

COIR OR COCONUT FIBRE*

SEPARATION OF THE FIBRE FROM THE HUSK

IT has become an axiom amongst those workers engaged in scientific investigation of industrial processes and practice that "there is always a good scientific basis for established industrial practice" even though this may be unknown to those actually performing the several functions of the process itself.

Thus when one considers the question of soaking and retting of the coconut husk in the tropics, although at first sight there may seem to be somewhat haphazard methods employed, yet closer observation will probably reveal that there is reason for each and every part of the performance. Let us therefore first of all review the various methods utilised at present for soaking the husks and then later study the question from the point of view of more recent discoveries in modern science and industry.

SOAKING

Choudary, in his excellent and critical review of the various factors regarding the retting of coconut husks outlines the methods used for soaking of coir on the West Coast of India very lucidly.

(1) The husks are usually soaked in pits by the side of the backwaters, which are provided with a channel to allow the water to flow in and out according to the state of the tide. To accommodate 1,000 nuts, a volume of 250 cubic feet is allowed, with a water depth of approximately four feet. The soil and water conditions for the sites of the retting pits are carefully selected since the owners realised that certain conditions produce the right colour and quality of fibre.

The knowledge thus utilised, perhaps empirical, but born of experience, is sound and as will be seen later, is based upon the presence of a suitable admixture of sand and clay in the mud and the amount of water movement in the mud of the river or backwater. The pits are basin shaped, but in contour may be square or round. The husks are laid in the basin of the pit upon a carpet of coconut or palmyra leaves and the whole mass is covered with further leaves after pressing the husks hard and levelling the top surface. The whole mass is then weighted down to prevent flotation when the water is admitted.

The latter is admitted through a small deep channel, and if effectively set in the pit, the tidal action should leave the husks undisturbed in position. Choudary states that the narrow channel is opened just before high tide, in order to let out the dirty water which has accumulated and is closed once more as soon as the flood of the tide has effected a complete change so that the pit is filled again with clear water.

(2) In other cases the husks are enclosed in a coir net, which is securely weighted and affixed to four stakes driven into the bed of the backwater, at the corners of a square. This method is frequently used in ponds and rivulets of fresh water not subjected to tidal action.

* From a Memorandum on Coir or Coconut Fibre, A Report on its Extraction and Properties by S. G. Barker, Ph.D.

(3) Soaking is commonly done on the West Coast of India in enclosures, divided off from the lagoons or backwaters. Places where a constant water depth of 4 to 5 feet is maintained are selected, and stakes of bamboo or poles are driven in as the primary foundation of the boundary of the enclosure. The interspaces are then filled in with coconut leaves or cadjan, whereafter the husks are put into the enclosure so made, covered with leaves, pressed down by the feet, and weighted in position. The poles project 18 inches above water level and are firmly fixed in the mud. This method finds more popular favour than the others mentioned above.

(4) The Bulletin of the Imperial Institute, (Vol. X. No. 2. July, 1912) makes the following statement: "In the preparation of the best commercial coir by modern methods, the husks are retted by being steeped in tanks of water warmed by steam, thus shortening the treatment considerably".

(5) Copeland in his book gives an insight into modern practice in the Philippines wherein he states that in the best equipped factories the husks are soaked in concrete tanks in fresh water and for only two or three days.

They are then removed and subjected to a mechanical decortivating or combing device, which holds them against a revolving cylinder furnished with long sharp teeth in the periphery. The combing is repeated four times or so. After this the fibre is washed by brushing in fresh water until practically clean, then it is sun dried in open yarns or upon concrete courts. The fibre thus obtained is combed again when dry, before sorting.

INVESTIGATION OF FACTORS CONCERNED IN RETTING

Before passing to a discussion of newer chemical methods of retting etc. let us examine the processes involved in the natural methods outlined above. Two outstanding pieces of research work on these points are available, namely that of Fowler and Marsden, and that of Choudary. The former workers devoted their attention to the microbiological and bacteriological aspects of the process, whilst the latter closely investigated the relative importance and functions of the several factors involved in retting as ordinarily practised. Fowler and Marsden concluded that the process of retting was due to organisms which were derived from the coconut husk direct, irrespective of water conditions, and they elucidated the activity of such organisms fully. Their argument may be quoted as follows: "If the coconut husk itself carries the bacteria which assist the sproutlet of the seed to force its way through the husk, and these bacteria in the presence of water are able to disintegrate and destroy the matter binding the fibres together, then soaking in water under suitable conditions should permit them to develop their activity and whether the water is salt or fresh should be immaterial so long as the necessary conditions for maintaining full bacterial activity are assured. The main condition for this would seem to be a controlled temperature and a sufficiently frequent change of water to prevent the killing of the bacteria by any accumulation of toxic life-products". After an exhaustive and logical sequence of experiments, they stated the following opinions:

(1) "That the effective retting of the coconut husk requires only suitable water-conditions. The effective organisms reside in the husk itself, and can exert their full influence in water changing sufficiently frequently to prevent the organisms being poisoned by the products of their action, provided the change is not so violent as to remove too rapidly the accumulating bacteria, etc. That temperature plays a part, and that the influx of cold water retards the retting process by diminishing the activity of the organisms.

(2) That the blue-black colour of the water and the dulling of the fibre are due to its coming into contact with ferruginous water brought down by fresh-water floods from inland, forming tannate of iron with the tannin-matter in process of extraction from the husk.

(3) That the brown colour of the water on first setting to soak is due to the tannin-matter extracted with the juice and that the reddening of the fibre is caused by exposure of the husk to the action of the air, the tannin-matter being highly oxidisable and readily convertible into coloured, insoluble phlobaphenes, similar to the oak-red obtained from the tannin of oak-bark. The growing organisms remove oxygen from the water, and if their activity is checked by fall of temperature, or they are washed away by too rapid a flow of water, the dissolved oxygen in presence of oxidising enzymes suffices to oxidise some of the residual tannin and cause discolouration.

(4) That the cork or pith of the husk is not itself the binding material, but that it is associated with a gum, mucilage or hemi-cellulose, which is disseminated throughout its cells, is insoluble in water and can be resolved by the action of bacteria or by treatment with water under pressure or by chemical agents. The nature of the tannin-matter however will preclude the possibility of obtaining a coir equal in quality to that obtainable by natural retting unless it can be removed by working under anaerobic conditions.

For producing good coir the conditions near Anjengo appeared to be the best suited, as there the husks are soaked in submerged fields of a fair area, the water being sufficiently shallow for the warming effect of the sun to have full value in accelerating the rate of retting and the narrow openings in the bunds regulating the flow of water and preventing the change being too rapid. No appreciable oxidation of the tannin-matter in the husk can take place therefore and if the openings into the 'fields' could be closed at flood time and clean water alone admitted, at high tide say, and any entry of ferruginous water thus prevented, there would be a diminished risk of 'blue' fibre being obtained.

As regards shortening of the period required for retting, experiments have shown that it might be feasible to set the husk to soak until the bacterial growth is well established and softening has commenced; then to lift, pass between heavy squeezing rollers and return without delay the squeezed husk to another pit, already prepared. The bacteria could then more rapidly remove the binding matter and since a period of five weeks sufficed for the complete disintegration of a husk in the laboratory the present requirement of ten or twelve months might be reduced to a period of at least three months''.

Now let us turn to the work of Choudary and examine his conclusions.

With regard to the freshness of the husks for soaking his experiments showed that it was far easier to beat soaked fresh green husks than soaked stored husks, i.e., whether soaked in salt or fresh water. In point of time, the stored husks took 1.8 times as long to beat as the fresh husks, showing that the economic factor of labour costs comes into the matter. The colour of the fibre, an important item in assessing its value, from the stored husks is invariably deeper and darker than that from the fresh husks showing that when once the husks are dried, mere water retting alone even under the best conditions, the fibre will be discoloured. It is thus obvious why the current practice postulates that the husks from the freshly harvested green nuts, should not be exposed to storage etc. for more than 48 hours after removal by splitting. Exposure to sun and weather, results

in the husks not soaking properly, the fibre being distinctly more difficult to separate, discoloured and more pithy. The conclusions of Fowler and Marsden would indicate that the nature of the water had little to do with the efficiency of retting, provided that proper conditions of flow and temperature were maintained etc.

Choudary's work confirms this view largely. He found that there is no difference observed in the ease with which fibres can be separated from husks soaked in fresh as compared with salt water. The colour of the fibre is very nearly the same. He made one vital observation, however, regarding the relative merits of the two methods, namely, that if the husks are kept in fresh water in ponds for as long a time as they are in salt water they are ruined. The salt in salt water or brackish water prevents over fermentation without discolouring the fibre, whereas the same is not the case with fresh water. Even with salt water one year seems to be the maximum time of soaking, if loss of colour, strength and brilliancy are to be avoided. If, however, the husks are removed from fresh water after six months' soaking the trouble does not arise, neither does it do so if frequent movement of the water, i.e. removal and renewal is maintained. Further experiments upon the addition of salt to fresh water retting tanks, led to the conclusion that "salt does not in any way add to the essential quality of the water for retting". The two main advantages of the salt water method are—(a) the constant changing of water due to tidal action and in consequence the continuous removal of deleterious matter which has been created; (b) the time of soaking may be extended to 10 months, thus rendering the process more complete and further, giving greater purity of product with ease of extraction. Where fresh water has to be used it is found that running water is a great advantage, and a shortening of the time of retting by as much as one third is recorded.

Whatever may be the method of soaking, the husks have to be soaked until complete separation is possible and incidentally not for a longer time in fresh water than in salt water. On the West Coast of India the husks are soaked for from six to ten months, and somewhere about the mean of these two figures, i.e., eight months may be taken as about the minimum necessary, under ordinary conditions, to obtain the best coloured fibre. In fresh water soaking, after about seven months, the outer skin gets rotten and cannot easily be removed, therefore, the husks should in these cases be removed when they are well-soaked after about six months. It has been found that the period of soaking can be shortened by crushing the husks before soaking. A simple crushing machine consists of two heavy rollers, similar to sugar cane crushers, and immediately after splitting the green husks are passed through such an arrangement. If, after soaking husks so crushed for one month, they are removed from the retting pit and again crushed, upon subsequent restoration to the retting pit the action proceeds more rapidly, the period of soaking being appreciably shortened even reducing the time to as little as three months. To sum up, therefore, it would seem that the time of retting could be reduced, if the economic factors involved made it worth while, and secondly thanks to the workers mentioned above, a much more complete understanding of current practice is now extant.

EXTRACTION OF THE COIR FROM THE RETTED HUSK

Before treating the subject of chemical retting, it would be well to note the methods used for extraction of the fibre after the retted husk is recovered from the pit. When the husk is sufficiently soft it is removed from the pit and any adhering mud or slime is removed by washing in fresh water, the outer skin being peeled off with the hand by squeezing. The husks are then placed upon wooden blocks and beaten with wooden mallets to separate

the soft inner fibre from the cork and pith, the latter being eliminated by the beating and shaking. The fibres, still wet, are next spread out in the shade to dry, and when this is attained they are threshed with smooth bamboos about 6 or 8 feet long, thus accomplishing a twofold purpose of freeing the fibre from entanglement and from residual pith or dust. Smooth and soft fibres should result from the treatment. The fibre, after extraction should not remain wet for more than 24 hours, and should be dried in the shade. Drying in the full sun is reputed to render the fibre more difficult to spin, even after re-wetting.

As thus obtained the material is now ready for willowing. A hand driven willowing machine is used, which consists of a cylindrical drum in the axis of which revolves a wooden shaft carrying a number of teathed blades set spirally and radially on its axis, which pass through similar teeth fixed to the inner part of the machine at the top and bottom. The pith and cork are thus removed leaving the clean and soft fibre ready for sorting and subsequent processing. Two persons can thus willow some 300 lb. of fibre in 8 hours. There are variations of the willowing process but in all cases the object is to secure clean fibre free from pith, dust or cork, and ready for subsequent use.

It will be convenient at this stage to leave the description of these uses until a consideration of other methods of retting has been accomplished.

CHEMICAL AND MECHANICAL METHODS FOR QUICK RETTING OF HUSK

It is generally recognised, that provided the raw material from which the start of a process is made, is of the same type and quality, great uniformity of final product can be obtained by carefully controlled and manipulated chemical treatment. It would seem a *sine qua non* that previous to chemical treatment the husks should be split or crushed as much as possible, a factor which may not be economic except upon a fairly big scale. In the study of such processes one may perhaps concentrate upon a discussion of some three or four methods:

- (1) The Nanji Process,
- (2) The Van der Jagt Process,
- (3) The "H. G." Process.

These are all different in principle. Now as to crushing. There are already machines on the market for this purpose, but in both the Van der jagt and the H. G. methods, special apparatus is provided to render the husk in the most suitable form for their specific treatment.

Apart from this a machine exists wherein the husks, fresh from the opening, are passed through heavy rollers into which they are fed mechanically and continuously through a hopper from above. One of the rollers is so arranged that it is capable of movement sliding backwards and forwards to meet the requisite variability in husk size. Although only occupying a floor space of five square feet, it is claimed that such a machine could deal with 8,000 husks per day, i.e. the total yearly crop from 2½ acres of plantation, approximately, thus requiring a large area and further, good transport facilities. The husks, crushed in one way or another, are then ready for the retting process.

(1) THE NANJI PROCESS

An Indian scientist, Dr. D. R. Nanji, working in the University of Birmingham, has studied the question of retting and separation of various vegetable fibres, one of which was coir. Owing to the low economic price level prevailing in the coir industry, his process has not yet found a

commercial application, and even so, needs careful investigation before adoption. The process briefly consists in the treatment of partially crushed green or dry husks with a mixture of lime or sodium sulphate or sodium carbonate containing a trace of aluminium sulphate at steam pressures of 80 to 100 lb. per square inch, for a period of one to two hours. On such treatment the inter-cellular pithy substance gets completely loosened from the fibre proper. It is then removable by washing off the digestion liquor and the remnant drops off completely in willowing or opening after subsequent drying. It is claimed that the strength of the fibre is not affected by the treatment although the colour is darker than that of commercial coir. The fibre so obtained is, in general, finer than that obtained by ordinary retting, and the best results are obtained with green husks freshly opened, although dried husks are quickly responsive to the treatment.

A similar method is apparently covered by Elod and Thomas in a U. S. A. Patent taken out in November, 1931. They state that the material is immersed for a short time in hot water, pressed, immersed again for a short time in hot water, after which the embedded fibres are separated from the cork and pith by mechanical treatment. During the second hot water treatment, substances of "the slaked lime type" are added to the water and discolouration is thus avoided. The author has had no experience of this method and therefore cannot pass judgment thereon.

(2) THE VAN DER JAGT PROCESS

It is claimed that by this method it is possible to extract the fibre in marketable form from fully matured nuts in less than two hours by chemical and mechanical means. The method also covers the subsequent spinning and weaving, and since matured nuts can be used it is stated that copra can be produced in the same factory, utilising the waste, the shell and coir dust in suction gas generators, to provide heat and power to drive the machines and dry the products. There is, no doubt, that such co-ordination of all branches of the industry would be most economical but it remains to be seen whether the methods now proposed could accomplish this. A full description of the Van der Jagt process has appeared in the "Engineer" for June, 1912, and can be consulted for details.

The raw husks are fed on to a conveyor and opened in a husk preparing machine. A second conveyor takes the opened husks to a boiler in which revolves an endless chain, equipped with paddles, carrying the husks round with it in a weak solution of caustic soda, raised to the boiling point. After boiling for the requisite time, adjustable by the speed of the endless chain, the soft weak husks are conveyed to a machine which not only opens but squeezes them thoroughly. The opening is performed by pinned bars fitted on chains moving at different speeds and finally the excess caustic soda solution is expressed from the fibre by means of fluted rollers. It is stated that the liquor thus recovered can be used again for boiling fresh charges, in fact the caustic soda seems to be only utilised to start the operations. Thus the process is really more mechanical than chemical. A picker card specially constructed to work fibre more than 100 per cent. wet, reopens the compressed fibre, and discharges it on to a conveyor, which delivers it to a softener and cleaning machines which, equipped with six pairs of fluted rollers, removes the last remnant of coir dust from the fibre. The material passes from the fluted rollers immediately on to a series of six pinned rollers, which after opening it out once more, cause separation of the coir dust; the action of cleansing and dust elimination being continued in the machine, where the fibre passes through four sections each of four rollers.

The fibre is now dried mechanically and softened for the spinning process which is to follow. The latter process is accomplished in an ordinary jute softener. The coir fibre so obtained is adapted for carding and thence forward, the process is carried out on machinery similar to jute machinery, with modifications to meet the special characteristics of the fibre. At the delivery end of the breaker card, there is an arrangement for subjecting the sliver to heavy pressure in order to keep it together. The sliver is collected in four rolls, side by side on the same shaft and is then fed into a finisher card.

From this stage a set of drawing frames of the ordinary jute type are employed and at the conclusion of this process the material is spun on a self-regulating gill spinner of the ordinary type, suitably modified. It is claimed that coir fibre can be thus spun into one lea yarn or 48 lb. yarn.

The cost of a complete unit, inclusive of buildings and bungalows for employees, for working five million coconuts per annum is given as £40,000.

Coir so produced has been woven into sacking for transport of manures, etc. and is certainly softer than ordinary type of coir produced normally. It is, however, considerably darker in colour than the best fibre produced ordinarily. The inventor claims that by rendering the fibre flat in form through compression, the binding power of the yarn is increased and thereby the strength is enhanced greatly. This statement should be carefully considered in practice. The process is one for which full patent rights have been acquired. It would seem, however, that such a softening process, would render the fibre unsuitable for many of its ordinary uses, and yet open out new spheres of utility, in some of which it would undoubtedly have to meet the competition of other fibres of similar character. The economic consequences are as yet undetermined. On the other hand, the progress of other industries is continually bringing forth new demands which might reasonably be met by such material as will be seen later.

(3) THE "H. G." PROCESS

This process has been developed by E. V. Hayes-Gratze of London, and is distinct from any other in regard to the method and the material used. Further it is adaptable to either factory or cottage conditions, although under the latter circumstances it is obviously not such an economic proposition as in the former.

Taking full cognisance of the existing methods for extraction of coir, it is proposed in the following short résumé to divide the description of the Hayes-Gratze process into three sections so that its alternative applications to existing methods and conditions may be understood, namely :

- (1) General outline of the process with mechanical and fluid treatment.
- (2) The treatment and softening of coir fibre already extracted and available.
- (3) Adaptability to the widespread extraction by native labour and methods.

For bulk production a central factory is necessary and here the process will embody :

- (a) The handling and treatment of the whole nut and husk.
- (b) The handling and processing of the husks alone.

In the former case (a) the nut is extracted and husk removed in one operation, effected by a single machine, the useless "core" or top where the stem had been connected being cut away and the husk (fleshy pith and fibre) sliced into sectional layers running lengthwise with the grain of the fibre therein.

The husk is, therefore, ready for retting treatment and the nuts for cracking and extracting of the kernel for copra, etc.

The husk contains a considerable percentage of moisture, etc. and as these are apt to stain the fibre during treatment the sections are compressed or rolled to exclude excess of these substances, after which they are passed continuously through one or more washes of water (preferably hot) and then rolled again.

The next operation subjects the husk sections to immersion in a solution of water and ionised water soluble H.G. oil, having a pH value of not less than 7, the solution being maintained for preference at boiling point, or not less than 200°F. The period of immersion depends on the freshness of the husk and will vary from one to four hours during which time the mass of saturated pith and fibre is kept in constant movement and subjected to intermittent mechanical pressing and rubbing action, by a special machine combining the tank and pressure jets, etc.

This machine ensures removal of the bulk of the fleshy and other extraneous matter through suitable grids and frames by allowing it to sink to the bottom where its removal is facilitated. The extracted fibre piles up at one end and may be removed at periods or continuously.

The ionised oil not only facilitates the splitting up and separation of the fibre and adhering matter, but has the effect of being absorbed by the former. The fibre is thus softened to an extent which enables it to be spun and woven on machinery of the jute type, eliminating the necessity of "flattening" the filaments, thus leaving them with their natural sectional structure. It is claimed, moreover, that the colour is lighter and elasticity improved without impairing their natural strength.

After removal from the ionised H.G. oil machine the fibre is pressed or rolled to exclude the excess of liquor; the fleshy matter or pith being treated in the same manner and the liquor returned and used again. By this means very little oil is wasted and that remaining on the fibre facilitates the subsequent operations of brushing, combing, carding, and spinning, etc. It may easily be made into a sliver, impregnated or dyed, moreover, it is absolutely immune from bacterial attack and enables the worked yarn or fabric to be self-scoured.

An even greater flexibility and softness may be imparted to the fibres by washing them after they have been pressed or rolled (following the oil treatment) if they are then dried and again immersed in a second solution of H.G. oil and water, squeezed again and finally dried.

No appreciable loss of oil or liquor (beyond the small percentage absorbed by the fibre) should occur during these operations and the excluded fluid is returned to the tanks.

The process is covered by patents. The ionised oils undoubtedly have a bleaching effect as well as being easily emulsified.

It may be noted that the splitting of the husk into sections enables the division or separation of the coarse and finer fibres to be attained more easily.

The fibre may be carded and spun immediately after the squeezing following the oil process provided machinery for this purpose is available.

Experiments are being carried out with a view to finding uses for the waste pith, which, when dried is similar to cork dust but physically stronger.

Many oils have been subjected to the ionisation and *ozonising* process, and there appears to be few limitations regarding the type of oil which can be used, coconut oil and groundnut oil, etc. already available, can be used after ionisation, with equally good results.

Alternatively, if the split husks, i.e. those husked on the field, are received at the factory for treatment, these are sliced into sections by a special cutting machine, and as they are naturally drier than the husk as in (a) they are first immersed in water, and then compressed or rolled, thus enabling the bulk of staining juices to be removed, after which the procedure is exactly the same as already detailed.

(2) Quite apart from the large amount of coir fibre already extracted and in existence, the supply is bound to continue to come from existing methods of extraction and sources. This fibre is unsuitable for fine spinning or making into thinner fabrics and the fact that it may be softened by the ionised H.G. oils at low cost is very useful.

The procedure is as follows :

The fibre is first immersed in hot (or preferably boiling) water for 30 minutes to one hour, then pressed or rolled to exclude as much moisture as possible. After drying it is placed in a tank containing the H.G. ionised oil and water solution and boiled for about one hour, the immersion period depending on the quality and fineness of the fibre. The solution is then excluded, the fibre dried and is ready for the following processing as previously detailed.

(3) With regard to the uses of the oil for local extraction by native labour, the method should reduce the time for retting from months to hours. Assuming financial and other problems preclude installation of large plant, it may be advisable to form small "centres" where the husks can be treated. This would enable the operations for cutting or sectioning the husks, mechanical action during immersion in the H.G. oil solution and rolling or pressing to be carried out in semi-bulk fashion. On the other hand individual or small growers can instal a tank to contain the oil solution, heat this from a fire made with shell or waste and immerse the broken husks for several hours, agitating occasionally. The loosened fibre and fleshy matter or pith must then be pressed or drained after which the fibre is cleaned and washed by the usual methods as performed after water retting. The consumption of oil will naturally be higher but further saving could possibly be effected by allowing the husks to dry partly (failing facilities for squeezing same) then steeping them first in a tank containing "used" oil solution.

The provision of suitable tanks should not present any great difficulty as these may be, if necessary, made of concrete, etc. at low cost.

It is claimed that in any case the extra cost would be more than compensated by the saving of time, higher yield and better fibre, quite apart from doing away with the pollution of water and other unpleasant effects of existing procedure.

Generally it is claimed that the technical and production advantages of the use of ionised oils over existing processes are :

- (1) Saving in time and cost of extraction.
- (2) Bigger yield of fibre.
- (3) Fibre lighter in colour, soft, flexible and maintaining its natural strength and structure.
- (4) Elimination of smells and fouling of rivers or ponds, etc.
- (5) Greater facilities for handling.
- (6) Adaption of the process to suit all conditions.

Commercial advantages are :

- (1) The fibre, being softer, will bale better and in less bulk for weight.

- (2) Easier grading for quality and fineness.
- (3) The better quality should command higher prices.
- (4) Its softness and strength should find new outlets and uses.
- (5) Its "self-scouring" properties after spinning.
- (6) Adaptability for weaving into fabric with existing jute machinery.

These claims have been investigated and to a large extent can be vindicated. It must be remembered, however, that full scale experiments on a manufacturing basis have not yet been completed; on the other hand, samples submitted in sufficient quantity to be treated on ordinary jute machinery have been successfully carded into a sliver and spun with little modification of the ordinary jute process. The colour of the fibre so produced left little to be desired and it was demonstrated that by further treatment the fibre could be almost bleached to a pale-straw colour, although in so doing, there was a slight loss of strength.

In any case, the process is now being developed and in view of the new uses for the fibre resulting therefrom, it is worthy of careful consideration and investigation.

Before passing on to the discussion of subsequent treatment of the coir there are two aspects that seem to call for investigation. Although the question of salinity of the retting liquor has been closely observed, yet the question of alkalinity, or in general, the pH value of such liquors has been apparently largely disregarded.

That such is of importance is indicated by the bacterial action which is stimulated upon ordinary pit retted coir fibre in contrast to the chemically and mechanically separated material. Retting with a view to subsequent dyeing or even with a view to subsequent utilisation may become a possibility when conditions, etc. are more definitely controllable.

SORTING THE FIBRE

Before utilisation, the coir has to be sorted into the various market gradings. The fibre has to be subjected to a process of combing or hackling with a view to ready separation into sorts of different lengths and qualities. Roughly a threefold commercial classification is made.

- (1) "*Mat Fibre*".—This is of the finest quality and is spun into yarns for the manufacture of ropes, twines and matting.
- (2) "*Bristle Fibre*".—A coarser and thicker quality employed in the manufacture of brushes and brooms.
- (3) "*Cured Fibre*".—A short variety, used for mattresses or for stuffing upholstery as a substitute for horse hair, etc.

Any dust or refuse resulting from such separation may be used locally as a manure or as fuel.

It has been suggested that the opening of the husk and sorting of the fibre could be mechanised. A method has been put forward by a British firm of machine makers and briefly may be described as follows:

After the retting is complete, by any method, the husk is quickly passed through a crusher and the crushed and retted husks are conveyed directly into an opening machine. Here they are seized by a pair of fluted rollers which carry the husks through to a cylinder and hold them whilst a serrated or toothed drum extracts the fibre and so shreds the whole husk up completely. In the extraction of the fibre, facilities can be provided for the separation of fibres of various degrees of fineness. The first treatment would subject the husk to the action of a steel drum, round the periphery

of which are fixed steel teeth. The teeth attack the husk and tear away the fibres. If the process is only partially completed on this machine and the husk then subjected to a similar treatment on a drum clothed with finer teeth, the second product naturally completed the extraction of all the fibre except that next the skin or outer layer. The outer layer consists of long, harsh, strong fibres known as "bristles" or "brush" fibre. This needs special treatment. The bristle fibre is passed into steel combs several times, and finally, after being freed from all extraneous matter, is dried, sorted into sizes, and made up in bundles ready for the brush makers.

The above processes separate the classes of the fibre mechanically and keep distinct the separate qualities of the fibre. Of course, if this separation is not required the whole extraction can be done in one treatment.

The fibre and the separated dirt and former adhering matter now fall together and are transferred to a willowing machine. This consists essentially of a gauze cage capable of rotation, attached to the axis of which are rapidly rotating steel beaters, carried spirally. The cage rotates slowly and the beaters rapidly, thus ensuring thorough willowing and cleansing. The waste matter, dust, dirt, short bits of fibre, etc. are thrown out through the interstices of the mesh of the cage and the fibre remains to be gradually withdrawn as the process is completed. By tilting the cage, the length of time of operation of the treatment can be controlled at will. The fibre is now ready for drying, either normally or by artificial heating methods. There seems to be a point here for investigation. Can quick artificial drying yield the same fibre characteristics as ordinary method? A partial bleaching action would seem to go on simultaneously with drying and one is tempted to wonder whether some form of irradiation during the process would ensure a better product. The speed of such a process as outlined above is obvious. On the other hand, Choudary and others have shown that removal of the husk from the pit and mechanical crushing during the time of ordinary retting greatly reduces the period necessary. This is the principle of the Van der Jagt and in part the H.G. Systems.

Mechanical action is maintained during the whole time of treatment continuously, so that the question of mechanical opening does not arise directly in their processes.

Sorting, however, is important, and no doubt both manual and machine methods could be profitably employed. The whole point would seem to become economic and if sufficient quantities are available for machine treatment without undue transport charges, then probably hand methods would prevail for sorting. Local conditions of production and marketing have to be considered in this regard. Nevertheless, just as in India the jute industry has progressed towards industrialisation in factories, and the cotton spinning and weaving industry, has moved similarly, it may be that the future of the coir industry, in conjunction with the copra and coconut oil industry will traverse a similar path. In any case, the latter has already done so to a large extent, the power driven driers and oil presses quickly replacing the older methods.

It may be argued that such developments would have a profound effect upon the economic life of the country in the coir producing districts. History shows that wherever progress is made from manual to power production, from the cottage industry to the factory, economic life is altered for a large number of people. On the other hand, history shows, as exemplified in the jute industries, that such transition inevitably results in larger production and a great increase in the number of the personnel

employed. Such economic dislocations are, therefore, to a large extent only temporary. At any rate the fact remains that in the Hayes-Gratze process, use can be made of coconut oil, *ionised and suitably treated*, and on this account it is worthy of close investigation.

UTILISATION OF THE RESIDUES FROM FIBRE EXTRACTION

It has been estimated that in point of weight the yield per nut of the pithy and cork-like matter constitutes as much as 70 per cent. of the husk. At present this is a waste product, which is largely irrecoverable. The mechanical and chemical retting methods suggested above make this portion of the nut definitely recoverable. Van der Jagt suggests its use as a source of gas or for combustion to supply heat and power, along with the shell, etc. Hayes-Gratze suggests that it is recoverable as a fine dust for which a variety of uses could be found, amongst others he mentions its possibility as a substitute for cork dust.

On the other hand, as Sampson has pointed out, in most countries coconuts are generally husked in the field and these are often spread on the ground to form a mulch as well as to assist in the maintenance of the fertility of the soil. Thus the idea of rendering the waste residues, which are highly carboniferous and contain a fair proportion of nitrogen, into manure may be examined. The scarcity of manure for purposes of tropical agriculture is often a serious matter in the production and development of various forms of cultivation. The creation of manure from waste products on the spot, with only minor transport costs, is worthy of consideration.

Sampson quotes comparative figures regarding the amounts of nitrogen, potash and phosphoric acid present in coir dust and cattle manure. His figures are appended below :

	Cattle Manure lb. per ton	Coir Dust lb. per ton
Nitrogen ...	21.73	9.75
Phosphoric acid ...	10.66	1.54
Potash ...	4.00	2.24

The analyses of the fresh and the retted husk suggest that there is not an excessive loss of fertiliser ingredients in the process of retting, except in the case of potash.

Calculated on Dry Weight.	Fresh Husk %	Retted Husk %
Nitrogen ...	0.53	0.74
Ash ...	6.71	8.07
containing Phosphoric acid	0.111	0.076
Potash ...	2.65	0.15

These figures for comparison of coir dust and cattle manure are taken allowing the same amount of moisture in each (50 per cent.) and the latter refers to stall-fed bullocks in the tropics. It is evident that in this form, as taken from pit-retted husk, the value is considerably less than cattle manure, but on the other hand, there may be, as a result of research, a method—bacterial or otherwise—as is known for other carbonaceous materials, of rendering the final product more valuable, in this direction. Alternatively, it is probable that the dust will prove to be most economically used as fuel in the process, especially where copra drying is done continuously and would supplement the supply of shell for this purpose.