

RP-46

SOME OBSERVATIONS ON THE GROWTH OF THE
COCONUT FRUIT WITH SPECIAL REFERENCE
TO SOME OF THE CHANGES UNDERGONE
BY THE FIBROUS CONSTITUENT
OF ITS MESOCARP

BY

S. R. K. MENON, M.A.

Research Chemist with the Ceylon Coconut Board, Colombo

(Received for publication on 2 August 1941)

(With two text-figures)

IN view of the facts that the coconut, unlike many other fruits, is composed of several physically and chemically distinct components, that each of these components has unique economic value, and that the fruit takes normally more than a year to ripen and fall down, it was thought expedient to trace the growth of the fruit with particular reference to the changes occurring in its several components. It is true that fairly detailed descriptions of the growth of the fruit are found in such classical treatises on the coconut palm as those of Copeland [1931], Sampeon [1923] and others, but those studies have not been of the strictly scientific type involving due insistence on all possible measurements and analyses. The present study is an attempt to exclude that serious defect and indicate a possible line of successful attack of several problems relating to the growth of this important agricultural product.

MATERIAL AND METHODS

It is a matter of familiar observation that coconuts belonging to the same bunch make the greatest approach to uniformity. Nuts of the same bunch are very nearly of the same age. Further, equidistribution of nourishment is ensured among these nuts, and they undergo identical vicissitudes of atmospheric and soil conditions. The approximate uniformity of the nuts in regard to shape, size and weight is to be attributed to these causes.

There is a general rule that the spacing in time of any two consecutive bunches on the palm is almost a constant, viz. a month. Whatever may be the value of this rule in general practice, it is undependable for rigorous scientific study. Conclusions drawn, therefore, from the measurements and analyses of nuts picked from different bunches of the tree at the same time are lacking in exactitude. Moreover, it has been observed that the coconut fruit is extremely sensitive to weather conditions, and inasmuch as different bunches have experienced different states of the weather, new factors creep in and vitiate the records set up by the mere passage of time.

In view of these factors, the method was adopted of keeping and following up the same bunch for a period of about 12 months during which the nuts were picked at intervals of about a month and weighed and analysed.

maturity on tree. The bunch with the largest formation of nuts was selected and on a specific date of each successive month a nut was sent up the tree and a nut detached from the bunch. This nut was then measured and analysed in accordance with the scheme embodied in the tables. For the purpose of confirmation of results and of conclusions drawn therefrom, the experiment was conducted on three trees, and two bunches were marked out on each tree.

The nut was weighed immediately after picking, and its volume determined in a specially constructed over-flow jar, a lead sinker of known volume being used whenever necessary. The kernel was scooped or cut out of the shell as required and weighed in the raw state. The husk was torn to pieces and boiled in about 2-3 litres of water with 5-10 gm. of sodium sulphite, for a couple of hours, when it softened to such an extent as to render possible the easy separation of the fibrous from the non-fibrous matter by simple mechanical means. After separation and thorough washing, each component was air-dried and weighed.

Before determining the specific gravity of the fibre and subjecting it to chemical analyses, a further purification was effected by boiling the finely divided fibre with 20 per cent acetic acid for half an hour, followed by repeated washings with distilled water, this procedure having been found suitable in previous work of the author [Menon, 1935]. The fibre was then dried, and after air-conditioning stored in a stoppered bottle.

Determination of the specific gravity of the various samples of fibre presented difficulty at first. Using the well-known method of the specific gravity bottle, it was found that there was no early limit to the time for which bubbles of air escaped from the immersed fibre. Consequently, values obtained by this method on the same sample disagreed profoundly. Complete satisfaction was secured, however, when the fibre was first boiled in a beaker with distilled water for about 15 minutes, when all the capillary air was expelled and the particles settled down. The beaker with contents was then rapidly cooled, and the fibre transferred into the specific gravity bottle by means of balance forceps. The bottle was then filled with water, stopper replaced, and weighings made as usual. The fibre was carefully shaken out from the bottle into a filter cone, which was later dried in the oven. The dry fibre was next transferred into a weighing tube, which was then introduced into a special drying apparatus by the aid of which its bone-dry weight was determined. This value represented the weight of fibre in the specific gravity calculation.

Lignin and furfural values recorded in Tables IV and V are based on the bone-dry fibre, and were estimated by the familiar 72 per cent sulphuric acid and Tollen's methods respectively.

DISCUSSION

Figs. 1 and 2 throw light on the value of the method adopted for tracing the growth of the coconut fruit.

When measured in C. G. S. units, the weight and volume of the fruit are very nearly equal for the first six months of growth, which in other words means that the specific gravity of the fruit taken as a whole is almost the same as that of water. After this period, the weight of the nut rapidly declines

until it becomes less than half the maximum value it had reached. This decline is in spite of the fact that the kernel goes on increasing in weight and the diminution in weight of the nut water is only a negligible fraction of the total loss in weight of the fruit. The obvious explanation is that the husk which is heavily soaked in water during the earlier stages of growth begins rapidly drying up even while the kernel is in the process of formation and undergoing active synthetic reactions. The volume of the fruit remains, however, constant but for the slight diminution that takes place owing to shrinkage as the fruit dries up.

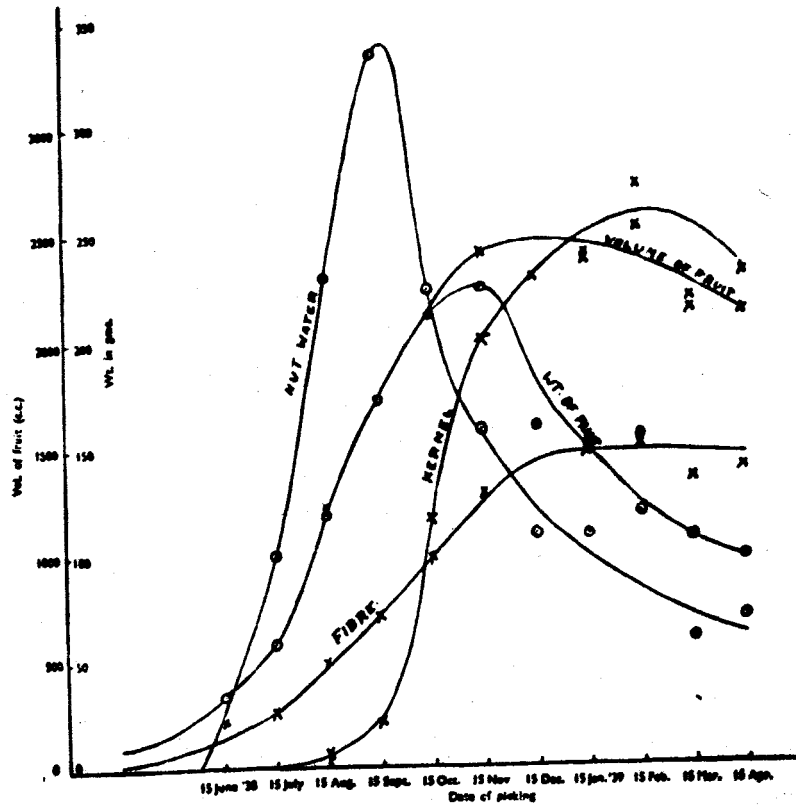


FIG. 1. Growth of fruit (Tree No. 171, Bunch No. 1)

TABLE I
Tree No. 171

Date of picking	No. of nuts in bunch	Weight of fruit (gm.)	Vol. of fruit (c.c.)	Vol. of nut water (c.c.)	Weight of kernel (gm.)	Weight of fibre (gm.)	Weight of pith (gm.)
-----------------	----------------------	-----------------------	----------------------	--------------------------	------------------------	-----------------------	----------------------

Bunch No. 1

15 June '938	14	..	348	..	0	23	8
15 July ..	12	581	585	100	0	26	14
15 Aug. ..	11	1193	1230	230	7	50	31
15 Sept. ..	10	1720	1710	335	22	72	44
15 Oct. ..	9	2122	2150	225	117	98	46
15 Nov. ..	8	2250	2420	160	201	129	75
15 Dec. ..	7	1614	2300	110	199	131	71
15 Jan. 1939	5	1515	2380	110	241	148	84
15 Feb. ..	4	1563	2530	120	272	151	103
15 March ..	3	1086	2145	60	219	134	92
15 Apr. ..	0*	984	2135	70	231	140	103

Bunch No. 2

15 June 1938	9	..	1048	..	0	59	9
15 July ..	8	1699	1690	325	9	71	39
15 Aug. ..	7	2385	2450	293	120	98	59
15 Sept. ..	6	2457	2582	210	187	126	82
15 Oct. ..	5	2398	2680	195	246	163	93
15 Nov. ..	4	2063	2915	140	299	161	128
15 Dec. ..	3	1429	2590	95	262	149	100
15 Jan. 1939	2	1510	2760	125	284	172	113
15 Feb. ..	1	1263	2550	83	267	156	106

*Both the remaining nuts grew dead ripe and fell down before date; one of them was analysed and recorded as above

TABLE II

Tree No. 152

Date of picking	No. of nuts in bunch	Weight of fruit (gm.)	Vol. of fruit (c.c.)	Vol. of nut water (c.c.)	Weight of kernel (gm.)	Weight of fibre (gm.)	Weight of pith (gm.)
-----------------	----------------------	-----------------------	----------------------	--------------------------	------------------------	-----------------------	----------------------

Bunch No. 1

15 June 1938	12	..	623	..	0	36	11
15 July .. .	10	1122	1090	250	0	51	29
15 Aug. .. .	9	1600	1600	240	80	70	48
15 Sept. .. .	8	1567	1560	145	162	83	53
15 Oct. .. .	7	1625	1670	..	206	89	47
15 Nov. .. .	6	1490	1610	85	204	99	76
15 Dec. .. .	5	992	1525	40	211	96	52
15 Jan. 1939	4	898	1440	25	207	103	59
15 Feb. .. .	3	864	1585	60	187	106	68
15 March .. .	1	742	1640	30	222	118	83

Bunch No. 2

15 June 1938	12	..	316	..	0	21	7
15 July .. .	11	584	540	115	0	29	17
15 Aug. .. .	10	1129	1140	197	..	53	29
15 Sept. .. .	9	1367	1350	170	91	73	45
15 Oct. .. .	8	1562	1590	110	138	81	41
15 Nov. .. .	7	1621	1680	105	174	89	39
15 Dec. .. .	6	1245	1730	55	186	102	67
15 Jan. 1939	5	919	1530	55	172	109	59
15 Feb. .. .	4	931	1740	50	252	115	72
15 March .. .	3	765	1490	40	185	109	71

The two remaining nuts fell before 15th April 1939, after growing dead ripe

TABLE III
Tree No. 145

Date of picking	No. of nuts in bunch	Weight of fruit (gm.)	Vol. of fruit (c.c.)	Vol. of nut water (c.c.)	Weight of kernel (gm.)	Weight of fibre (gm.)	Weight of pith (gm.)
<i>Bunch No. 1</i>							
15 June 1938	8	..	238	..	0
15 July ..	7	604	590	135	0	28	15
15 Aug. ..	6	1400	1430	297	0	60	45
15 Sept. ..	5	1822	1860	335	34	89	53
15 Oct. ..	4	1942	1960	255	91	100	66
15 Nov. ..	3	1917	2035	180	143	110	107
15 Dec. ..	2	1797	2240	175	221	133	88
15 Jan. 1939	1	1522	2185	155	263	137	92
<i>Bunch No. 2</i>							
15 June 1938	8	..	138	..	0	9.4	1.5
15 July ..	7	368	340	65	0	18.5	11
15 Aug. ..	6	912	897	207	0	41	27
15 Sept. ..	5	1659	1700	345	6	82	52
15 Oct. ..	3	1823	1830	300	57	97	57
15 Nov. ..	2	1783	1845	180	139	104	87
15 Dec. ..	1	1907	2330	205	209	129	83

This branching of the weight-volume curve signals the beginning of a new series of chemical changes within the husk. It will be observed in Figs. 1 and 2 that the increase in weight of the fibre is almost uniform during the early period of growth, but the rate of growth declines after the weight of the fruit has begun to diminish. The reason for this may be that the formation of the non-lignin constituents of the husk comes to an end as soon as the husk begins to dry up, and that thereafter the increase in weight of the fibre content is only due to the lignification of the fibre, which proceeds more rapidly after the husk has begun to dry up. There is reason to suppose that the type of lignification that takes place after the drying up of the husk has commenced is significantly different from the type that precedes it. In the former, it is more a case of deposition of phenolic compounds on the cellulose framework of the fibre than

a case of chemical linkage of the ring compounds with the chain-like structure of the cellulose. In this connection the author's conclusions based on the study of the nature of the lignin complex of coir fibre [Menon, 1936] may appear meaningful. Table IV shows that the lignin value of the fibre goes on steadily increasing practically to the very last stages of growth of the fruit. This is in agreement with a previous observation of the writer [Menon, 1935] that the methoxyl value of coir fibre increases with the growth. Table V shows the quantity of non-lignin present in the fibrous matter of the fruit at the various stages of growth. Up to November 1933, the non-lignin content steadily increased, but the figures obtained for the next five months do not indicate, making due allowance for individual variation of nuts, that it increased subsequently. The practical significance of this observation is considerable. It proves that in picking the nuts before they are fully ripe, not only no loss in yield of fibre results unlike in the case of copra, but there is the striking advantage of obtaining a cleaner and whiter fibre that registers a higher non-lignin value and a lower lignin value. The advantage regarding colour and gloss is vital. The discoloration that the fibre is subjected to as the drying of the husk becomes intense and the extraneous tannin matter of the husk deposits itself on the fibres, is permanent and ineradicable; it is responsible for the very low prices obtained for such fibres in the market. The practice adopted, therefore, in Malabar of picking the nuts while they are still green, is scientifically justified from the view-point of coir production.

TABLE IV
Analysis of coir fibre extracted from nuts of varying growth
(Palm No. 171, bunch No. 1)

Date of picking	Age in months*	Moisture (per cent)	Specific gravity	Lignin (per cent)	Furfural (per cent)
15 June 1933	X	10.0	1.52	23.0	16.5
15 July ..	X+1	8.9	1.52	27.4	16.0
15 Aug. ..	X+2	10.0	1.50	31.1	15.6
15 Sept. ..	X+3	9.2	1.50	32.1	..
15 Oct. ..	X+4	10.0	1.50	34.1	..
15 Nov. ..	X+5	10.3	1.51	34.4	14.3
15 Dec. ..	X+6	9.7	1.50	34.3	..
15 Jan. 1934	X+7	..	1.49	35.5	..
15 Feb. ..	X+8	9.6	1.48	36.4	14.4
15 March ..	X+9	11.3	1.48	36.0	..
15 Apr. ..	X+10	..	1.49	37.2	..

*The value of X, as read from the graphs, is about 1 1/2—2 1/3 months

TABLE V
Variation of the non-lignin content of coir fibre with growth

Date of picking	Weight of fibre gm. (W)	Lignin per cent (x)	Non-lignin per cent (100-x)	Weight of non-lignin in fibre $\frac{W(100-x)}{100}$ gm.
15 June 1938	23	28.0	72.0	16.6
15 July ..	26	27.4	72.6	18.9
15 Aug. ..	50	31.1	68.9	34.5
15 Sept. ..	72	32.1	67.9	48.9
15 Oct. ..	98	34.1	65.9	64.6
15 Nov. ..	129	34.4	65.6	84.6
15 Dec. ..	131	34.3	65.7	86.1
15 Jan. 1939	148	35.6	64.4	95.6
15 Feb. ..	151	36.4	63.6	96.1
15 March ..	134	36.0	64.0	85.8
15 Apr. ..	140	37.2	62.8	87.9

Another remarkable fact revealed by Table IV is that the specific gravity of the fibre during its growth undergoes a little alteration, but this alteration is surprisingly on the negative side. This may be of great theoretical significance, inasmuch as the process of increasing lignification is not only not attended by any increase in specific gravity of the lignified material, but attended by a perceptible diminution of the same.

The furfural value of the fibre too diminishes by slight degrees during its growth. Making allowance for the increasing proportion of lignin in the fibre, this indicates that the cellulosic portion of coir fibre is very rich in furfural-yielding substances from the very beginning. The proportion of such substances in the cellulose remains practically undiminished to the very end.

One fact remains to be mentioned regarding the husk of the coconut. The non-fibrous constituent of the husk, as has already been stated, was separated from the fibres by preliminary boiling with dilute sodium sulphite solution. The reaction that takes place is not quite clear, but it is found to be very effective in treating coconut husk during all stages of growth. The non-fibrous matter isolated from the immature nuts was not a corky powder as is commonly obtained from mature coconuts but a fine sticky paste which on drying assumed a leathery consistency. This paste was capable of binding the fibres into a tough mat. Elaborate experiments were recently conducted on this subject,

followed by large-scale trials at the Forest Research Institute, Dehra Dun, and a patented process has been perfected for the manufacture of a variety of useful articles, now styled as 'Menonite' products, from the entire husk of immature coconuts naturally falling from the tree and obtained as an agricultural waste in coconut plantations.

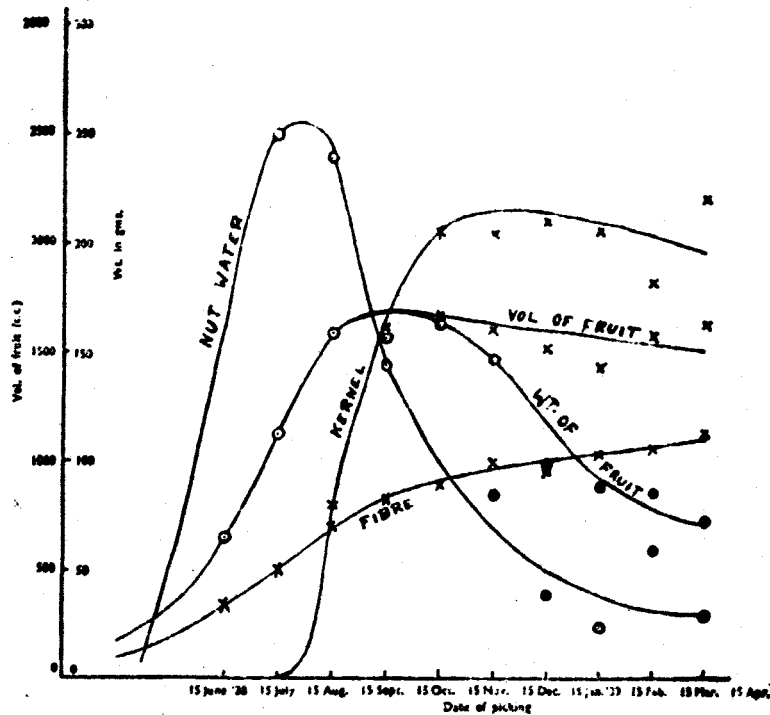


FIG. 2. Growth of fruit (Tree No. 152, Bunch No. 1)

Passing on to the remaining constituents of the coconut, Figs. 1 and 2 reveal several interesting features. The kernel is the last constituent to begin formation, and from the interpolated curves it is found that its formation does not commence during the first three or four months. Once it commences formation, its growth is of a 'blitz' nature for the first two or three months, during which time it gathers most of its raw material. Afterwards growth in the form of weight slackens, the kernel thickens and increases in density, and the formation of fat becomes vigorous. Ultimately, as the moisture content of the kernel falls, its gross weight also registers a decline. An analysis of the kernel at various stages of growth, similar to the one conducted in the case of coir fibre, was not carried out, as the author is exclusively confined to work on coconut husk. But there is ample evidence to conclude that the fat content of the kernel goes on increasing to the last days of growth of the fruit,

and that from the view-point of the oil industry the nuts are most advantageously gathered as late as possible. There is thus a conflict between the interests of the oil and coir industries. A compromise is the result, as practised in Malabar and the Southern Province of Ceylon, where the nuts are picked before they are fully ripe.

SUMMARY

Certain changes undergone by the various components of the coconut fruit during its growth from infancy to maturity have been traced by means of experiments performed over a period of about a year on select bunches of three different trees.

ACKNOWLEDGEMENT

Thanks are due to the Board of Management and the Director of Research of the Coconut Research Station of Ceylon for the grant of estate and laboratory facilities.

REFERENCES

- Copeland, E. B. (1931). *The Coconut*, pp. 20-1
Sampson, H. C. (1923). *The Coconut Palm*, pp. 68-73
Menon, S. R. K. (1935). *Biochem. J.* **29**, 282
_____ (1936). *J. Text. Inst.* **27**, T 229; T 241