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THE

INDIAN COCONUT JOURNAL

II.

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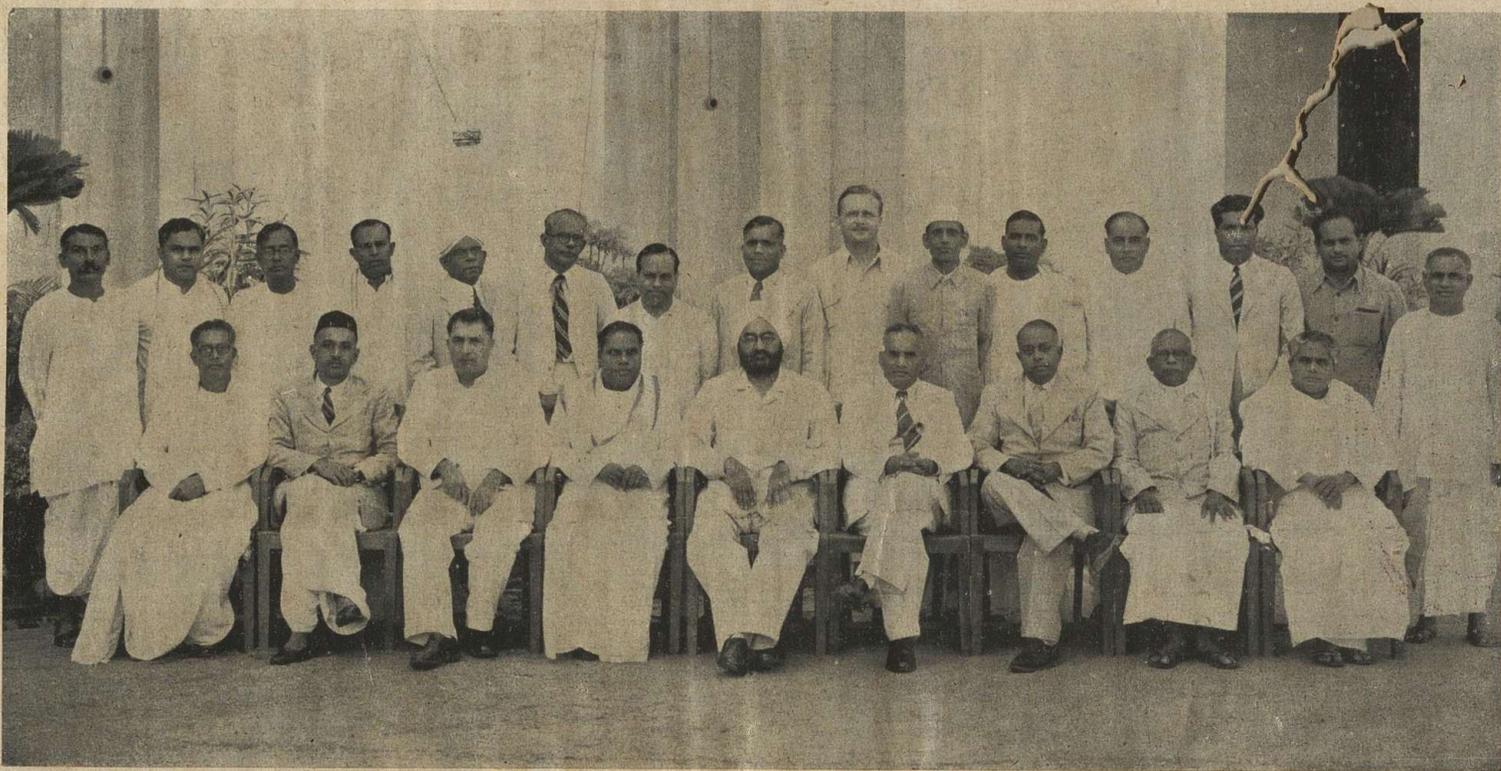
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INDIAN COCONUT JOURNAL

OCTOBER TO DECEMBER, 1948.

AS WE SEE IT

WITH this issue "The Indian Coconut Journal" enters upon the second year of its life. While we may not take credit for any spectacular achievement during the year that has closed, there is, we believe, no reason for self-deprecation either. We have spared no pains to make the Journal as useful a publication as possible and we would take this opportunity to thank our many contributors for their valued help in this direction. There is now little doubt that the Journal has come to serve a felt need of the Indian coconut industry, as the growing demand for it amply testifies. The Journal is devoted to the promotion of the best interests of the industry and we hope that it will play no mean part in building it into one of the important national industries of India.

Disease of Coconuts in Travancore & Cochin" by Dr. K. P. V. Menon and Mr. U. K. Nair. The first part was published in the issue of this Journal for January - March, 1948 (No. 2, Vol. I), and dealt with the Symptoms, Incidence and Cause of the Disease. The present part is a study of the physiology of the causal fungi.

DEPARTURES from the normal naturally excite curiosity. To the scientist they are of more abiding interest. Mr. T. A. Davis has met with certain abnormal palms in Travancore, made a study of them and written about them. His paper on "Proliferation in Two Coconut Palms" included in this issue, is one of those studies and should provide the research worker with some food for thought.

IN this issue we present the second part of the paper on "The Leaf-rot

MR. P. Sivarama Pillai whose article entitled "Survey of Coir

and Coconuts in Travancore" was published in "The Indian Coconut Journal" for January - March 1948 has contributed to this issue an article on a unique form of co-operation prevalent among coconut growers in certain parts of Travancore State. It consists in the surrender to a co-operative society by its members of a certain number of coconut trees in their gardens, so that the income from them might be credited against loans due from the members to the society or in the absence of loans as deposits from them. This device has the supreme advantage that, under it, there is no possibility of a member of a co-operative society defaulting repayment of loan as the society arranges for the harvesting and sale of the nuts. Its adoption for the co-operative cultivation of coconut trees deserves serious consideration. Growers of particular localities could band themselves into co-operative societies for purchase and distribution of quality seedlings, manures, fungicides etc., adoption of measures against pests and diseases and inter-cultivation of coconut gardens with proper implements, and surrender to the society a sufficient number of coconut trees, the income from which would be adequate to cover the expenses for the purposes mentioned above. There appears to be no doubt that it is a form of co-operation which merits active encouragement.

THAT more and more thought has begun to be bestowed on the question of the artificial drying of copra is seen from Mr. K.K. Kuruvila's article on the 'Rehabilitation of the Coconut Industry in India' published in this issue. Mr. Kuruvila advocates the use of a rotary louver drier instead of a kiln and the drying of the coconut kernel in chips instead of in cups. The rotary louver drier, he claims, can be worked without interruption so that a continuous output of dried copra is ensured. Uniform drying and the presence of least moisture in copra, it is said, are made possible by drying the kernel in the form of chips rather than of cups. The suggestions hold out an attractive prospect to copra-makers intent on defeating the monsoon.

THE value of the coconut shell as a raw material for various chemical industries has yet to gain wide recognition. Mr. S.R. C. Poti's paper on the Dry Distillation of coconut shells, with the practical economics of it worked out, should therefore, serve as an eye-opener to entrepreneurs wanting to start new industries.

IN the issue of the Journal for April-June 1948, we had reproduced Part I of a paper on the Retting of Coconut Husks published in the "Journal of Scientific & Industrial Research". Part II of the paper is republished in this issue.

INVESTIGATIONS ON DISEASES OF THE COCONUT PALM
IN SOUTH INDIA

II

THE "LEAF-ROT" DISEASE OF
COCONUTS IN TRAVANCORE
AND COCHIN

STUDIES ON THE PHYSIOLOGY OF CAUSAL FUNGI

By

K. P. V. MENON and U. K. NAIR

CONTENTS

- I Fungi studied.
- II The growth of the fungi on different media.
- III The nutritional requirements of the fungi.
- IV Toxic concentrations of some chemicals with regard to the growth of these fungi.
- V Effect of PH. concentrations on the growth of the fungi.
- VI Thermal death point of the fungi.
- VII Summary.
- VIII References.

I. THE FOLLOWING FUNGI WERE
USED FOR THESE STUDIES:—

1. *HELMINTHOSPORIUM*
HALODES.
2. *GLOEOSPORIUM SP.*
3. *GLIOCLADIUM ROSEUM.*
4. *PESTALLOZIA PALMARUM.*

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These were isolated from coconut palms infected with the "Leaf-rot" disease. Infection experiments have shown that they are intimately associated with the disease (Menon K. P. V. and Nair U. K. 1948). Pure cultures of the fungi were obtained by Brown's hyphal tip method (Brown 1924) and stock cultures were maintained in tubes of Brown's glucose asparagin agar.

II. GROWTH ON DIFFERENT MEDIA

The growth of the fungi on different media were studied. The media used and their composition are given below:

1. Malt agar.	Distilled water		1000 CC.
	Agar		17 grms.
	Malt extract		25 grms.
2. Oatmeal agar.	Distilled water		1000 CC.
	Oatmeal		100 grms.
	Agar		17 grms.
3. Brown's synthetic agar.	Glucose	— 2 grms.	MgSo ₄ — 0.75 grms.
	Potato starch	— 10 ,,	Agar — 15 ,,
	Asparagin	— 2 ,,	Water — 1 Litre.
	K ₃ Po ₄	— 1.25 ,,	
4. Potato starch agar.	Potato starch	— 10 grms.	Agar — 15.0 grms.
	K ₃ Po ₄	— 1.25 ,,	Water — 1 Litre.
	MgSo ₄	— 0.75 ,,	
5. Richard's agar.	Cane sugar	— 50 grms.	MgSo ₄ — 2.5 grms.
	Pot. Nitrate	— 10 ,,	Ferric Chloride — Trace.
	Di-hydrogen phosphate	— 5 ,,	Agar — 20 grms.
			Water — 1 Litre.

Six sterilised petri-dishes containing the medium were used for each fungus. The plates were of uniform diameter and 50 cc. of the medium were poured into each plate. They were inoculated carefully in the cen-

tre with spore suspensions of the different fungi. Radial measurements of the rates of growth of the colonies were taken. The diameters of the colonies, three and seven days after inoculation are given in table I.

TABLE I.

Showing the diameters of the colonies of the different fungi.
Average diameter in centimeters.

Organism	Malt agar.		Oatmeal agar.		Potato starch agar.		Brown's agar.		Richard's agar.	
	After 3 days	After 7 days	After 3 days	After 7 days	After 3 days	After 7 days	After 3 days	After 7 days	After 3 days	After 7 days
<i>H. halodes</i>	4.4	9.0	4.6	9.0	4.6	9.0	4.6	9.0	3.8	9.0
<i>Gloeosporium sp.</i>	3.2	6.9	5.5	9.0	3.8	7.9	3.2	7.9	4.0	9.0
<i>Gliocladium roseum</i>	1.6	4.0	3.2	9.0	4.2	9	7.7	9.0	4.5	9.0
<i>Pestalozzia palmarum</i>	3.3	9.0	3.6	9.0	3.4	9	2.2	9.0	2.8	8.6

The description of the growth of the fungi on the different media is given below:

1. *H. halodes*

Malt agar.—Good aerial growth of mycelium, but poor sporulation.

Oatmeal agar.—Slow growth, but profuse sporulation.

Potato starch agar.—Profuse aerial growth of mycelium with fair sporulation.

Brown's agar. — Profuse aerial growth of mycelium with fair sporulation.

Richard's agar.—Fair growth of mycelium—sporulation commencing late.

2. *Gloeosporium sp.*

Malt agar.—Poor growth of mycelium.

Oatmeal agar. — Fair growth of mycelium.

Potato starch agar.—Fair growth of mycelium and sporulation.

Brown's agar. — Fair growth of mycelium and sporulation.

Richard's agar. — Fair mycelial growth—Poor sporulation.

3. *Gliocladium roseum*

Malt agar.—Poor growth of mycelium.

Oatmeal agar.—Poor growth of mycelium.

Potato starch agar.—Fair mycelial growth and sporulation.

Brown's agar. — Good mycelial growth and sporulation.

Richard's agar. — Fair mycelial growth and sporulation.

4. *Pestalozzia palmarum*

Malt agar.—Poor mycelial growth and sporulation.

Oatmeal agar. — Fair mycelial growth and sporulation.

Potato starch agar. — Fair mycelial growth and sporulation.

Brown's agar. — Fair mycelial growth and sporulation.

Richard's agar.—Matty growth of mycelium and poor sporulation.

III. NUTRITIONAL REQUIREMENTS OF FUNGI

In order to study the nutritional requirements of the fungi, Richard's synthetic solution (complete) and the same lacking in each of its constituents was prepared and the growth of the fungi in these solutions was compared. Erlenmeyer flasks 250 cc. each containing 50 cc. of the medium was sterilised in the autoclave and inoculated with spore suspensions of the fungi. Triplicate flasks were maintained for each series. The inoculated flasks were left undisturbed for a fortnight after which the growth of the fungi in the different flasks was examined. The results of these experiments are given in table II.

TABLE II.

Growth of the fungi on Richard's solution and in the same solution consecutively lacking in one constituent each.

Organism	Richard's solution	Richard's minus Ferric chloride	Richard's minus MgSo ₄	Richard's minus K ₂ H ₂ PO ₄	Richard's minus KNO ₃	Richard's minus sugar
<i>H. halodes</i>	Good (fluffy)	Good	Good	Fair	Poor	very little growth
<i>Gloeosporium sp.</i>	Good	Good	Good	Fair	Poor	—do—
<i>Gliocladium roseum</i>	Good	Good	Good	Fair	Poor	—do—
<i>Pestalozzia palmarum</i>	Good	Good	Good	Fair	Poor	—do—

The absence of Ferric chloride and Magnesium sulphate did not appear to have any visible effect on the growth of these fungi. In the absence of sugar, growth was exceedingly poor while the absence of potassium nitrate affected growth only to a lesser degree. Without dihydrogen potassium phosphate a fair amount of growth was noticed.

IV. TOXIC CONCENTRATIONS OF SOME CHEMICALS

The minimum toxic concentrations of chemicals like copper sulphate, mercuric chloride and phenol were determined for the different fungi. For this purpose Richard's solution

was distributed equally in a series of 250 cc. Erlenmeyer flasks. Different quantities of the chemicals were added to each flask thus making up a range of varying concentrations of the chemicals. The flasks were all sterilised in the autoclave and when cool, were inoculated with spore suspensions of the different fungi. They were then left undisturbed and examined again after a fortnight. The lowest concentration of the chemical at which growth of the fungus was inhibited in the flask was regarded as the toxic concentration of that substance with regard to the fungus. The results of these experiments are given in table III.

TABLE III.

Toxic concentrations of chemicals.

Organism	Copper sulphate per cent									Mercuric chloride per cent			Phenol per cent				
	0.5	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.025	0.05	0.1	0.05	0.1	0.15	0.2	0.25
<i>H. halodes</i>	X	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—
<i>Gloeosporium sp.</i>	X	X	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—
<i>Gliocladium roseum</i>	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Pestalozzia palmarum</i>	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—

X Means mycelial growth present. — Means no growth.

H. halodes was observed to be growing up to concentrations of 0.3 per cent of copper sulphate, *Gloeosporium sp.* up to 0.35 per cent, *Gliocladium roseum* up to 0.2 per cent and *Pestalozzia palmarum* up to 0.15 per cent.

V. THE EFFECT OF PH. ON GROWTH

In order to study the effect of PH on the growth of the fungi they were grown in petridishes on Brown's syn-

thetic medium adjusted to different PH. concentrations by the addition of varying quantities of boric acid and sodium bicarbonate. PH. determinations were made by means of the Hellige comparator. The range of PH. tried was from 4.5 to 9.8. Six petridishes were inoculated in each series and the radial rates of growth of the fungi were measured. The average diameter of colonies four days after inoculation are given in table IV.

TABLE IV.
The effect of PH. on growth.

Organism	9.8	8.6	8	7	6.5	5.5	4.5
<i>H. Halodes</i>	1.1 cms.	3.4	6.9	7.0	6.5	1.8	No growth
<i>Gloeosporium sp.</i>	No growth	1.5	3.3	4.0	4.0	3.8	No growth
<i>Gliocladium roseum</i>	—do—	1.4	6.2	7.6	6.2	No growth	—do—
<i>Pestalozzia palmarum</i>	—do—	1.0	4.5	5.0	4.9	—do—	—do—

Optimum growth took place round about the neutral point while high alkalinity or acidity had a depressing effect on growth.

VI. THERMAL DEATH POINT

The thermal death points of the spores of the fungi were determined according to the method described by Vasudeva (Vasudeva R. S. 1936). Spore suspensions of the fungi were prepared in sterile water. Capillary tubes were drawn out from narrow glass tubing and cut into small pieces, each piece being about an inch in length. One end of each piece was sealed by heat fusion. The tubes were then dropped into spore

suspensions of the different fungi and exhausted under an air pump. By doing this the capillary tubes got filled with the spore suspension. The capillary tubes thus charged were then placed in beakers containing water maintained at different temperature from 30 to 75°C. for five seconds. They were then broken off at the ends and the contents collected on Richard's agar in petridishes. The minimum temperature at which germination of the spores in the petridishes was not observed was regarded as the thermal death point for that fungus. The results obtained are given in table V.

TABLE V.

Showing the thermal death point of the different fungi.

Organism	30°	40°	45°	50°	55°	60°	65°	70°	75°
<i>H. Halodes</i>	X	X	X	X	X	—	—	—	—
<i>Gloeosporium sp.</i>	X	X	X	X	—	—	—	—	—
<i>Gliocladium roseum</i>	X	X	X	X	—	—	—	—	—
<i>Pestalozzia palmarum</i>	X	X	X	X	—	—	—	—	—

X Signifies growth. — Signifies no growth.

Thus it may be seen that the spores of *H. halodes* lose their vitality at 60°C. while the spores of the other three fungi get killed at 55°C.

VII. SUMMARY

The nature and rates of growth of the fungi on different media were studied. Studies were made regarding the nutritional requirements of the four fungi with reference to dependence of growth of the fungi on the important constituents of a synthetic medium.

Toxic concentrations of copper sulphate, mercuric chloride and phenol with regard to the growth of these fungi were determined.

Studies made on the effect of PH. on the growth of the fungi showed

that the optimum growth took place near the neutral point. High acidity or acidity had a depressing effect on growth.

The thermal death points of the spores of the fungi were determined.

The authors wish to thank the Indian Council of Agricultural Research and the Government of Travancore for providing the funds necessary for these investigations.

VIII. REFERENCES

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Plate I

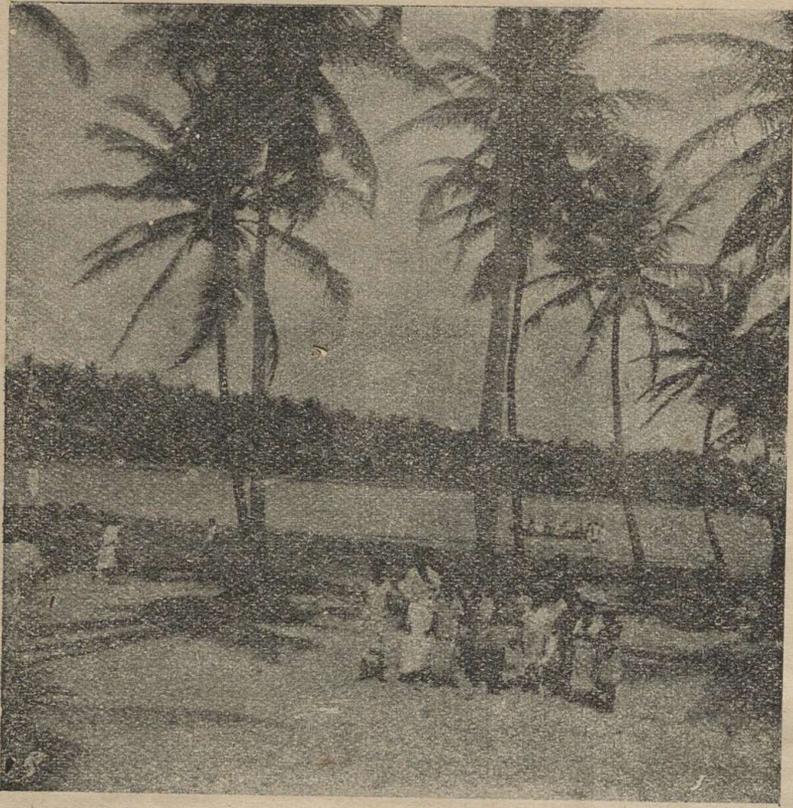


Plate I.

A picturesque view of the lake Manakudy. The urchins are seen to flock around the stem of one of the two abnormal palms.



Plate II.

The general (barren) appearance of the crown of the abnormal palm.

PROLIFERATION IN TWO COCONUT PALMS

(*COCOS NUCIFERA*, L)

By T. A. DAVIS

INTRODUCTION

IN a paper entitled "A Bulbiferous Coconut Palm" (10), an account of a palm which gives rise to 'bulbils' in the place of the entire spadices has been given. In this note a curious case of "Proliferation" or "Chloranthy" in two coconut palms is described. These rare palms give rise to normal spadices, the flowers of which develop into small vegetative "shoots", each resembling a miniature coconut seedling.

During a visit to Manakudi, a place very near Cape Comorin I found two 'divine' coconut palms which had never flowered, but on which seedling-like "shoots" were found grown. Plate I gives a view of the place. Some urchins are seen to flock around the stem of one of the two abnormal palms. The palms which give hundreds of small bulbil-like "shoots" from the spadices stand at the eastern side of the lake Manakudi and

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near the waters of the Arabian Sea. They stand nearly twenty feet apart from each other. Plate II gives the general appearance of the crown of one such abnormal palm. The crown is crowded neither with nuts as in ordinary palms, nor with bulbils as the palm described on a previous occasion (10). The palms are now nearly forty years old and nearly thirty-five feet high. It is stated by the local people that the trees have never fruited, but exhibited the same abnormality from an early period. The superstitious people in the locality attribute this abnormality to something 'divine' and 'supernatural', more so because the palms stand very near an ancient place of worship.

THE COCONUT FLOWER

In order to follow the deviation in the flowers of these palms, a detailed knowledge of a normal coconut flower is given below. In the coconut inflorescence the spadix is formed in the axil of every leaf of a bearing tree. The entire inflorescence is covered by a large sheath in the young stage called the spathe.

There are two more smaller sheaths, one on the inner and the other on the outer side of this large spathe. The inflorescence consists of many flower-bearing ramifications or spikelets situated on a fleshy peduncle. Each branch is fringed with numerous male florets from tip downwards and its lower region bears one or more female flowers, all the flowers being sessile or subsessile. The male flowers are unsymmetric sepals, three valvate and small; petals oblong, acute and valvate; stamens six, filaments subulate, anthers linear, erect and a minute pistillode in most cases is seen. The female flowers are much larger and ovoid in shape generally. The perianth leaves are greatly accrescent and grow with the fruit. The sepals are imbricate and the petals shorter, convolute with imbricate tips. An annular disc is also present. Ovary is three-celled, typical of palms, but usually one ovuled.

REVIEW OF LITERATURE

Both the entire spadices and the individual flowers of some coconut palms are reported to prolifer and to produce vegetative 'shoots' or 'bulbils'. Iyengar (14), Ridley (19), Furtado and Barreto (11), Sands (20), Burkil (3) and others report the occurrence of such 'bulbils' in coconuts. According to them the abnormal condition was due the

foliation of the bracts of the inflorescence so that the inflorescence was turned into a leafy branch. Furtado (12) while considering a bulbiferous coconut palm as a 'branched' one, suggests that it is a case which ought to go under the title 'chloranth' or 'proliferation'. It consists in the metamorphosis of an inflorescence shoot. Petch and Gadd (16) say that "virescence", that is the conversion of the inflorescence into an axis bearing abnormal leaves is not uncommon, but these abnormal inflorescences die soon. Quisumbing (9) says that when the terminal bud of coconut is injured, there seems to be a tendency for the adjacent buds, probably axillary or adventitious to develop and replace the destroyed terminal bud. He says that "this is possible when we consider the possibilities of the inflorescence failing to develop into flowers and fruits, instead of producing branches. This is also possible when we consider that flowers are metamorphosed leaves". He observed such a development in a coconut palm in Cebu Province, Philippines.

Rare cases are also reported where the individual flowers of the spadix prolifer to produce bulbil-like "shoots". Shortt (12) has seen at a Horticultural show in Travancore that from one of the flowers of the spadix a shoot of spring leaves was thrown out with a slight tendency





Plate IV. (above)

Bulbil "shoots" arranged in series to show the gradual development.

a) A part of a young rachilla of the abnormal spadix.

Plate V. (below)

Pen and Ink sketch to show that the leaves are the modified perianths.



to fructification from the flower and then converted into spring leaves, apparently forming a young shoot. The same author has seen a forked tree which never puts forth well developed fruits; on the contrary, the flowers terminate in vernal leaves. Venkataraman (22) observed an instance of bulbulliferous spadix, which he called parthenogenesis occurring in a coconut palm from a village near Nannilam. The 'buttons' or the young nuts in the spathe did not develop into normal fruits, but some of them grew into bulbils somewhat resembling ordinary seedlings. The abnormality, he says, could be traced to a very early stage before the spathe actually opened. Andy (17) has described a monstrosity which consisted in the phyllody of the greater portion of the female flowers in the spadix, and not of the whole inflorescence itself.

THE ABNORMAL SPADIX AND THE DEVELOPMENT OF THE "SHOOTS"

In the interesting palms which form the subject of this note the inflorescence develops like a normal palm. It begins as a protuberance at the axil of a petiole at the base of which two primary bracts, outer and inner spathe respectively, are cut off, the latter outgrowing the former as inflorescence develops. The main axis then cuts off secondary bracts at the axils of which, pri-

mordia of the rachillae (lateral branches) develop. The rachillae similar to the main axis cut off bracts (tertiary bracts) at the axils of which the bulbil-like structures arise. All the bracts—primary, secondary and tertiary—are persistent even in an aged specimen. The secondary and tertiary bracts never attain great size in these palms unlike those of the bulbulliferous palms. The length, size and general appearance of an inflorescence of these palms are almost the same as normal ones. The individual 'flowers' of these abnormal spadices have their normal place of origin. But the determination of sex in them is rather difficult as they all look alike in the early stages. They are in general bigger than the normal male flowers. Even during the later developments no sexual organs could be noticed as they all directly develop into leafy "shoots". A series of examinations made of these 'flowers' at different stages of development reveal the following particulars. The apparently flower-like structures have nothing in common with the normal coconut flowers. Regular perianths are missing. Neither stamens in the male 'flowers' nor carpels (ovary) in the female ones is visible. These "shoots" produce numerous perianths of different shapes and lengths at the expense of the stamens and carpels. The perianths gradually develop into true leaves as is seen by the pen and ink sketch

(Plate V). The first one or two perianths are shorter, somewhat triangular and very stout and they resemble the perianths of normal flowers. The successive ones elongate gradually and become proportionately thinner and narrower. As more and more new perianths are formed, small leaflets make their appearance towards the apices of these much elongated perianths. The lately formed perianths with the leaflets resemble normal pinnately compound leaves. Thus the lamina region, it is seen from the sketches, develops from the petiole which is the developed bract. According to Arber's (1) phyllode theory of monocots, the monocot leaf is simply the expanded petiole of an ordinary leaf, the lamina portion having been lost in the course of evolution. And the lamina portion of a palm leaf, that is the 'fan' or 'feather' limb is according to her (2) therefore, not morphologically lamina but only a modification of the distal region of the true petiole. After the production of four or five such small pinnate leaves the "shoots" appear like miniature coconut seedlings. Many such seedlings in different developmental stages are noticed in the spadix as shown in Plate III. B.

HOW THE "SHOOTS" RESEMBLE THE COCONUT 'BULBILS'

These seedling-like "shoots" after forming ten to fifteen leaves attain

a maximum height of nearly eight inches. They resemble typical bulbils common in some Liliaceous plants. These "shoots" though they appear like the bulbils described in the previous paper and one of which is seen in Plate III. A., there is wide difference in size (five feet to eight inches respectively). The leaves of the bulbils are the modified secondary bracts of the spadix, whereas in "shoots" the leaves are the metamorphosed perianths of the flowers. The bulbils are formed in the place of the entire spadices, and the "shoots" in the place of flowers. That is, one spadix gives rise to three hundred to five hundred "shoots". Even the leaflets of the early leaves of the bulbils are free, whereas those of the "shoots" are plaited, typical of normal coconut seedlings. The bulbils bear secondary bulbils from the axils of the leaves, the "shoots" do not give rise to any such thing from the axils of the leaves. The bulbils have a comparatively longer life in the mother palm (seven to eight years), the "shoots" die off and fall away after three or four years.

GROWTH TRIALS WITH THESE "SHOOTS"

A trial to see whether the "shoots" will strike roots and establish themselves into palms or not, has been made. Since fresh "shoots" were available in plenty, some of them were first tried at Nagercoil in sandy, loamy and clayey soils. None of

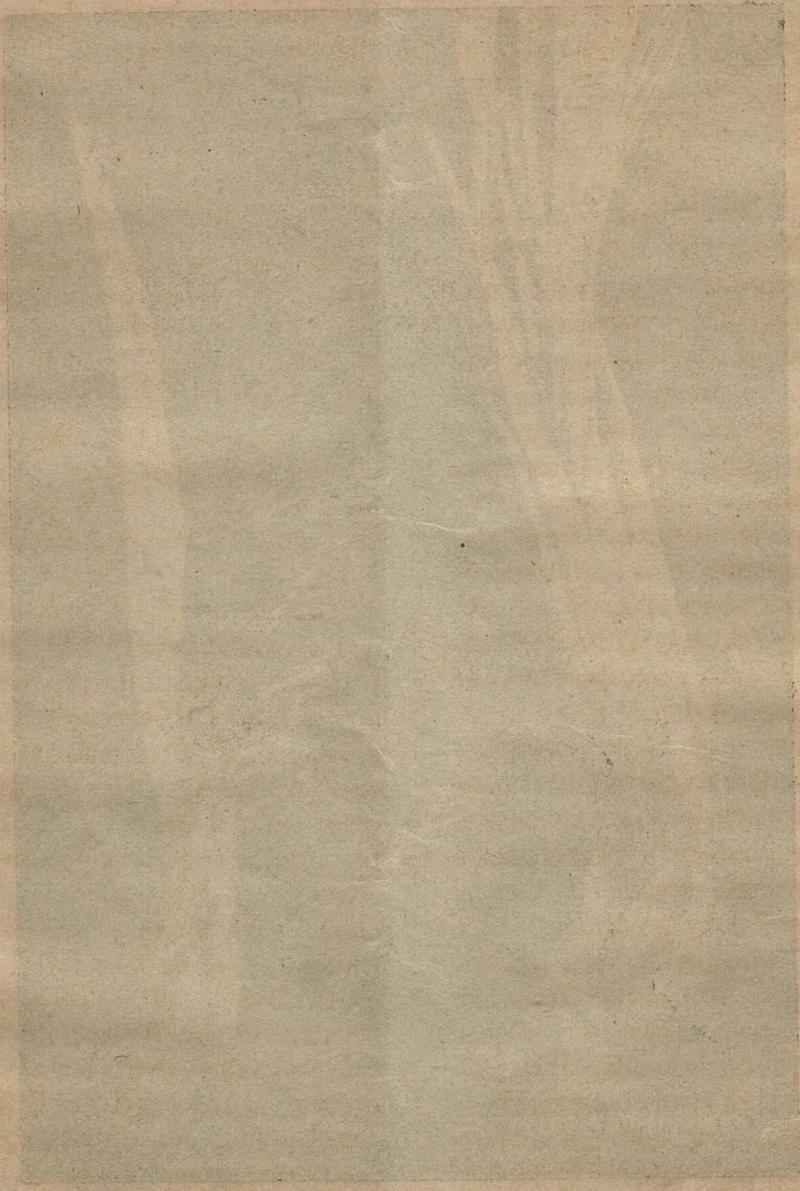
Plate 4



Plate III.

Two kinds of coconut bulbil compared. Left one derived from an entire spadix. Right one showing hundreds of bulbil "shoots" from a single spadix.





Faint, illegible text or markings at the bottom of the page, possibly bleed-through from the reverse side.



them struck roots and established, in spite of watering. It is intended to treat the "shoots" with some of the growth promoting hormones like Indolyl acetic acid, Thiourea etc., before planting, so that they may induce the promotion of roots.

DISCUSSION

Though the occurrence of bulbils in coconut has been recorded, a case of proliferation of all the flower initials like the present case has not so far been recorded. Though a few cases are recorded where some coconut flowers foliate into vegetative shoots, still in all these cases the foliation is only due to the parthenogenetic development of the female flowers or the young 'buttons'. Venkataraman reports a case of parthenogenesis in a coconut. The coconut which he had reported had not borne a single mature fruit with the endosperm, but that it produced only 'buttons' (unfertilized young nuts) some of which strangely grew out into green seedlings, which were still attached to the parent tree. Several of the 'buttons' he had cut across and examined. They all proved to be unfertilized ovules without any sign of endosperm whatever. The scrutiny of the tender inflorescence cut open from an unopened spathe revealed to him that some of the ovules had started to develop, and had produced growth primordia. Since normal pollination

can take place in coconuts only after the natural splitting of the spathe and the dehiscence of anthers, the fact that some ovules in the immature unopened spathes showed signs of development and growth unmistakably points to parthenogenetic development. The single shoot observed by Shortt developing from one of the flowers of a spadix may also be a case of parthenogenesis. No details regarding the mode of development is given by him. What Andy describes may also be a similar case. He says that only the female flowers (buttons) produce leaves. Thus he makes it clear that the palm which he described had produced both male and female flowers, and only some of the female flowers started premature production of leaves. It was considered that an examination of an unopened spathe of the palms under description might give some interesting insight into the origin and development of the "shoots". For the purpose a number of unopened spathes were cut from the same palms and were ripped open. Even in the very early stage no trace of the formation of female flowers was found. Instead, all the flowers which are quite alike in development, cut off numerous small perianths even from the very early stage which go to form the leaves. Since there are no distinct female flowers or 'buttons', there is no chance of the formation of embryo

and hence this, in no way, can be attributed to parthenogenesis.

Furtado and Burkil mention the bulbulliferous palms and the palms from some of whose flowers vegetative shoots are produced as branched ones. According to their view the present two palms may also be called branched ones. Strictly in no way can they be grouped under the branched palms. No doubt these outgrowths (vegetative shoots from floral region) have usually a much longer time than normal inflorescences or the leaves of the palms. But even if their lives are prolonged for more years they will not give rise to the permanently branched palms. However, Quisumbing makes an observation of a coconut, which after the destruction of the main shoot continued its growth through a vegetative shoot produced from the place of an inflorescence.

An attempt to find out the cause for this abnormality proved futile. The fact that the two palms are perfectly healthy without any symptom of disease and insect attack and have remained so for so many years producing the same abnormality year after year indicates the possibility of a change having occurred in the genetic constitution of the palms. It would be worth studying this aspect further.

SUMMARY

In this short paper a report is made about the occurrence of proliferation in two coconut palms of Travancore. Unlike the bulbulliferous coconut palms which are reported by some authors, these two palms produce numerous vegetative "shoots" from the spadices in the place of flowers. These "shoots" differ from the bulbils in size, origin and in number, though analogous to them.

These "shoots" develop and look like normal flowers in the early stages, but gradually as they develop they produce numerous perianths which go to form leaves. Thus the formation of stamens or carpels is replaced by the formation of leaves and such "shoots" after full development resemble miniature coconut seedlings.

This phenomenon cannot be called parthenogenesis since there is no 'button' or even unfertilized embryo, even in the very early stage. Moreover, the proliferation is taking place irrespective of sex, (in both male and female 'flowers'), which is an impossibility with parthenogenesis.

Neither the bulbulliferous nor the proliferous palms can be called branched ones, since the bulbils and the "shoots" respectively die and fall off though after a considerably long stay in the mother palm. They do not develop into permanent branches.

The fact that two similar palms from the same place possess the same phenomenon suggests that there is a definite cause responsible either genetical, physical, or physiological which is worth pursuing further.

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I have great pleasure in thanking Sri S. N. Chandrasekhara Ayyar, M. A., the Govt. Lecturing and Systematic Botanist and Mr. C. M. John, the Oil Seeds Specialist, Madras Agricultural College Research Institute, Coimbatore for their valuable suggestions in preparing this paper.

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CO-OPERATION AMONG COCONUT GROWERS

THE "KETTUTHENGU" SYSTEM OF TRAVANCORE

BY P. SIVARAMA PILLAI

"IN the Taluks of Vaikom, Sertallai and Parur several societies, we have noticed, have introduced a very interesting device by which they take over the management of some of the coconut trees of their members, market the produce and credit the income against the loans that may be due from them or in the absence of loans as deposits from them. This system has enabled many members to clear off their debts to the society. We, therefore, recommend that it be adopted wherever possible." — *Report of the Travancore Co-operative Enquiry Committee.*

The system or device referred to in the quotation given above is known as *Kettuthengu*.

The expression *Kettuthengu* is derived from the Malayalam word *kettu* meaning a knot or bond and *thengu* meaning a coconut tree. Where a certain number of trees were marked out or set apart for a

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specific purpose and as an indication thereof a piece of string or rope was tied round them, they would naturally be referred to as *Kettuthengus* or coconut trees with the knots. Gradually the practice of tying with a string must have fallen into disuse and the trees concerned marked in some more convenient manner, say with tar, while they continued to be referred to by the old appellation.

The *Kettuthengu* system is a unique method of saving and repaying debts through the yield of coconut trees and is generally prevalent in the coconut growing areas of Travancore. It is a very old economic institution and was originally intended more as a charitable endowment, than as a method of saving. People used to set apart the yield of a number of coconut trees as a gift to the nearest temple or church or *Karayogam* (village association) or such other social and religious institutions. Similarly where old and aristocratic families used to maintain *Thannirpanthals* or water-sheds for giving diluted butter milk or water to thirsty travellers during the hot season, the yield from a certain number of coconut trees was set apart for this purpose.

Even to-day it is very common to find *Kettuthengus* being maintained by Christians for their churches. The entire yield from the particular coconut tree or trees is collected by the Church authorities and sold in public auction. The usual practice is to set apart the best tree as the *Kettuthengu*. Now-a-days, for raising public subscriptions for the construction of a school building or a reading room or for digging a public well, people resort to this *Kettuthengu* system. The owners of coconut trees agree to set apart the yield from a certain number or the entire number of trees in a particular compound for a specific period for any of the above purposes. The payment is so evenly distributed through a fairly long period, that its burden is not so keenly felt by the benefactor. Besides, even small scale growers do not feel the pinch when they set apart two or three trees out of about 100 trees for this special purpose. Large amounts have been collected from poor and middle class people in different parts of Travancore through this unique method, and very imposing structures have been put up in the form of churches, temples and schools. The writer is personally aware of a school building costing more than Rs. 20,000/- having been put up entirely with money collected through the *Kettuthengu* system by a few villages mainly composed of poor and middle class agriculturists.

The economic possibilities of this system are so large and varied, that the principle underlying it could be extended to various other activities of our economic life.

Pooling of Produce

The *Kettuthengu* system does not, however, appear to have been copied by co-operative societies directly from this ancient institution. It seems to have developed from the practice of pooling for sale the produce of members' coconut gardens. It is said that about 23 years ago, the Cherukol Sri Mula Vilasam Nair Co-operative Society, Mavelikkara realised that it would be more profitable if the coconuts from its members' gardens were pooled and sold in bulk, than if they were sold by the members themselves in small lots to middlemen purchasers. The society undertook the harvesting of the nuts and their sale by public auction and paid the members the proceeds of the sale of their nuts after deducting the expenses incurred in the transaction. Members got by this means Rs. 10 to 15 more per thousand nuts when the market was rising and Rs. 5 to 8 when the price tended to decline. The Cherukol Society was held up as an example to other societies and soon it came to be followed by many in the coconut growing taluks of Travancore such as Vaikom, Shertallai and Parur.

Trees Surrendered to Repay Loans

When once the societies began to harvest, collect and sell the produce of members' coconut gardens, the next step was pretty obvious. If a member, whose nuts were sold by the society, had also taken a loan from the society, it was found convenient for both if the instalments due to the society were deducted from the sale proceeds. And when it was found how smoothly this arrangement worked, members who took loans from the society but who did not have the yield of their coconut trees sold through the society offered to surrender to the society a few trees the yield of which would be sufficient to cover the instalments due to be paid to the society. Soon, however, the economic depression set in and societies began to insist, when advancing loans, that a certain number of trees should be surrendered to them so that the value of their yield could be adjusted towards repayment of the loans.

The coconut trees which came under the societies, control in one or other of the above ways were referred to as *Kettuthengus*.

Liquidation of Agricultural Debts

During the last several years a very large number of agricultural debts have been repaid by resorting to this method. In the *Kettuthengu* system of repayment, the co-operative societies in Travancore have

played a very prominent part. In the taluks of Parur, Shertallai, Vaikom, Ambalapuzha and Karthigappally, the co-operative societies have been very helpful in the repayment of agricultural debts. The debtors who are members of the co-operative societies are given loans to liquidate their debts on the security of a number of *Kettuthengus*. The yield from these coconut trees is collected by the societies and sold in public auction and the amount realised by the sale of nuts is adjusted towards the interest and principal of the debts of the members concerned. The *Kettuthengus* are released to the owners when their entire debts are cleared. The societies maintain separate registers for this purpose. Agricultural debts amounting to very large sums have been liquidated by this method particularly in the taluks of Shertallai and Vaikom.

Fair Price Assured

The debtors get various advantages by resorting to the *Kettuthengu* system of co-operation for clearing their debts. First, they are able to escape the clutches of the village moneylender whose interest rates are abnormally high. Secondly, they are enabled to get the maximum prices for their coconuts because they are sold in public auction by the co-operative societies. When the village copra dealer advances amounts to the agriculturists, the

latter is forced to sell the coconuts to the former at the rates dictated by him. If it also happens, as is not unlikely, that the copra dealer himself is the creditor of the agriculturist, the latter is wholly at his mercy. By the intervention of the co-operative society which advances the entire amount to clear the debts of the members of the society, the agriculturist, however, gets a fair price for his produce and at the same time he is able to clear his debts on very advantageous terms.

The bane of the co-operative societies is that, even debtors who can afford to pay do not regularly remit the instalments due to the societies. The *Kettuthengu* system has the inestimable advantage that the society gets regular payment and the debtor can never be a defaulter.

A Typical Society

It may be interesting to know how a *Kettuthengu* co-operative society functions. The Vadayar Nayar Co-operative Society No. 266, in Vaikom Taluk may be taken as a typical one. It is a flourishing society, as such societies go, covering an area of about four square miles and having on its rolls 287 members. The share value is Rs. 10/- payable in 30 monthly instalments of 7 chuckrams* each. An admission fee of 5 chuckrams is also levied with the first instalment. The society advances loans up to 5

times the value of the shares held by a member, but no single loan may exceed Rs. 350/- irrespective of the number of shares held by a member. Besides surrendering to the society a certain number of trees the yield of which would be sufficient in value to cover the instalments of repayment of the loan, a borrowing member has to find two personal sureties also in the usual course. On the security alone of the trees surrendered no loan is advanced. The society also advances loans against the usufructuary mortgage of coconut gardens taking the yield of the trees until the loan is completely repaid. The society has now under it 2000 *Kettuthengus* with an annual yield of 120,000 nuts. The nuts are sold as a single lot in public auction to the highest bidder. The Managing Committee of the society meets and decides the date on which the harvest is to commence and this information is passed on to coconut merchants. On a day immediately before the harvest they assemble and the one that bids the highest rate (for one thousand nuts) purchases the entire quantity of nuts harvested, at that rate. The nuts are transported and delivered to the purchaser in his boat at the nearest landing place. It takes about 9 days for a single harvest. Before removing nuts from the owner's premises rotten and immature ones are rejected and credit is given only for pucca ones.

* 28½ chuckrams = Re. 1/-

The cost of harvesting comprises three items, namely, cost of climbing the trees and plucking the nuts, cost of collection and transport of the nuts and the cost of supervision of the above operations. For the first item the rate per tree is $\frac{3}{4}$ of a chuckram and one coconut for every garden in which there are ten or more *Kettuthengus*. The cost of transport works out on an average to Rs. 4/- per 1000 nuts. As far as supervision is concerned this is done by three members of the Managing Committee selected for the purpose and they are paid an honorarium at the rate of 8 annas per 100 trees. The only deductions made from the proceeds of the sale of members' produce are the cost of the first two items. The cost of supervision is met by the society itself. The society also undertakes to harvest and sell non-members' nuts. In such cases besides deducting the actual expenses of harvesting and transport the society takes for itself Re. 1-2-0 for every 1000 nuts handled by it. The society is also running a rice ration shop as part of its activities, and gives to deserving, needy members credit up to 8 weeks against the yield of *Kettuthengus* surrendered for the purpose.

Few Depositors

Although the sale of coconuts through the society is definitely advantageous, the number of deposi-

tors (as distinguished from debtors) who have handed over trees to the society is only 10; and these are among the more well-to-do among the members. It would appear that the poorer class member, unless he has to set apart some trees against loans taken by him, would rather cling to a freedom of doubtful value which would enable him to go up his tree at any time, denude it of its fruits, tender or mature, and dispose them off for such price as he may get.

The society described above runs also chit funds of the aggregate value of Rs. 2,500/- for collecting the subscriptions to which also the *Kettuthengus* system is pressed into service.

The Secretary of the society is an honorary worker getting only 18 per cent of the annual profit as bonus. (This was Rs. 192 for the last co-operative year). There is a clerk on Rs. 20/- p.m. and a peon on Rs. 12/- p. m. mostly for help connected with the ration shop.

All *Kettuthengus* co-operative societies function basically as the one described above. Differences, if at all, are only of minor importance. For example, the Vayalar Dharmodayam Society in Shertallai Taluk does not sell the harvested nuts either in a single lot or on f.o.b. basis. The nuts collected at different spots after harvest are sold in public auction in separate lots and the successful bidders have to remove them at their

cost. The cost of harvesting etc. deductible from the sale proceeds of the nuts is 1 chuckram and 1 cash or 17 cash per tree. Of this 12 cash are paid as labour charges, 4 cash to the Committee Member supervising operations and 1 cash goes to the society. The Secretary of the society is paid an annual bonus equal to 20 per cent of the profits and this amounted to Rs. 249/- for the last co-operative year. He is also paid for his clerical work $\frac{3}{4}$ per cent of the arrears due for collection. He got Rs. 128/- this way last year.

In the case of the Puthenvelikara Co-operative Society in Parur Taluk, sale of the harvested nuts is not by public auction but on the basis of tenders. The nuts are sold to the person who tenders the highest rate per thousand nuts. The cost of harvesting is Rs. 3/- per 100 trees and the cost of handling and transport Rs. 3-12-0 per 1000 nuts. The nuts are collected in one lot on the society's premises after which the tenders are opened and the sale confirmed. The Secretary's bonus is fixed at 20 per cent of the profits.

Good Work in Shertallai Taluk.

Some of the societies engaged in this system of co-operative work more particularly in Shertallai Taluk, are turning out a considerable volume of business. There are societies which have got more than 20,000

Kettuthengus and their annual transactions run into lakhs of rupees. Some of these societies tried to make copra and sell it at Cochin or Alleppey. But due to the fluctuations in the market, it was found neither profitable nor desirable to continue that business. Hence they are selling the nuts to wholesale copra dealers at the best rates available.

Deposits

Certain co-operative societies have a system of *Kettuthengu* deposits. These deposits are like current deposits and bear small rates of interest. This is analogous to the Savings Accounts in the Banks. The depositors also get the maximum price for their coconuts. Absentee landlords, who are unable to attend to the proper maintenance of coconut trees resort to this method. The societies undertake the responsibility of manuring and watering the coconut trees and the amounts so spent are reduced from the income derived from such trees, and the balance is credited towards *Kettuthengu* deposits in the accounts of the societies.

Volume of Business

In the Vaikom taluk 18 co-operative societies are engaged in the *Kettuthengu* business. During the last five years these societies gave 2,391 loans involving an amount of Rs. 2,31,677/- on the security of *Kettuthengus*. Out of this Rs. 1,65,147/-

has been repaid during the same period. The amount outstanding under this system of loans at the end of the last year in Vaikom Taluk was Rs. 1,19,022/-. Under *Kettuthengu* deposits nine societies had collected Rs. 51,314/- during the last five years.

In Parur Taluk, 8 co-operative societies were engaged in issuing *Kettuthengu* loans. They issued 661 loans amounting to Rs. 1,63,137/- during the last five years. Nearly 7000 coconut trees were set apart as *Kettuthengu* in the Parur Taluk for the repayment of the loans. These societies had Rs. 62,924/- as *Kettuthengu* deposits alone during the period.

Twelve prominent co-operative societies in Kuthiathode, Shertallai Taluk which were engaged in the *Kettuthengu* system of co-operative business, realised as much as Rs. 1,49,540/- by the sale of coconuts in 1947. *Kettuthengus* of the order of 19,340 yielded 8,37,200 nuts during the year. During the same period a sum of Rs. 33,894/- was realised from 684 loans by adopting the *Kettuthengu* system of deposits. These figures would show how popular this economic institution is in the coconut growing areas of Travancore and how far co-operative institutions have taken advantage of the system.

If the societies could market the copra produced from the coconuts

obtained from the *Kettuthengus* directly through co-operative marketing societies at Alleppey and Cochin, it would have conferred more advantages on the producers.

Possibilities Ahead

The *Kettuthengu* system described above and worked by co-operative societies in the coconut growing areas, bids fair to be an effective means of improving and developing the coconut cultivation and industry. Apart from the pooling of produce and bulk sale which are bound to give the small grower better prices, the co-operative purchase and distribution of quality seedlings and manures, purchase and hiring out of intercultivating implements and sprayers would all be rendered easy and possible if only growers would set apart for each specific purpose or for all required purposes, a certain number of their trees so that the yield from them could be devoted to meet the cost of the above necessary operations. What would be considered as beyond the means of an individual small grower, will be made possible by the co-operative and at cheaper rates too. And, as ready cash need at no time be found, the question of payment need not unduly worry him either.

The only reason why this system has not developed beyond its present dimensions or has not benefited coconut growers more extensively and intensively, appears to be the feckless

apathy of the ordinary small grower and the lack of adequate selfless propagandist zeal on the part of co-operators. There have been instances of societies which once flourished on the *Kettuthengu* system and successfully rescued their members from the clutches of middlemen and copra merchants, gradually losing their initial drive and enthusiasm, getting bogged up in petty local politics and fading out of existence, with

the inevitable result of members relapsing into their original state of economic bondage to the middlemen.

It does not, however, seem to admit of any doubt that if only co-operators would hitch their wagon to a star and refuse to be diverted by minor considerations they can revolutionise the economic life of coconut growers by adopting the "*Kettuthengu*" system.

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REHABILITATION OF THE COCONUT INDUSTRY IN INDIA

By K. K. KURUVILA

INDIA, once a world supplier of coconuts and coconut products, has practically ceased to play that role. On the other hand, her own consumption of these products is progressively increasing, so much so a considerable proportion of her demand has to be met by imports from abroad.

India was once satisfied to be a supplier of raw materials to the industrial countries of the west. At present, however, the export of the crop recedes in favour of the export of finished or semi-finished products. To-morrow, the holders of oil-yielding produce, instead of supplying crude commercial products to outside countries, will pass on semi-finished goods to their own industries. What is known as *industrialisation at the plantations* is the result of this evolution.

The coconut industry has been carried on in this country from time immemorial. The manufacture of

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Travancore.

copra by solar drying or by smoking, and crushing it for oil have always been profitable and well-paying. The country method of manufacture of the coconut oil which takes about 8 days coupled with the uncertainties of fluctuating prices, has, however, always exposed this industry to speculative financial risks. The producer has been able to get only a price which is wholly inadequate compared with the real worth of his product.

No great improvement has been noticed in the coconut industry either in the method of manufacture or of marketing since the earliest days though in other plantation industries like rubber and tea, up-to-date methods are employed to manufacture quality products at the plantations. The reasons for the steady improvement in these two plantation industries, patronised as they are by the Westerner, are obvious—capital and modernism. Coconut has all these years been the Cinderella of the Government as well as the capitalist.

Now that, however, the Indian Central Coconut Committee has been set up for the avowed object of improving the methods of cultivation

and production and the quality of coconuts and coconut products, it is high time that we thought out ways and means of improving the coconut industry in India.

MECHANICAL DRYING OF COPRA

Quality copra could be manufactured by solar drying for a few months in the year only. Even then the percentage of water in it is higher than that in the best possible variety and the yield of oil from it less. So mechanical methods of drying copra have to be thought of, if we are to produce quality products throughout the year.

The main factors which should be taken into account when we consider the suitability of a dryer for manufacturing coconut products are (1) easy working methods requiring least technical skill, (2) continuous production of the finished product, (3) high labour-saving equipment, (4) economy of production and (5) low capital expenditure.

1) **Easy working methods requiring least technical skill:** The main difficulty industrialists in India have to face is the absence of skilled labour. In all industries of a pioneering nature this want is keenly felt and usually experts from abroad have to train our men at heavy expense before we can actually start production under our own auspices. Therefore, wherever a new project

is under consideration this should be one of the factors that should be borne in mind.

2) **Continuous production:** In industries involving large quantities of raw materials and finished products, continuity of production is an essential factor for labour-saving purposes as well as for increased production. The system of production by charges is outmoded and costly in so far as the whole establishment will have to wait till the conversion is complete and then set out to make another charge. If the process is continuous the factory works in full swing throughout the day and by adopting "increased-production" techniques the production could be increased.

3) **Labour-saving equipment:** The saving of labour will mean corresponding decrease in cost of production and in these days of high cost and scarcity of labour, all possible labour-saving equipment should be provided.

4) **Economy of production:** The actual cost of production should be comparatively lower than the existing production costs and the economy in this field is the essence of success in any industry.

5) **Low capital expenditure:** The capital cost of the equipment must be sufficiently low so that it may be an incentive for others to take to it.

ADVANTAGES OF ARTIFICIAL DRYING

The advantages of artificial drying of the coconut kernel are manifold. It relieves the manufacturer from the constant strain of having to anticipate the vagaries of the weather for a number of days together, which he must do if he is not to be satisfied with manufacturing inferior quality copra. The primitive method means that the industrialist should be satisfied with inferior quality oil, the main product of the coconut.

The main factors that have to be reckoned with in any scientific approach to the drying of coconuts should be that as far as possible the dried product should be similar in all respects to the best specimen, that the process should not destroy any valuable ingredient of the product and that the time involved in the manufacture should be the minimum possible.

The moisture content of the coconut before drying varies with different varieties. But, on analysis of different samples, it is found that moisture varies from 20-25 per cent and fat from 30-40 per cent. After drying, the copra should not contain more than 4 to 5 per cent moisture to get the best result out of it. The fat content will then be at least 70 to 75 per cent. The oil obtained will not then contain more than 0.4 per cent moisture.

Thus we find that the moisture content of the raw nut should be reduced on the average by 15 to 20 per cent to make it conform to the standard quality of copra.

CUPS *versus* CHIPS

The traditional method of making copra is to cut the coconut into two halves and dry the halves. This, however, does not ensure uniform drying of the kernel. The brim of the copra cup is found to be more dry than the central portion, but all along people have been satisfied with such drying. The usual familiar smell near any copra depot or oil mill is due to the rancidity of the copra, resulting from incomplete drying of the cup-shaped kernel. This increases the acidity of the copra and is a great drawback as far as its keeping qualities are concerned. In considering methods of mechanical drying tradition need not deter us from obtaining the best quality product. The main factor contributing to the absence of uniform drying of a copra cup is its big size. For obtaining the best oil best quality copra must be used whether it is cup-shaped or not. The dicing of the material to small chips before drying will not only guarantee uniformity of dryness but also accelerate the speed of drying. Further, as copra millers have to disintegrate the cups before passing on the copra into the expeller or rotary mill, it is advantageous to

the millers, also if copra is made in the form of small chips.

RAPID DRYING OF COPRA

To follow the processes involved in the rapid drying of copra we have to know in some detail the actual physical changes that are gone through. The three common states in which water may be associated with the material in normal cases are:—

- 1. Surface moisture i. e. water adhering to the surface.
- 2. Internal moisture i. e. water occupying and permeating pores and interstices of the kernel.
- 3. Hygroscopic moisture i. e. moisture absorbed from the atmosphere till equilibrium is attained.

(This is possible only in cases of over-dry copra)

- 1) **Surface moisture:** This will evaporate readily.
- 2) **Internal moisture:** This must diffuse to the surface before evaporation can take place. This can best be carried out by hot air or gases. These do not absorb water but associate with water vapour as gaseous mixtures. The passage of the internal moisture to the outer surface of the particle requires conducted heat through the material. The moisture must move continuously to the surface of the chip of coconut. The evaporation rate must

exceed the rate at which the internal moisture travels in order to bring water to the surface. The heating must be so controlled that this goes on as a continuous process i. e., the internal moisture must be brought to the surface and from there the surface moisture must be evaporated. The drying is complete when there is about 4 to 5 per cent moisture in the product.

CONTINUOUS PRODUCTION

Several types of dryers are operated in various countries. Each drier has some advantages over the traditional methods adopted in India. Of these dryers the *Pearson's Patented Kiln** is worth considering. Such a dryer is installed in the estate of the Coconut Research Scheme, Ceylon. It has the advantage of large capacity and the capacity can be increased by increasing the size of the drying chamber. Though the claim is made that continuity of production can be achieved with the aid of this dryer, the dryer could not be worked in conjunction with an oil mill because the dryer cannot give an even feed of copra into an oil mill with a crushing capacity of a similar quantity of copra. The other types of dryers are not considered here since they do not ensure continuous production.

The most up-to-date mill in Ceylon preparing desiccated coconut or copra

* For a description of this Kiln please see "The Indian Coconut Journal", Vol. I, No. 4, p. 41.

is not worth emulating. The machinery used there does not satisfy one who wants the best. No labour-saving devices are used and there is great wastage. The only improvement noticed over the Indian industry is that most oil mills are equipped with expellers giving a higher yield of oil than rotaries.

EXPERIMENTS IN ARTIFICIAL DRYING

Keeping the above factors in mind I attempted artificial drying of copra using electric power or oil and tried to devise the best drying apparatus possible.

An oven with an infra-red radiation equipment was fitted up and coconuts in different forms—cups, chips and ribbons—were put in it and dried in the laboratory. In the case of cups the brim of the cup was well dried but the inside of the cups was only partially dried. The time involved for drying was three hours. After the first $1\frac{1}{2}$ hours the kernel could be removed from the shell and a further $1\frac{1}{2}$ hours were sufficient to dry the kernel to commercial quality. It was noticed that a thick crust was formed inside the cups which prevented further drying as the pores were shut off. It was thus proved that if we have to adopt the radiation equipment or for that matter any equipment for artificial quick drying the cup was hardly the

best shape in which the kernel should be dried.

Chips and ribbons which were dried were perfect. The economics of the method were worked out and it was found that the electric current consumed was out of all proportion to the amount of kernel dried. If this method was commercially workable we could arrange a drying chamber with about 100 units of infra-red equipment and make it work on the continuous production principle.

THE ROTARY LOUVER DRYER

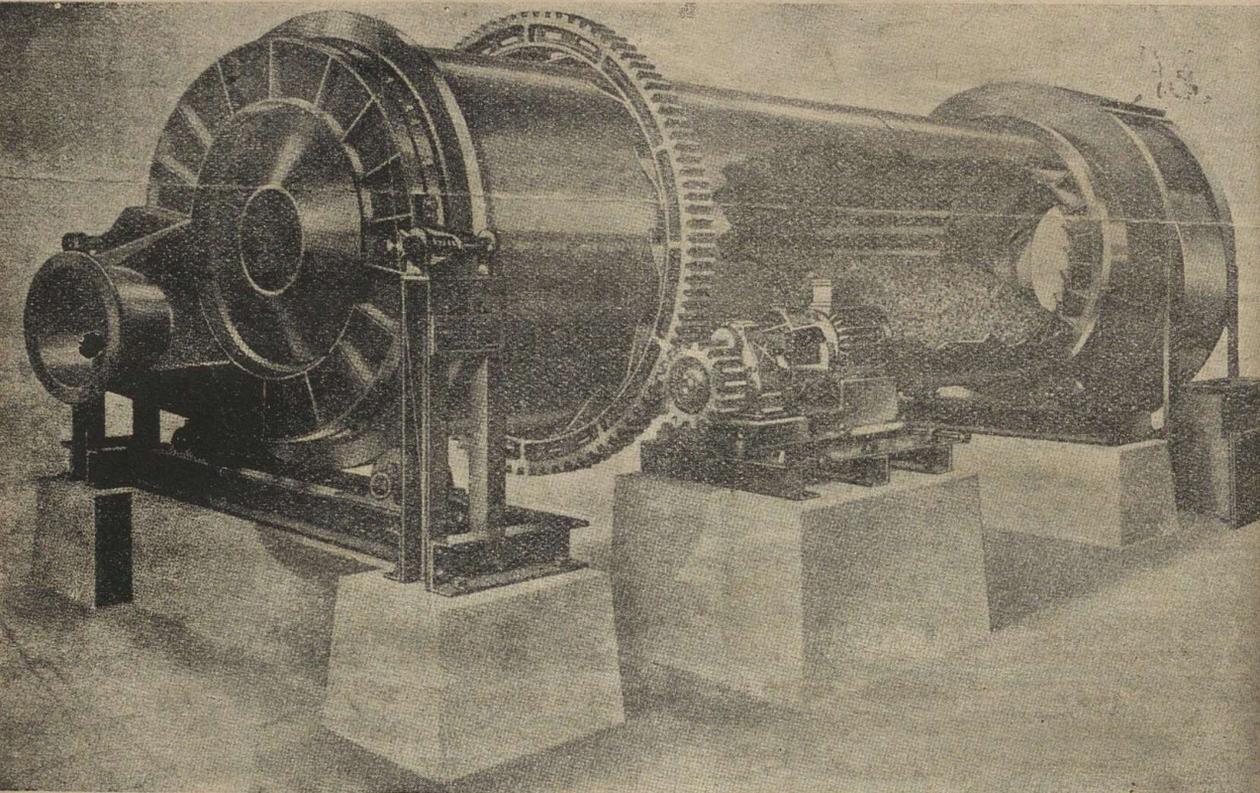
The next experiment was to dry the chips with hot air. This yielded the best results. The copra made was found to contain 76 per cent oil which according to usual standards was the very best.

The best drying machine according to known standards is the *Rotary Louver Dryer*. The Rotary Louver Dryer comprises a shell (drum) with a series of radial plates fitted into its internal circumference, forming channels integral with the shell into which the heating medium is admitted. These channels taper in depth from inlet to discharge ends and are covered by tangential louvers which overlap in such a way as to leave passage for the heat to the inside of the drum and at the same time prevent any material from falling into the channel. This forms an inner

The following is a list of the books in the collection of the University of Madras.

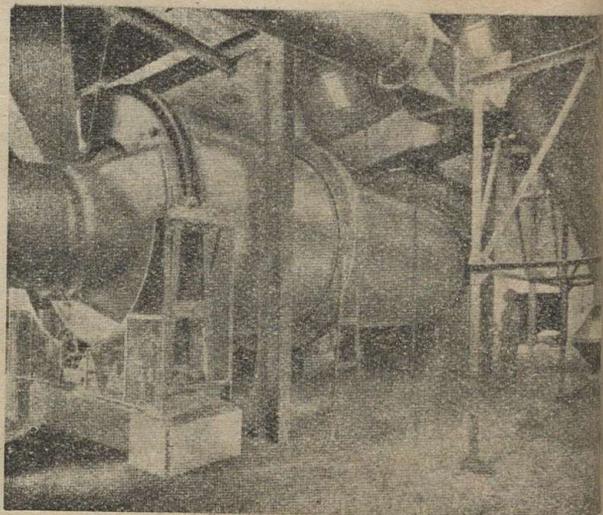


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The Rotary Louver Dryer showing Diced Coconut Chips, $\frac{1}{4}$ " cube inside the Drum.

A view of the Drying Installation from the feed end.



drum increasing in diameter from inlet to discharge ends.

A manifold on the stationary head at the feed end admits the heating air only to those channels underneath the charge of material.

As the drum revolves at slow speed, fresh channels come into line with the inlet mouth and the heating medium passes through the bed of material.

The chips travel to the discharge end as a result of the slow rotation of the drum and the increasing internal diameter, and the time taken for the material to travel the full length of the drum is sufficient to convert the raw chips to copra dried completely and uniformly.

The heating air is delivered to the drum under pressure while the exhaust is taken from the drum under suction so that a balanced condition is obtained in the drum. This condition allows the use of an open discharge end which has the advantage that the internal operating condition may be observed.

The actual process of drying in a Rotary Louver Drum may be described briefly as follows:—

The small chips of coconut to be dried are fed by means of a vibrating feeder at an even and continuous rate into the drum. The heating and drying medium is provided by

means of a combustion chamber fired by furnace oil.

The main fan specially designed to suit the operating temperature induces the hot air at a predetermined temperature which is automatically controlled and delivers it by way of the hot air inlet through the manifold into the effective air channel which is covered by the material to be treated.

After passing through the material the exhaust air together with the water vapour is extracted by means of an exhaust fan. The dried product is discharged continuously from the spigot.

ECONOMICS OF LOUVER DRYER

A financial estimate of the working of the rotary drying plant will reveal that this machinery could with advantage be introduced in India. In the following estimates the rates for the several operations are based on the prevailing piecework rates in Travancore. The capacity of the dryer is 4 tons per 12 hours operated on by an oil fired combustion chamber.

The coconuts are collected from the producers direct and are husked and split in the factory.

The estimates are based on the ruling prices of coconuts and coconut products as on 15-5-1948 (Prices taken from the "Bulletin issued by the Indian Central Coconut Committee").

BEST RESULTS

The main drawbacks pointed out by critics (experts) of artificial drying have been (1) that excessive smoke affects the colour and appearance of the copra (2) that condensation of saturated air leaves deposits of water on copra making it slimy (3) that copra at the bottom layer gets over-dry and semi-burnt while the upper layers are not completely dry (4) that kiln-dried copra contains a lesser percentage of oil (63-65 per cent only).

In the above described dryer all these drawbacks are eliminated. The drying is done through cheap furnace oil, thus saving valuable coconut shells. No smoke occurs during combustion as this is done in specially prepared burners in a combustion chamber. The hot air passed into the drum will give paper-white copra. The appearance and quality is the best possible. The method of letting in air and its exhaustion by suction eliminate the possibility of condensation of saturated air. The principle of the rotary gives no chance for any material getting over-dried or under-dried as the rotary motion will bring each chip in contact with the hot air continuously. The length of the drum is so fixed as to get complete and uniform drying to the material before it comes out and so the product is completely dried. The oil content

in the copra is the maximum possible.

DESICCATED COCONUT

The main products of the coconut kernel are desiccated coconut, copra (edible and milling), oil and oil products.

Desiccated coconut is prepared from coconut by first removing the husk and shell, then paring off the brown skin from the kernel and passing the white meat through cutting or shredding machines to produce threads or chips and drying the same in hot air dryers. The specification for good quality desiccated coconut is that the water content should be as low as 3 per cent.

The chips or ribbons should be prepared under a temperature higher than that for making copra. Since the water content is as low as 3 per cent it should not be exposed to the atmosphere as hygroscopic moisture from the atmosphere will be absorbed by it to the detriment of its quality. Therefore, it is usually packed in lined cases similar to tea chests.

The system of grading the meat by a system of sifters, as in tea factories, has been prevalent in Ceylon. Most mills make only three grades, the fine, medium and coarse, depending on the size of each particle. Some European-owned mills also produce fine threads and chips which fetch higher prices in the market.

Though it is usually packed carefully in lined cases similar to tea chests, its keeping qualities are not high and it becomes rancid and mouldy soon. Prophylene Glycol may be sprayed on it up to 3 per cent in weight or it may be mixed with sugar when packing, as both these prevent rancidity and moulds.

POSSIBILITIES OF MANUFACTURING COCONUT PRODUCTS

As copra and oil are readily absorbed by the Indian mills and industries, their economic possibilities need not be stressed here; but the improvement in the quality of the products will no doubt give a better return to the manufacturer than at present.

Doubts have been expressed in some quarters regarding the possibilities of the manufacture of desiccated coconut. The main point stressed by the Indian Central Coconut Committee in 1945 was that since there was short-fall in the supply of coconuts in India and the whole production could be utilised for the oil and soap industries, encouragement of the manufacture of desiccated coconut could not be considered till supply position was better.

The view of the Coconut Committee in this regard is no doubt based on an over-all view of the oil and soap industries. But the idea of the grower of coconut may be that, if alternative industries are found for his

produce, he is likely to get a higher price for it. Hitherto the main buyer of coconut has been the oil miller and he dictated the price to the producer. If desiccated coconut is also manufactured, there will be competitive buying of coconut and there will be an appreciable increase in the price of coconut. This will be better appreciated if we looked at the price figures for raw coconut in Travancore State during the "control" days. The Travancore Government fixed the prices of milling copra and coconut oil, but allowed free prices to prevail for edible copra. The edible copra used to fetch a premium in the markets and this was reflected in the price got by the producer. The price was higher than the price the producer would have got if control had been clamped on all products.

The same will be the effect of manufacturing desiccated coconut in India. Ceylon had contracted with the Ministry of Food in Great Britain giving her all her coconut products in the form of oil; but subsequently the contract was widened and Ceylon was allowed under the contract, to manufacture a limited quantity of desiccated coconut. The effect of this was to improve the price of coconuts considerably over the precontract price. In short, if alternative uses are found for the coconut kernel, instead of the price being dictated by the oil miller, it will be based more

on the supply and demand principle. And the coconut grower will be benefited to that extent.

Already enquiries are being received in India from foreign countries regarding the export of desiccated coconut. One firm alone asked the present writer if they could be supplied with a minimum of 100 tons per month. This will show the high demand for the product all over the world. Indian demand for this product is also very high.

The desiccated coconut industry is assured of a very good future in view of the heavy demand for the product. It will also help the coconut grower by giving him a very good price for his produce.

In the foregoing pages the prevailing condition of the coconut kernel products industry has been examined and remedies suggested so that it may be done on a scientific and organised manner. Industrialisation at the plantation could successfully be worked only if the estates themselves are economic units. This very necessary development could not effectively be undertaken in India by the growers of coconut as the number of plantations that are more than 50 acres in extent is very small. The remedy would seem to lie in a system of co-operatives, organized according to schemes so far adopted by the Indian Central Coconut Committee.

Let us take a look at the other plantation industries like tea. In large estates, no doubt, there are good tea factories. But we find small tea factories also operating in areas where the holdings are small. These cater to the very large number of small estates which cannot afford a factory of their own. They either purchase the green leaf from the producers or make tea for the producer by charging a small fee for the work. This has been found to be workable and such tea factories are flourishing and are a source of untold benefit to the small producers.

Similar schemes could be worked in the case of the coconut also. Since mechanised drying is new to the country the first one or two factories may have to be subsidised and once the advantage of starting such copra mills is understood by our enterprising businessmen, they will be set up in sufficient numbers.

Ceylon's advantage was that there the European who had got interested in coconut showed the way for the others to follow. Here the Indian Central Coconut Committee should take the lead in the matter either by undertaking the erection of an up-to-date drying plant or subsidising the starting of one or two copra mills.

This is, of course, a bold step. But bold steps alone have brought results.

A CHEMICAL INDUSTRY BASED ON DRY DISTILLATION OF COCONUT SHELLS

BY S. R. C. POTI

INDUSTRIALLY backward as we are in India today we have yet to establish in this country many industries which are economically feasible and are of economic importance. Taking our own land of Kerala, one of such industries is a chemical industry based on the dry distillation of coconut shells. The economic position of such an industry can be gauged by a comparison with the wood distillation industry. The latter, after many vicissitudes and fluctuations in its fortune, has now become fairly stabilised, especially in America, and in India itself this industry has fairly bright prospects. The wood distillation plant attached to the Mysore Iron and Steel Works produces about 60 tons each of acetic and methanol, the charcoal being used by the iron and steel industry. Further expansion of this industry

is in the programme of Mysore, Bengal and other Provinces where wood is reasonably low-priced.

Coming to coco shells, the content of carbon, acetic, methanol and acetone is greater than in the most suitable of woods; further, the charcoal from the shells finds a special use, viz., for conversion to Active Carbon. It is accepted that for making Active Carbon, nut shells and fruit pits are the best raw materials, the best of them being coconut, babassu and cohune shells. So far as India is concerned, we are concerned only with the first.

Thus, from a comparison with the wood distillation industry the shell distillation industry has definitely a bright future. In pre-war days thousands of tons of shell charcoal used to be exported to foreign countries from Travancore and Cochin, and India used to import, and still imports, all her requirements of Active Carbon. Development from now on envisaged for the vegetable oil industry definitely points to a much higher consumption of Active Carbon and there is no reason why all our

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requirements of this material should not be met by indigenous manufacture.

At present all the shell charcoal is being made by the uneconomical burning of the shells in the open, wasting into the atmosphere very useful chemicals like those already mentioned. If the burning is done under proper conditions of control these important products could be recovered and commercialised. In the matter of active carbon alone, the carbon manufactured by the local industry would have the advantage over the carbon imported, inasmuch as freight to and from the charcoal, unactivated and activated respectively, would be eliminated and there would be a reduction in total costs due to the commercialisation of the by-products. With this advantage over the imported carbon and the increasing market for this material in this country, the economic position of this industry should be very encouraging.

PROCESS—A SHORT DESCRIPTION

Dry distillation of coconut shells: When heated in suitable equipment, coconut shells undergo what is termed destructive distillation, and gases begin to be given off at about 300 Deg. C. At about 600 to 700 Deg. C. the volatiles are completely driven off, though sometimes a maximum temperature of 900 Deg. C. may be reached in the stills.

The gases that come off are condensed, the non-condensable portion being scrubbed and used in suitable burners for heating the shells. Such gases would be about 20 per cent of the shells, by weight, or about 6,000 c.ft. of gases of calorific value about 320 B.T.U's per c.ft. (Wood gives only 5,000 c.ft. of gases of 290 to 300 B.T.U's per c.ft.)

The condensed or settled pyrolygineous acid contains Acetone (B.P. about 56 Deg. C.), Methanol (B.P. about 65 Deg. C.) and Acetic Acid (B.P. about 118 Deg. C); and Carbolic acid, Creosote, Pitch, etc., are recovered from the 'Settled' Tar.

Fractionation of the pyrolygineous acid: The first fraction that comes off in the first still (of copper) is a mixture of methanol and acetone. It was thought, till very recently, that it would not be possible to separate out methanol and acetone entirely, but recent advances in the direction of separating components with only a difference of 0.5 Deg. C. in their B.Ps. solve this difficulty (*vide* The Journal and Proceedings of the Royal Institute of Chemistry, part VI, 1945, page 224). But even if they were not entirely separated there would be no harm done as the mixture itself has a good market. The old method was to neutralise the acid with lime and thus there was introduced grey acetate of lime. But now this too can be avoided and acetic acid distilled off directly, as done in all big wood distillation plants.

The tar, which would be about 10 per cent of the shells, settled out at the bottom of the tank, is then fractionated in suitable stills and phenols and creosote recovered. The remainder is pitch, which is a wood preservative and can be used for roadmaking purposes.

Activation: The carbonised shells or 'char' from the first still is then given suitable treatment with steam and acid in suitable vessels, and batches standardised. The char is then powdered in a closed grinding circuit with air separation system, bagged and sold as activated carbon.

PRODUCTS AND THEIR COMMERCIAL VALUE

The various economic products that could be obtained from the dry distillation of the shells and further processing of the distillate are: shell charcoal, active carbon, acetic acid, methanol, acetone, a mixture of these two latter chemicals, carbolic acid and pitch.

SHELL CHARCOAL

The charcoal obtained from the shells, 30 per cent of the shells as commercially obtained, has a smaller percentage of ash than wood charcoal and therefore, if provided in proper shape and form should do better than wood charcoal as a fuel for automobile gas generators. The presence of moisture and volatiles in wood charcoal, as ordinarily obtained is objectionable in the Up-draft and

Cross-draft generators and hence, recourse is now had to the less efficient Down-draft generators. The incentive has been to alter the generator to suit the lower grade of fuel than to find the fuel suitable for the more efficient type of generator.

It is here that the shell charcoal, as obtained from this industry, entirely free from moisture and volatiles, should play a prominent part as fuel for automobile gas producers. This has special economic significance for S. India and especially for the West Coast, as there is a large number of motor vehicles in this region on producer gas. At present this clientele has not taken kindly to shell charcoal for the simple reason that the shell charcoal is not made available in proper sizes and shape. This could be easily rectified by mechanical crushing of the carbonised shells or by bricquetting powdered charcoal.

ACTIVE CARBON

Active carbon is used in great quantity in the refining of vegetable oils, sugar, glycerine and syrups, as a gas absorbent and in water purification.

In the refining of vegetable oils active carbon and Fuller's-earth (activated) are used as decolorisers but active carbon is by far superior to Fuller's-earth in that active carbon, in less than 1/5th of the quantity of earth is sufficient for the same

duty. Absorptive loss of oil by earth is greater, as is evident, because more oil is necessary to wet a greater quantity of earth. Carbon decolorises and deodorises, earth only decolorises. It may even leave in its wake an 'earthy' smell, very characteristic and difficult to be removed entirely. Addition of carbon prevents or minimises this secondary odour while bleaching oils and hence to be preferred in good practice. Besides, in colour removal, the 'red' chromo factor in oils can be removed completely only by using carbon along with earth. The most efficient and economical decoloriser is a mixture of active carbon and Fuller's-earth.

During the past two decades there has been considerable growth in the use of active carbon for sugar refining. This is a more powerful decoloriser than bone char and much smaller quantities are sufficient. This reduces the quantity of water required for washing the char and of fuel for revivification.

Active carbon is used in the recovery of solvent vapours and the wide usage of volatile solvents in paint and lacquer applications and in the manufacture of coated fabrics makes the recovery of solvent vapours released on drying, highly desirable.

Active carbon is used for controlling flavour and odour of water, especially in the beverage industry.

Active carbon (vegetable) has replaced bone char (animal) in purifying and decolorising juices, syrups, molasses, oils and other food products. Further, it is used in the pharmaceutical industry for its absorbent action for alkaloids, enzymes, toxins and poisons of various sorts.

An indication of the market for active carbon in this country could be had from its use in the vegetable oil and sugar industries alone.

Vegetable oils require 0.5 to 1 per cent by weight of active carbon in decolorising, and estimating the total oil refined in this country at 3 to 4 lacs tons per year a minimum of 1,500 tons of active carbon would be consumed by this industry alone. Moreover, the vegetable oil industry is marked for an appreciable expansion when the production of vegetable ghee shoots up by another 2 lacs tons per year with the installation of the plants recently allocated by the Government for the various provinces. This industry alone should provide one with a good market for active carbon.

In sugar refining the quantity of carbon required is about 0.25 to 2 per cent of the weight of sugar refined. With an output of more than 12 lacs tons of sugar in the year, one should be provided with a very good market for active carbon.

ACETIC ACID

Acetic acid is a basic product for numerous chemical industries and is used in dyeing, rubber manufacture, preparation of white lead, cellulose acetate, all acetates and acetones and in medicine.

The doubt that synthetic acetic acid may be cheaper and hence will displace distilled acetic acid may be laid to rest. It is like 'ghani' oil *versus* expeller oil. One will always supplement the other. This is borne out by the fact that with all the advantage of the synthetic acid, the acid made by wood distillation still amounts to 10 per cent of the acid used in America. The acid obtained from the shells is more economically produced than the one obtained from wood.

Pre-war imports into India of this acid amounted to about 300 tons but in 1939-40 it amounted to 500 tons. This was in addition to the acid produced in India itself. Wood distillation plant attached to the Mysore Iron & Steel Works produces annually 60 tons of acid. Hyderabad Chemicals and Fertilisers have recently purchased the Government Acetic Acid Plant. Parry & Co., propose to set up a plant with a capacity of 150 tons annually.

From the above demand in India, which is definitely bound to go up much further with the expansion of

the consuming industries, the marketability of Acetic acid should present no difficulty.

ACETONE

This is used in the manufacture of explosives and acetylene gas supply and is primarily an industrial solvent used in the manufacture of various varnishes. This is already manufactured in India by the Cordite Factory at Aruvankadu and the Mysore Iron & Steel Works, but there is still an unmet demand for this in the country. With the expansion of the consuming industries the marketing of this will not be a problem at all.

METHYLACETONE

According to old methods of manufacture the separation of methanol and acetone presented difficulties, but now the fractional separation of these from their mixture is not difficult. This point has been already dealt with earlier. Even if we do not separate them fully it is not at all difficult to find a market for the mixture as such, as it is a solvent used in the paint and varnish industry.

METHANOL

We shall assume that only a portion of it is separated out. Its largest use is as a denaturant for ethyl alcohol. It is used in the manufacture of formaldehyde, which is used for making organic medicinal compounds, synthetic dyestuff and plastic moulding powders. It is also used

as a disinfectant and in the plywood industry.

At present Mysore Iron & Steel Works has a production of about 60 tons. The plywood industry alone consumes more than this and a much higher consumption is expected in the future due to expansion in the synthetic dyestuff industry and the manufacture of moulding powders.

PHENOLS

Phenol or carbolic acid is used as a disinfectant and in the manufacture of fungicides and germicides as also in the manufacture of plastics and dyestuffs. The acid that would be obtained from the shells would give a much purer form of product, able to compete favourably in price with the acid now obtained from the coke ovens as a bye-product.

PITCH

The residue left over after the recovery of the above products is pitch, useful as a preservative and for road-making.

YIELD

About 7,000 shells go to make a ton. The ordinary undried shells contain about 10 per cent moisture, which pass on into the distillates on distilling the shells in the first still.

1 ton of shells on analysis:—

Non-condensable gases	20 per cent
Charcoal	35 „
Distillates	45 „

The distillates contain acetic acid, methanol, acetone and tar, and this tar on further distillation gives creosote and carbolic acid, the remainder being pitch. A portion of the methanol and acetone remains as a mixture and though this could be completely fractionated it is not necessary to do so unless the market for the mixture is poor.

The following is the percentage of the various commercial products that could be obtained from the shells by distillation and further fractionation of the pyroligneous acid:—

Charcoal	...	35 per cent.
Acetic acid	...	6 „
Methylacetone	...	1.5 „
Methanol	...	0.5 „
Carbolic acid	...	0.6 „
Creosote	...	0.5 „
Pitch	...	10 „

or

1 ton of Shells would give:—

Charcoal	...	7 cwts.
Acetic acid	...	130 lbs.
Methylacetone	...	30 „
Methanol	...	10 „
Carbolic acid	...	13 „
Creosote	...	10 „
Pitch	...	200 „

MACHINERY, STEAM, FUEL & POWER REQUIREMENTS

All the machinery required are locally fabricable and auxiliary equipments like Boiler, Superheater,



Pumps, etc. can be also had locally, either new or second-hand. The chief items of machinery required are:-

1. Still or Firebrick oven for the dry distillation of the shells, complete with suitable containers for the shells, pipe connections, condensor for the pyroligneous acids, etc.
2. Equipment for the collection of non-condensable gases and for feeding it back to the primary still as fuel, complete with gas fan and scrubbers.
3. Secondary Still for fractional distillation of the various acids.
4. Equipment for steaming carbonised shells.
5. Vessels, lead-lined and otherwise for processing the charcoal.
6. Auxiliaries like tar pump, pumps for pyroligneous acids and fractions, water pump, grinding and classifying mill, gas fan, pressure fan, etc.

We require superheated steam for processing the charcoal to activated carbon and for heating the secondary stills. The requirement would be about 1,000 lbs. of steam per ton of

pyroligneous acid fractionated, and a similar quantity per ton of carbon activated. The fuel requirement per ton of shells for the activation of the charcoal obtained and for the fractionation of the pyroligneous acids from the same would be about 5 cwts. of coal or firewood.

If we take a factory where 10 tons of shells are processed per day the power requirement of the same would be about 500 to 600 units per day. The horse power required would be about 60.

As the site of the factory has to be such as to make cheap water transport facilities available water required by the industry will not present a problem. The processing aids mainly required are Lime (if at any time grey acetate of lime is made), Sulphuric acid, Caustic Soda and Soda Ash, in very small quantities. These also will not present any difficulties.

CONCLUDING REMARKS

The speaker had been in correspondence with the Council of Scientific and Industrial Research regarding the utilisation of the shell charcoal as a fuel for Gas Producers in Automobiles and the information provided by the Council is given below:—

	Casuarina	Coconut Shell
	Charcoal.	Charcoal.
Speed	2,000 rpm.	2,600 rpm.
Maximum H. P. developed .	21.6	26
Moisture	4.65 per cent.	4.2 per cent.
Calorific value, on moisture and ash free basis	12,000 BTU's.	12,400 BTU's.

“From the above it would appear that coconut shell charcoal is superior to ordinary charcoal” for use as a fuel in gas producers for automobiles. “There is also the necessity for determining the most suitable grading range which will allow the coconut shell charcoal to flow freely in the hopper generator without causing arching”. It is here that we have to concentrate on supplying the shell charcoal in suitable size and shape, as mentioned earlier.

Activation will, of course, pay us much more than the sale of the charcoal as such, but we have gradually to work up the market for the active carbon and therefore, it may sometimes be advisable to sell a portion of the charcoal as such only as an interim measure.

Today active carbon is sold by regular importers at prices ranging from Rs. 1200 to Rs. 2000 per ton. Our own cost of production for active carbon, with the ruling price of charcoal, would not be more than Rs. 600 to 650 on a very liberal estimate. Therefore, we can easily gauge the profitableness of an industry based



on the activation of shell charcoal. The active carbon which is imported bears a 30 per cent import duty which is a straight advantage to active carbon manufactured in the country. Further, the freight paid on the imported carbon is an additional point in favour of carbon of indigenous manufacture.

—Paper read before the Kerala Engineers' Association and published in the Journal of The Kerala Engineers' Association.

RETTING OF COCONUT HUSKS- PART II- THE TENSILE STRENGTH OF COIR FIBRE

By A. O. MATHAI, N. S. VARIER AND K. L. MOUDGILL

EVEN though coir is exported from Travancore in large quantities for matting and cordage purposes¹, very little work has been done on the tensile strength and elastic properties of the fibre of different varieties and the variation of these factors under different conditions of retting. There are many varieties² of coir fibre in Travancore, viz., (a) *Angengo*; (b) *Alapat*; (c) *Ashtamudi*; (d) *Paravoor*; (e) *Kayamkulam*; (f) *Vaikom*; etc. But these varietal differences are mainly based on the nature and amount of the adhering impurities like pith and sand and also on the colour which ranges from golden yellow to greyish black. It is obvious that for a scientific grading of these varieties their tensile strength must be an important factor. With a view to collect data about the tensile strength and elongation of these varieties, an apparatus was specially designed and a large number of determinations conducted.

THE APPARATUS

The principle of working of the apparatus is the same as that of the instrument used by O'Neill for cotton

fibre³, namely, to increase the pull by means of a float. In the case of cotton, a load of the desired magnitude and appropriate volume, having tubular shape, is attached directly to the fibre to be tested. The load is made to float in an outer jacket of water, which is emptied gradually, and by which the resultant weight of the float increases and finally breaks the fibre. The load at the moment of breaking is read on a graduated scale on the float by the level of water in the outer jacket.

In the present case the method had to be slightly modified so as to cover the desired range. The range required was between 1 and 5 lb. weight, within which even the thickest fibre gave way. A float of this maximum weight was found to be too inconvenient. Therefore, a smaller load in the shape of a glass tube closed at the end, of length about 50 cm. and radius of cross section 1.5 cm. was used. The weight of the tube was adjusted by means of lead shots to be just sufficient to make the float sink in water. The pull exerted by the float was stepped up by means of a wheel and axle

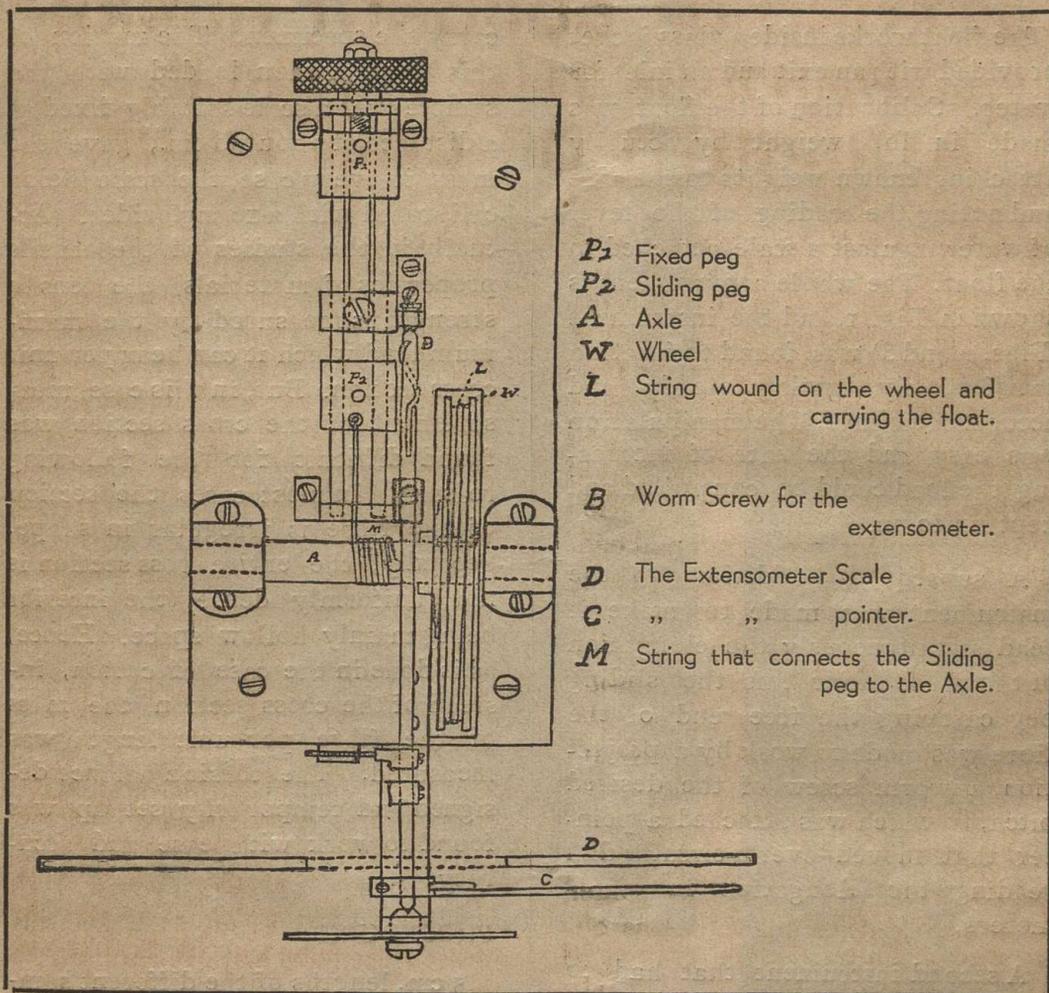


FIG. 1. Schematic Drawing of the Tensile-strength Apparatus.

arrangement so that the fibre attached to the axle could be given a maximum pull of about 5 lb. by applying the full weight of the float on the wheel.

In actual practice it was found that the attachment of the fibre to the instrument was not quite easy. Invariably there was a tendency for

the fibre to break at the points of attachment. This was finally overcome by fixing the fibre to metallic terminals by means of sealing wax. These terminals were then fixed in position, one on a fixed peg capable of adjustment and final clamping and the other on a sliding peg, attached to the axle by a strong string.

The float works inside a glass jacket provided with an exit and an inlet for water. Calibration of the float was made in lb. weight by actually attaching known weights to the axle and noting the reading of the level of water against a scale attached to the float. The whole arrangement is shown in Fig. 1, and the instrument (Figs. 2 and 3) was found to function satisfactorily, giving steady and accurate readings. The manipulation was easy and the rate of increasing the load could be controlled and kept uniform.

A subsequent addition to the instrument was made to make it read simultaneously the elongation of the fibre. For this the sliding peg carrying the free end of the fibre was made to work by a projection, a worm screw of the desired pitch, to which was attached a pointer that moved over a circular dial reading the elongation in millimeters.

A second instrument that had to be designed along with it was a torsion balance with which the weight of a short length of the fibre could be measured easily and accurately. This was in the form of a slender phosphor bronze filament about 10 cm. long supported between rigid metallic supports and carrying a lever fixed to the middle point in the form of a thin steel wire having a hook at the farther extremity to

carry the specimen. The motion of this lever, when loaded with the sample over a scale suitably fixed at a distance of about 5 cm., gave the mass, in every case, the scale being calibrated with a 10 mg. rider. Actually in the studies of the tensile properties of materials, the tensile strength is measured by the maximum load which it can bear per unit cross section. But, in this case, measurement of the cross section was found difficult for the following reasons. In most cases the section of the fibre is irregular in shape. Secondly, the entire cross section is not uniformly dense, the interior being mainly hollow space. Hence, as is done in the case of cotton, instead of the cross section, the mass of the fibre per unit length was measured. The torsion balance designed and temporarily set up was found to work with ease and accuracy.

PROCEDURE

5 cm. lengths of the different samples of the fibre were cut from the central uniform portion and were weighed in the torsion balance. These were attached to the metal terminals and mounted one after the other on the instrument. The water from the outer jacket was gradually drawn out until the breaking of the fibre, when the reading of the water level against the scale gave the tension at that moment. The elongation

Photos

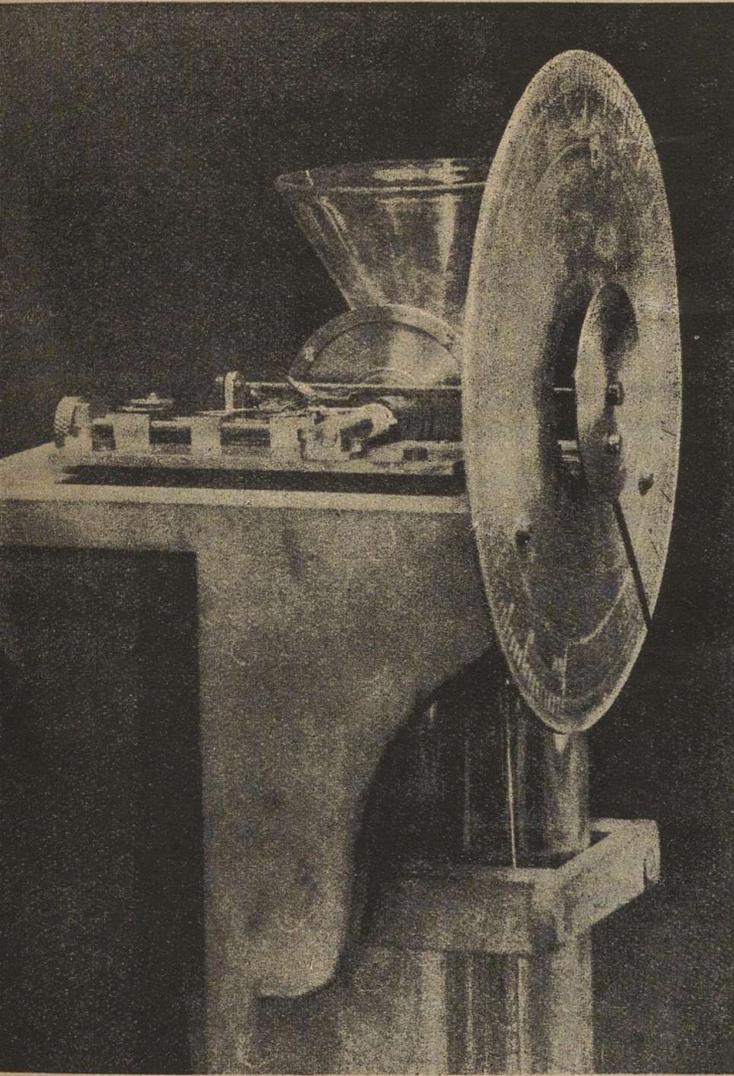


Fig. 2.
The Tensile-Strength
Apparatus (close up view)

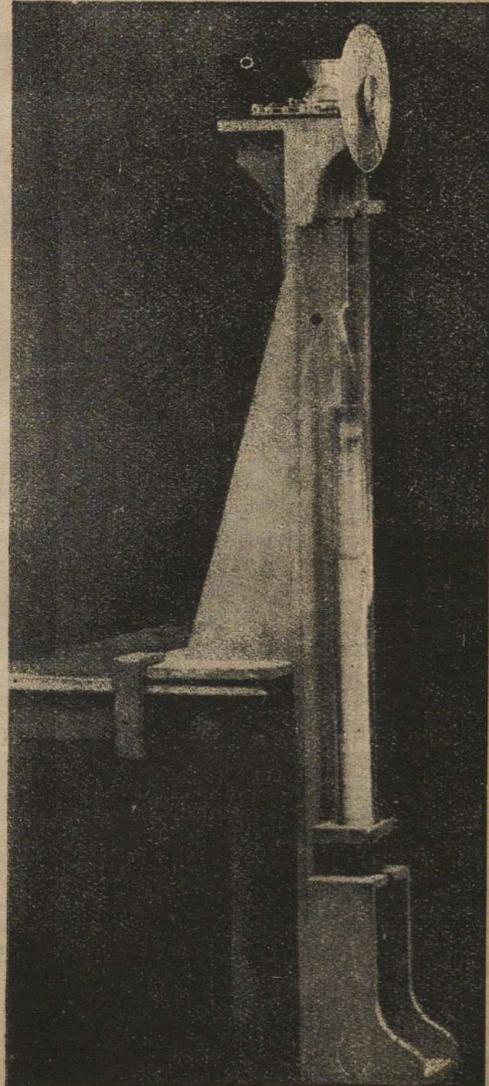


Fig. 3.
The Tensile-Strength Apparatus



was read directly from the extensometer dial. Measurements in this case were mainly confined to the maximum tension which each fibre can bear.

RESULTS

Studies have been made on two groups of fibres: (a) samples got from different stations of Travancore, viz., *Ashtamudi*, *Paravoor*, *Anjengo*, *Kayamkulam*, and, (b) samples made by different chemical treatments on one of these. In group (a) 18 samples and in group (b) 12 samples were tested in every case.

The data relating to the measurements taken have been statistically analysed.

STATISTICAL ANALYSIS

Table I gives the measurements of mass (x) for 5 cm. of fibre in scale

divisions of the torsion balance, viz. 1 division = $\frac{5}{18}$ mg. and breaking load (y) in lb. weight for fibres from 4 different localities.

From the scatter diagram for each locality the regression appears to be linear, and to test whether there is any significant difference in the fibre measurements for the 4 localities, the analysis of co-variance technique has been adopted. Table II gives the results of the analysis.

The value of F is significant.

Table III gives the adjusted means (y) for the 4 localities. Reference to the table of Student's " t " brings out, that *Paravoor* variety is the worst and the *Kayamkulam* variety is the best.

Table IV gives the constants for x and y .

TABLE I—Values of x and y .
Localities.

Sample No.	Ashtamudi		Paravoor		Anjengo		Kayamkulam	
	x	y	x	y	x	y	x	y
1	9.20	3.06	10.25	3.06	5.25	1.69	14.00	4.19
2	10.10	3.25	6.50	2.13	6.25	2.13	14.25	4.00
3	9.90	3.13	12.25	3.56	10.00	3.13	8.50	2.63
4	8.00	2.63	5.50	1.94	10.00	3.19	9.50	2.25
5	9.50	3.31	12.00	3.38	11.25	3.25	10.75	2.38
6	4.10	1.38	7.50	2.25	5.00	1.69	10.25	2.75
7	8.00	2.00	6.25	1.81	3.50	1.13	9.75	2.69
8	7.90	2.25	8.00	2.69	7.50	2.13	4.25	1.25
9	12.70	4.25	5.00	1.31	7.25	2.75	12.75	3.25
10	15.60	5.25	9.00	2.38	8.25	2.38	10.75	3.00
11	14.00	4.38	6.50	2.00	13.25	4.06	12.50	3.81
12	6.00	2.00	7.50	2.38	11.75	3.63	9.75	3.13
13	8.00	2.13	9.50	2.50	10.75	2.63	10.25	3.44
14	4.00	1.25	9.75	2.94	14.25	4.00	7.75	2.50
15	7.50	2.50	6.50	1.88	6.00	2.00	6.50	2.13
16	9.20	2.63	8.25	2.25	10.25	3.50	5.25	1.56
17	7.25	2.38	11.00	2.31	11.75	4.00	8.25	2.50
18	11.75	3.50	7.25	2.25	11.25	3.56	9.25	2.69

TABLE II - Analysis of Co-variance.

Source	Degrees of Freedom.	Squares and Products			Errors of Estimate.		
		Sx^2	Sy^2	Sxy	Sum of squares	Degrees of freedom	Mean square
Total	71	544.37	50.56	156.91	...	...	...
Locality	3	18.60	1.93	4.76	...	...	...
Sample	17	152.73	14.48	45.65	...	...	...
Error	51	373.04	34.15	106.50	3.74	50	0.075
Error and Locality.	54	391.64	36.08	111.26	4.47	53	...
Difference for testing adjusted means for y		...	...	...	0.73	3	0.243
$F = 0.243/0.075 = 3.24$							

TABLE III - Adjusted Means for y .

Mean	Locality			
	Ashtamudi	Paravoor	Anjengo	Kayamkulam
	2.73	2.51	2.75	2.92

TABLE IV.

Locality	Mean		Standard Deviation		Correlation coefficient Between x and y .
	x (mg)	y (kg)	x (mg)	y (kg)	
Ashtamudi	2.51	1.2923	0.827	0.4581	0.976
Paravoor	2.29	1.1095	0.584	0.2663	0.958
Anjengo	2.52	1.2814	0.829	0.3910	0.965
Kayamkulam	2.69	1.2637	0.736	0.3425	0.923

TABLE V.
Measurements of chemically treated fibres.
Chemicals Treated

Sample No.	Water		Dil. H ₂ SO ₄		Oxalic Acid		Bleaching Powder		Tartaric Acid		Chlorine Water		SO ₂ solution		Original (Ashtamudi)	
	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>	<i>x</i>	<i>y</i>
1	7.50	1.50	4.00	0.81	4.25	1.50	5.25	0.97	4.25	1.44	9.00	2.31	6.25	1.75	9.20	3.06
2	5.25	1.56	6.00	1.09	8.50	2.50	4.00	0.81	12.25	3.38	3.30	0.81	8.25	2.69	10.10	3.25
3	9.25	2.53	7.00	1.22	6.75	1.81	5.25	1.38	3.25	1.13	6.50	1.56	5.50	1.69	9.90	3.13
4	7.75	2.13	7.75	1.41	5.25	1.69	11.50	3.16	4.75	1.47	3.25	0.75	7.00	2.00	8.00	2.63
5	7.25	2.00	8.50	1.75	8.50	2.63	8.75	2.38	3.00	0.81	13.75	3.94	6.50	1.88	9.50	3.31
6	6.75	2.00	5.00	1.91	4.00	1.25	4.75	1.88	10.25	3.03	8.25	2.25	3.00	0.69	4.10	1.38
7	4.75	1.38	9.25	1.31	3.00	0.69	6.75	1.94	6.25	2.13	12.50	3.63	5.50	1.53	8.00	2.00
8	8.00	2.06	6.50	1.13	7.25	2.25	11.75	5.41	5.25	1.63	11.25	3.75	4.00	1.31	7.90	2.25
9	4.75	0.97	9.00	1.56	5.00	1.97	6.75	1.44	2.75	0.75	9.75	2.81	4.50	1.00	12.70	4.25
10	8.00	2.16	3.50	0.43	6.50	2.25	11.25	2.63	4.50	1.44	7.75	2.00	7.25	1.81	15.60	5.25
11	12.25	3.31	4.00	0.50	5.25	1.53	7.25	1.94	2.00	0.78	9.00	2.38	4.25	0.88	14.00	4.38
12	12.00	3.03	6.00	0.75	7.25	2.31	11.25	3.06	8.25	2.94	8.00	2.34	3.50	0.75	6.00	2.00

TABLE VI.
Analysis of Co-variance

Source	Degrees of freedom	Squares and products			Errors of Estimate		
		Sx^2	Sy^2	Sxy	Sum of squares	Degrees of freedom	Mean square
Total	95	805.64	86.47	242.10	...	...	...
Treatment	7	192.42	28.21	63.44	...	...	...
Samples	11	48.94	3.97	11.25	...	...	...
Error	77	564.28	54.26	167.41	4.62	76	0.061
<hr/>							
Treatment and Error.	84	756.70	82.50	230.85	12.07	83	...
<hr/>							
Difference for testing adjusted treatment means.	7.45	7	1.064

$$F = 1.064 / 0.061 = 17.44$$

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TABLE VII.

	I	II	III	IV	V	VI	VII	VIII
Treatment	Water.	H ₂ SO ₄	Oxalic acid	Bleaching powder	Tartaric acid	Chlorine water	SO ₂ sol.	Original
Mean of <i>y</i> (adjusted)	2.18	1.76	1.63	2.18	1.52	2.40	1.49	2.71

The regression equations for the four localities are as follows:

1. *Ashtamudi* $y = 0.5413x - 0.0664$
2. *Paravoor* $y = 0.4380x + 0.1065$
3. *Anjengo* $y = 0.4553x + 0.1078$
4. *Kayamkulam*. $y = 0.4290x + 0.1097$

x represents weight in mg. and y represents breaking load in kg.

The measurements corresponding to the different chemical treatments are given in Table V and the analysis of co-variance in Table VI.

The value of F is significant.

Table VII gives the adjusted treatment means (y). Reference to " t " — Table shows that the original differs from every other treatment.

CONCLUSION

It will be seen from the statistical analysis that the tensile strength of coir fibre varies from locality to locality. Among the samples analysed thus far, *Kayamkulam* variety is the best. Treatment with different chemicals affects the strength considerably.

ACKNOWLEDGEMENT

Our thanks are due to Professor U. S. Nair and his assistant Sri K. C. S. Pillai for carrying out the statistical analysis of the collected data. Our thanks are due also to Mr. S. Krishna Iyer who made an endowment to the University of Travancore for work on the retting of coconut husks.

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-Do-	15	1	21	'Pyomene'	'Phyomone'
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