

107  
**STUDIES ON EAST PAKISTAN COCONUTS**

MUHAMMAD QUDRAT-I-KHUDA AND MUHAMMAD RAHMATULLAH,

*East Regional Laboratories, Pakistan Council of Scientific and Industrial Research, Dacca*

**Introduction**

East Pakistan produces quite a large number of coconuts. This grows all over the country but the southern belt of the province is specially noted for it. These fruits vary in size from place to place but on an average they are bigger here than those obtained in southern India and Ceylon. Although it is reported that about 420 millions of fruit are produced every year yet the province is dependent on external supply of coconut oil as well as coir-fibre. It is necessary therefore that adequate attention should be paid to its industrial utilisation.

Extensive work has been done with coconuts in other countries but no work appears to have been carried out in Pakistan with the species grown here. The present work was undertaken with a view to study the special qualities of these fruits and to see how local industries can be developed with it.

The fruit consists of four different parts, (A) the outer fibrous shell, (B) the inner hard shell, (C) the copra or kernel and (D) the coconut milk. Complete examination of these constituents has been made. The respective quantities of the constituents are described in Table 1.

TABLE 1.—CONSTITUENTS OF COCONUT.

Experi- ment.	Wt. of whole coco- nut (gms)	Wt. of fibrous shell (gms).	Wt. of hard inner shell (gms.)	Wt. of Copra or kernel (gms.)	Volume of milk (c.c.)
No. I ..	1568	751	125	290	278
No. II ..	1456	429	220	367	455
No. III ..	1442	300	287	336	255
No. IV ..	996	275	149	370	280
B. with a lot of 4.	4501	1169	792	1337	829
C. six small fruits.	2791	1047	430	792	695

**A Outer Fibrous Shell.**

Many patents<sup>1</sup> have been taken on the separation of coir-fibres from the outer shell. The preliminary examination in the laboratory has shown it to be a tedious process. The method for the separation of the fibres that we could employ was of three types, such as (a) treatment with cold water, (b) treatment with hot water and (c) treatment with dilute alkali. Of these three methods, the one most suitable was hot water treatment. On a larger scale, it may be somewhat uneconomic unless the waste heat from some other operation can be utilized for the purpose. In the alternative a prolonged treatment with water under the sun may be a suitable second process, as has been used elsewhere.

The fibres have been graded into coarse, medium and fine qualities, suitable for different uses. Previously the fibres had been treated with various chemicals to improve their resilience, strength and gloss but the processes are protected by patent.<sup>2</sup> Experiments that have now been carried out are described later in the article.

The fibre obtained by proper bleaching is white in appearance and promises to have a variety of uses. Alkali treatment of the fibre produces dark colour but increases the strength considerably.

**B. Inner hard Shell.**

The hard inner shell is an interesting component as it is capable of giving a number of useful products. Of these, particular mention may be made of the charcoal that it yields on distillation, which is a good decoloriser and can be put to quite a number of uses as absorbents also. The samples prepared in the laboratory have shown that after proper treatment they are as good as ordinary animal charcoal.

The importance of the volatile product of distillation is indeed very great because it yields considerable quantities of acetic acid, methanol and acetone, together with phenolic bodies and a tar. In the phenolic fraction creosote oil deserves special mention. We have no other source for getting any of these chemicals locally and, therefore, this distillation is expected to provide a nucleus of an important chemical industry.

#### C. Copra or Kernel.

The kernel or the fatty pulp is the most important part of the fruit. Ordinarily from the dried kernel, coconut oil is pressed out. Patents have been taken by a number of persons<sup>3</sup> for the extraction of the oil by the wet process. The method we followed was considerably different, and it was particularly expected to help in separating the defatted pulp from the protein constituents, which is expected to develop into a method for utilization of the carbohydrate and protein, so separated as human food constituent. The process is quite successful and has been of advantage in yielding practically the entire quantity of the oil. In the pressed-out cake there is still about seven per cent of oil which could be recovered only by solvent extraction but in the wet

process, the yield of the oil depends on the weight of the moist pulp and the temperature of the water used and goes up to 20 per cent

#### D. Coconut milk.

The other constituent of the fruit that is the juice is a by-product of the industry and it does not appear to be of much economic value. But pressed as we are for proteins and carbohydrates in food, it should be carefully considered if really this constituent could be thrown away. Perhaps with the help of waste heat of the destructive distillation plant of the hard shell, it may constitute a useful attempt to separate the mineral, protein and carbohydrate constituents that may go to help the food industries. Constituents of Ceylon coconut milk have been reported<sup>4</sup>, and their food value has been discussed<sup>5</sup> but their utilisation has not been defined.<sup>6</sup> An examination of the green and matured coconut water has now been made with the result shown in Table 2(a) and 2(b). The figures indicate the quantities in grams per 100 grams of coconut milk. It is found in this connection that the percentage of mannitol in matured coconut is about .9 per cent, whereas in green coconut it is not more than .05 per cent.

TABLE 2(a).—COMPOSITION OF COCONUT MILK.

	Carbohydrate		Mannitol	Calcium	Phosphorus	Iron.	Copper	
	Protein Reducing Percentage	Non-reducing		Percent- age in sample	Percent- age in sample	Percent- age in sample	Percent- age in sample	
Matured Coconut	.00695	.84	1.402	.905	.025	.0036	.00065	.00013
Green Coconut	.0148	1.92	1.374	.05	.034	.0054	.002	.00019

TABLE 2(b).—COMPOSITION OF ASH FROM THE MILK.

	Ash percentage	Calcium percentage in ash	Phosphorus percentage in ash	Iron percentage in ash	Copper percentage in ash
Matured Coconut	.18805	13.09	1.73	.341	.069
Green Coconut	.2911	11.67	1.904	.685	.063

## Experimental

### A. Separation of fibres.

Ordinarily either soaking in water or a treatment with alkali is the method employed for separating the fibres.<sup>1</sup> Of these the first is a time-consuming process, and the other is rather an expensive one; at the same time alkali darkens the colour of the fibre. We therefore preferred treatment of the shell with hot water. The fibrous shell was cut into thin slices and kept immersed in water heated to 60°-80°C., and maintained at this temperature for about 24 hours when the binding material was sufficiently loosened to be separated by hand-picking.\* During the treatment the binding material in the shell gets rather swollen and is separated as a husk. The proportion of the fibre and the husk in the shell of the coconut in dry condition is shown in the Table 3.

After separation, the fibres were graded into three sizes i.e. coarse, medium and fine. The sizes and the proportions of the different grades were as mentioned in Table 4.

Attempts to separate the fibres from the shell of the green fruits were unsuccessful.

\*A mechanical device to separate the fibres is also under consideration now.

TABLE 3.—RELATION OF FIBRE AND HUSK WITH FIBROUS SHELL WEIGHT.

No. of Expts.	Wt. of the outer shell (gms.)	Wt. of the fibre (gms.)	Wt. of the husk (gms.)
1	751	112	639
2	492	85	407
3	275	70	230
4	342	56	272
Average	333	58.9	278.3

Neither hot water nor mechanical thrashing produced any change in the shell.

*Treatment of the fibres.*—The prepared fibres were treated with various chemicals in aqueous suspension at different temperatures. The results are given in Table 5. The treatment of the fibres with alkali of 10%, 20% and 30% strength gave interesting results which have also been shown in Table 5 on the next page.

Attempts to decolourize the fibre with hydrogen peroxide and other agents produced rather undesirable effects on the fibre but the action of a certain strength of a particular agent 'A' gave very interesting result. A patent for this process is being applied for.

*Husks.*—Experiments were performed to determine the composition of the husk. The constituents are mentioned in Table 6.

Husk (50 gms.) was cooked with a 10 percent solution of caustic soda under ordinary pressure and the alkaline solution of the lignin was oxidised with potassium permanganate at 75°-85°C. From the product some (3.1 gms.) oxalic acid could be separated in the usual way through its barium salt.

On cooking the husks with a 4% caustic soda solution and on bleaching the product

TABLE 4.—COIR.

Grade	Thick-ness (cms.)	Length		Percent-ages
		Maxi-mum (cms.)	Mini-mum (cms.)	
Coarse	0.04	19	5	47
Medium	0.025	21.6	6.3	31
Fine	0.015	23.7	7.6	22

TABLE 5.—EFFECT OF CHEMICALS ON FIBRES.

Chemicals used	Strengths	Duration of treatment	Temperature	Effect on fiber. Re: colour change	Effect on fibre Re: strength
NaOH solution	10% 20% 30%	30 mins.	room temp. (25°C.)	Deep brown with a black tinge, slightly curly.	No appreciable change noted.
„	10% 20% 30%	10 „	100°C.	Turns black with a brown tinge, becomes curly	Strength increases appreciably
„	20% and 30%	30 „	100°C.	Turns deep black and becomes very curly	Strength increases considerably
Cl <sub>2</sub>	gas	30 „	„	Turns pale brown	Becomes brittle
Cl <sub>2</sub>	in water.	„	„	Turns light brown	Strength decreases appreciably
SO <sub>2</sub> gas	..	„	..	Reddish brown	Becomes brittle
H <sub>2</sub> O <sub>2</sub>	10%	6 hrs.	room temp. 25°C.	Not complete white	Not much altered
„	20% 50%	„	„	„	Decreases appreciably
„	100%	overnight	„	Turns completely white	Becomes brittle
NaOCl	5%	30 mins.	room temp.	Slight change, colour lightens	Strength decreases appreciably
„	10%	10 „	60°C.	Appreciable change in colour.	Fibre strength decreases considerably

TABLE 6.—COMPOSITION OF COCONUT HUSK.

Constituent	Ash	Proteins	Calcium		Phosphorous		Iron		Copper	
			Sample	Ash	Sample	Ash	Sample	Ash	Sample	Ash
Husk pith	2.539	3.19	.786	30.884	0.0126	0.495	0.624	0.963	0.0039	0.155

with a suitable agent a colourless pulp was obtained which appears to be useful for making paper-board. More work on the husks is in progress.

### B. Chemicals from the Inner Hard Shell

*Wood-spirit and acetic acid.*—Destructive distillation of the hard shell has been described in a patent.<sup>7</sup> We have carried out the work somewhat differently. The shells were subjected to destructive distillation taking 1816 gms. at a time. The temperature was maintained at 275°-450°C. and the duration of distillation was 7 hours in each case. This was repeated four times. The distillates of all the charges were mixed together and allowed to settle. After 3 days two different layers were formed and they were separated. The aqueous layer was fractionated, before treating it with lime. The low boiling fraction i.e., a mixture of methanol and acetone (wood-spirit) boiling at 55-64°C. amounted to 100 c.c.

The fraction boiling at 95°-100°C. was separately collected and neutralized with milk of lime. The supernatant liquid of clear brownish tinge was filtered and evaporated to dryness when the grey acetate of lime was obtained. This was heated to about 200°C. to remove moisture and other impurities and then mixed with commercial concentrated sulphuric acid and distilled under partially reduced pressure to obtain crude acetic acid (40-60%). This acid was neutralized with caustic soda solution and the sodium acetate thus obtained

was fused to free it from traces of water and was then carefully acidified with pure and concentrated sulphuric acid and distilled, when 146 c.c. of acetic acid 85%, b.p. 118-120°C., sp. gr. 1.505, was obtained. Results of four experiments are given in Table 7.

*Phenolic bodies and carboxylic acids.*—The tarry matter (750 gm.) consisting of the residue of the aqueous distillate and the settled tar referred to above was treated with a strong solution of sodium hydroxide, when it dissolved completely. Freshly prepared carbon dioxide was passed through this solution and the resinous precipitate that was formed was removed completely with ether. The ethereal solution was dried over anhydrous sodium sulphate and distilled, when the phenolic bodies (114.35 gm.) were collected. These are at present under investigation.

The alkaline solution containing the salt of carboxylic acids and sodium bicarbonate was then just acidified with concentrated hydrochloric acid, when a mixture of resin and acid was precipitated out, from which the acid was extracted with sodium bicarbonate solution and then precipitated with mineral acid and removed. The acid mixture was further purified from any acid resin by a repetition of the process. The ethereal solution was dried and distilled when an acid mixture (53.4 grams) was separated in the usual way.

TABLE 7.—PRODUCTS OF DISTILLATION OF INNER SHELL.

No. of Expts.	Quantity of shell used in each charge (gms.)	Quantity of charcoal in each charge (gms.)	Quantity of distillate in each charge (c.c.)	Volume of gas in each charge (litres)	Quantity of Tar (c.c.)	Acetic acid (c.c.)	Wood spirit (c.c.)
I	1816	553	756	195.65	..	..	..
II	..	524.9	758	200.6	790	149	100
III	..	524.9	768	196.7	..	..	..
IV	..	567	743	207.4	..	..	..

The quantity of acid resin separated in this way weighed 43.23 gms. The different experiments gave results as shown in Table 80.

TABLE 8.—COMPOSITION OF HARD SHELL TAR

No of expts.	Quantity Tar (gms.)	Quantity of phenolic bodies (gms.)	Quantity of carboxylic acid. (gms.)	Acid resin
I ..	250	38.12	18.5	14.43
II ..	250	36.76	17.2	12.9
III ..	250	39.47	17.7	15.9
Total ..	750 gms.	114.35 gms.	53.4 gms.	43.23

*Activated Charcoal.*—500 gms. of the powdered (100 mesh) charcoal were mixed with 600 c.c. of saturated zinc chloride solution containing five per cent hydrochloric acid. The mixture was digested for six hours and then dried on the sand-bath. 105 gms. of this treated charcoal was carbonized at 700-800°C. for two hours. The residue was next boiled with 10% hydrochloric acid solution for a little while, filtered and washed with distilled water several times till the chloride iron was removed. It was finally dried in an air-oven at 250°C. when 23 grams of activated charcoal were obtained (compare Mukherji and Battacharya)<sup>9</sup>. The activity of the charcoal so prepared was observed to be of a high order.

*C. Cocomut Oil.*—The copra contains the entire quantity of the oil, with some carbohydrate, protein and a little cellulose<sup>10</sup> and moisture. The amount of moisture present in our pulp was estimated first. The wet copra (130 gms.) was dried in an oven at a temperature of 60-70°C. for about 12 hours when the weight dropped to 62.65 grams. This means that the wet copra contains 51.82 p.c. of moisture. This will give an idea of quantity of the oil in the copra on dry basis as has been shown later. Some methods for extraction of oil in water have already been described.<sup>12</sup> Our procedure is somewhat different.

The white copra (kernel) was crushed, made into a paste, mixed with water at a temperature of about 60-100°C., was agitated for half an hour and then allowed to stand. Finally the mass was pressed through filter

cloth to separate oil-in-water emulsion and the oil free pulp. The pulp was dried and extracted with petroleum ether to bring out the last traces of oil. The oil of the emulsion was separated by either allowing it to stand overnight when a creamy layer floated on the top; or it was cooled sufficiently when the oil solidified and floated over the water. The oily layer was separated and the aqueous layer was extracted with some petroleum ether in each case. The solvent was removed and the oily residue was heated long enough to drive out all moisture. The results are given in Table 9. The oil thus obtained was crystal clear and colourless. It was examined and found to have iodine value 9.0, saponification value 257 and acid value .77 per cent.

The aqueous solution from the above experiment, on being evaporated to dryness, gave a solid mass (35 gram from 3443 grams of kernel) which is under examination now for its constituents i.e. protein and carbohydrate. The main bulk of the defatted pulp is also under examination for its use as a food substitute.

#### D. Food from the Coconut water.—

From each coconut on an average some 200 to 300 c.c. of water is available. On concentration under reduced pressure 400 c.c. gave a residue of 19.1 grams, which consist of protein, a small quantity of mannitol, some carbohydrate and minerals. The protein is water soluble but coagulates on heating. The carbohydrate consists of some reducing sugars and non-reducing sugars. The minerals consist of calcium, iron, phosphorous and potassium. The solution of carbohydrate, after coagulation of protein, was allowed to undergo fermentation in the presence of Toddy yeast. On completion of the process, the residue did not show the presence of any trace of sugars and it amounted to about .905 per cent in weight and consisted of mannitol; whereas the green coconut water on estimation,<sup>12</sup> gave about .05 per cent of mannitol. The results have been shown in Table 10.

To compare the quality of green coconut juice with the milk from matured coconut an examination of the same has also been made. The results have been given in tables 2 and 10.

STUDIES ON EAST PAKISTAN COCONUTS.

TABLE 9.—QUANTITY OF OIL IN COPRA.

Experiment	Weight of copra (gms.)	Wt. of oil obtained (gms.)	Wt. of dry pulp recovered (gms.)	Wt. of residue after oil extract (gms.)	PERCENTAGE ON THE BASIS OF	
					Wet copra	Dry copra
A. I ..	290	57.2	38	2.82	13.1	41.5
II ..	367	66.0	30	4.1	17.9	38.0
III ..	287	57.0	42	3.35	19.8	41.0
IV ..	370	65.0	62	7.34	17.5	39.0
B (lot of 4)	1337	271	140	14.0	20.2	42
C (lot of six small ones)	792	171	129	3.55	20.3	44.5

TABLE 10.—ESTIMATION OF MANNITOL.

Expts.	Volume of water (c.c.)	Residue in gms.	Per-centage of the residue	Quantity of man-nitol
Matured Coconut water I ..	106	.959	.9	.9%
II ..	277	2.4822	.89	.88%
III ..	184	1.73	.94	.91%
IV ..	240	1.6244	1.09	.93%
Green Coconut water ..	455	2.468	.55	.05%

Discussion

The findings recorded above hold out a very bright prospect for establishing an industry with coconut alone. The by-products, such as husk, pulp and the juice, may have different applications. The distillation of the husk has been studied earlier. It is now felt that this material can yield a pulp along with lignin,

which may produce some kind of paper board and other products. Extended work on it may give more encouraging results.

Wet process for the production of coconut oil can easily be adopted as a cottage industry in East Pakistan. The quantity of matured fruit that is now marketed is not negligible. It can be supplemented by additional plantation.

The pulp from the oil factory will be available in fairly large quantity and therefore a suitable method for its utilisation should be worked out.

Coconut will be giving a variety of chemicals and solvents, besides oil, coir and husk. If we can use only half of the total number of matured coconuts at present marketed, the number will come to about 133 millions. In that case the industries that will develop with it is expected to yield 15.5 million pounds of oil with 1.3 million pounds of acetic acid, six hundred thousand pounds of wood spirit, one million pounds of phenolic bodies, 16 million pounds of

charcoal and 7.25 million pounds of coir. This is rather a hopeful position and these products will help us considerably in several other fields of industries as well.

### Summary

East Pakistan coconuts are rather large in size and consequently quantities of their constituents are comparatively more than what they are in smaller varieties. The outer shell of the fruits yields several sizes of coir and a powdery matter which has been called husk. The inner hard shell has been distilled with the consequent production of a number of chemicals like wood-spirit, acetone, acetic

acid, phenolic bodies and charcoal. The charcoal can be converted into an efficient decolouriser and deodoriser; it can also be used as a good absorbent in medicine. The quantity of oil is about 20 percent of the weight of the wet copra. Some proteins and carbohydrates have also been separated from the pulp and the water.

### Acknowledgement.

The authors wish to thank Dr. S. Siddiqui for his keen interest in the progress of the work and many helpful suggestions.

### References

1. Thomas Ludwig and Etold Egon, German Patent 513769, Jan. 15, 1928 and U. S. Patent 1831740, Nov. 10, 1932.
2. Owen Tudor Hart, French Patent 763284, April 26, 1934; Ivan Tudor, and Owen Tudor Hart U.S. Patent 1941451, Jan. 21, 1934.
3. Turner and Layton, U. S. Patent, 124759, Nov. 10, 1918; W. Alexander, U. S. Patent, 1366338, Jan. 25, 1921; E. G. R., Gaddart, U. S. Patent 1431519, Oct. 10, 1922; W.S. Cook Son, U.S. Patent 1407930, Feb. 28, 1922; W. Hoskins, U.S. Patent, 1638530. Aug. 9, 1927, and V.G. Lava, U.S. Patent, 2101371, Dec. 7, 1938.
4. W. R. Dunsta, Trop. Agr. Mag. Ceylon, sqr. soc, 26, 377 (1907).
5. Jamet M. Walker, Food Ind., 4, 56-7 (1932.)
6. Rieginald Child, and Wilfred R. N. Nathanael, R.W. Howard Trop. Agr. (Ceylon) 103, 89 (1947.)
7. Archer and Albert Gilbert Tomlinson, Australian Patent, 113672, Aug. 13, 1941.
8. Lin Sheng Tsai and Kung Yao Chnang, Ind. Eng. Chem., 34, 812 (1942.)
9. Mukherji and Bhattacharya, J. Ind., Sc. Ind. Res., IV, 235, (1945.)
10. Hannemon Ito, J. Agr. Chem. Soc., Japan, 20, 97 (1944.)
11. Anon, Tropenplanger, 14, No. 61.
12. M.C., Canerson A.G. Rossand E. 19 V. Percival, J. Soc. Chem. Ind. 67, 161 (1948).
13. H. O. Parker and H. C. Brill Phillip, J. Sc. 12A, 87, 1917, and Lava, Torres V.G., P.E., and Sanvictors, S, Phillip, J. Sc. 75, 143-56 (1941.)