. Abst.* **18**, 2538.

Menon, K. P. V. (1959). Some aspects of research on coir. *Coir.* 3 (4), 25-28.

Menon, K. P. V. and Pandalai, K.M. (1960). *The Coconut Palm - a Monograph.* 534 pp., Indian Central Coconut Committee, Ernakulam, S. India.

Nathanael, W. R. N. and Tissera, M. P. T. (1968). A quantitative study on the recovery of coir fibre from the coconut husk. *Ceylon Cocon. Q.* **19**, 137-152.

Padmanabhan, C. V. (1959) Jute and coir. *Coir* 4, (1), 18-20.

Pandalai, K. M., Nair, U. K. and Menon, K. P. V. (1957). A Note on the quality of water in relation to the retting of coconut husks. *Coir* 1 (3), 30-32.

Prabhu, G. N. (1959 a). Coir-possibilities of non-conventional uses. *Coir* 3 (3), 11-12.

Prabhu, G. N. (1959 b). Methods of fibre extraction Part II. *Coir* 3 (2), 11-12.

Robert Krik. (1931). Text Manuf. VII, 103.

Watson, C.M. and Baruah, H. K. (1946). Application of hiparol and bacterial enzyme preparations to modern jute spinning practice. *Textile mfr.* 72, 434-7. Abstracted *Chem. Abst.* 40, 7645.

Winogradsky, S. and Friebks, C. (1895). *c. cr. hebd Seanc, Acad. Sci. Paris.* **121**,742 Reported by Bhat, J. V. and Nambudiri, A. M. D. (1972) *Coir* 16 (4), 17-28.