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H. de Silva

UTILISATION OF COCONUT WATER

REGINALD CHILD, B.Sc., Ph.D. (Lond.), F.R.I.C.
DIRECTOR, COCONUT RESEARCH SCHEME, (CEYLON)

AND

WILFRED R. N. NATHANAEL, B.Sc. (Lond.)
RESEARCH ASSISTANT TO THE DIRECTOR, COCONUT RESEARCH
SCHEME (CEYLON)

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REGINALD CHILD, B.Sc., Ph.D. (Lond.), F.R.I.C.

DIRECTOR, COCONUT RESEARCH SCHEME, CEYLON

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WILFRED R. N. NATHANAEL, B.Sc. (Lond.)

RESEARCH ASSISTANT TO THE DIRECTOR, COCONUT RESEARCH SCHEME (CEYLON)

WE have had occasion recently to analyse a large number of samples of coconut water. The studies in connection with which these analyses were done may not be ready for early publication and the present note is intended to report briefly only those results which have a bearing on the possible utilisation of waste coconut water.

The composition of coconut water alters markedly as the nut ripens. All through this paper we are concerned only with the water from ripe nuts which have been further "matured" by one month's storage after plucking, as is the usual practice in Ceylon with nuts intended for copra or desiccated coconut manufacture. These industries give as a by-product large volumes of coconut water, about 30 gallons for every thousand nuts.

For water from "matured" coconuts the range and weighted averages of our analytical figures are as follows:—

	Range.	Weighted mean.
Total Solids, gms./100 c.c. ..	3.9–5.5 ..	4.71 gms./100 c.c.
Reducing sugars (as invert sugar) gms./100 c.c. ..	0.23–1.30 ..	0.80 ..
Additional reducing sugars after inversion (as sucrose) gms./100 c.c. ..	0.98–3.15 ..	1.28 ..
Total Sugars, gms./100 c.c. ..	1.70–3.38 ..	2.08 ..
Ash, gms./100 c.c. ..	0.50–0.84 ..	0.62 ..
Organic solids not identified (i.e., Total solids less total sugars and ash) ..	— ..	2.01 ..

W. R. Dunstan (1) found for water from Ceylon nuts: total solids 4.7, reducing sugars, as glucose, 0.5, sucrose 2.6, other organic matter 1.1, ash 0.5 gms./100 c.c. A. Lahille (2) found that the water from ripe nuts as used for copra making in Indochina contained about 2 per cent. of sugars, and 0.5–0.6 per cent. of ash.

The literature contains occasional reports of much higher figures for total solids and sugars, the highest we have encountered being that of C. G. Mathews (3), who reported on one sample 13.06 per cent. total solids and 7.3 per cent. of sugars. It will be found that such high figures have always resulted from samples of nuts sent to Europe or America, the water in which had become concentrated by evaporation during long storage.

We regard our results as typical of waste coconut water as it arises in Ceylon from copra curing and desiccated coconut manufacture, and we must

agree with the first two writers quoted that there is little likelihood that coconut water, although available in large quantities, could be successfully used as a raw material for sugar manufacture. Not only is the sugar concentration low but it is associated with too much mineral and non-saccharine organic matter.

Recently we were offered the suggestion that although certainly not an economic source of sugar, coconut water might, after fermentation, contain enough alcohol to be economically recoverable. It is true that processes have been worked, particularly in Sweden and the U.S., to recover alcohol from the waste sulphite liquor of wood pulp mills; such liquors contain only about 2 per cent. or less of fermentable sugar (4, 5). The waste material in this case, however, is produced in quantity in one place, whereas waste coconut water arises intermittently on hundreds of estates distributed over a wide area. Furthermore, coconut water, as collected, readily becomes inoculated with casual micro-organisms and spontaneous fermentation and acetification are rapid. It would hardly be possible to collect to a central factory the unfermented water.

We have made a preliminary study of the spontaneous fermentation of coconut water (as actually obtained from copra curing on Bandirippuwa estate) with the following results:

TABLE I.—PROGRESS OF SPONTANEOUS FERMENTATION OF COCONUT WATER.

Date and Time of analysis	Ash gms./100 c.c.	Total solids gms./100 c.c.	Reducing sugars (As invert sugar) gms./100 c.c.	Additional reducing sugars after inversion (as sucrose) gms./100 c.c.	Organic solids not sugar: gms./100 c.c.	Alcohol w/v Per cent.	Acidity as gms. acetic acid per 100 c.c.
5.2.47 9 A.M.	—	4.26	0.41	1.77	1.31	—	0.04
5.2.47 5 P.M.	0.77	4.42	0.34	1.86	1.45	—	0.06
6.2.47 8 A.M.	—	4.06	0.32	1.61	1.36	0.05	0.09
7.2.47 8 A.M.	—	3.41	0.78	0.07	1.79	0.24	0.30
8.2.47 8 A.M.	—	2.77	0.11	—	1.89	0.40	0.38
9.2.47 8 A.M.	—	2.75	—	—	1.98	0.21	0.42

Alcohol reached a maximum of 0.40 per cent. on the third day, and then decreased owing to acetification.

Doubtless the yield of alcohol could be increased (but not above about 1 per cent.) and the quality* improved by fermenting the previously sterilized fresh water with pure yeast cultures. We do not, however, regard this as possible under field conditions on a large scale.

The prospects for production of industrial alcohol from waste coconut water in Ceylon are not, in our opinion, very promising.

As regards potable spirit a local patent (6) covers the production of beverages from coconut water; in this patented process the water is concentrated to a sugar content of 5 per cent., or reinforced with added sugar or jaggery, before fermentation.

Development of Acidity.—Fermented coconut water develops after four or five days an acidity of about 0.5 gms. per 100 c.c. calculated as acetic

* By partly concentrating the bulked distillates obtained in the course of the above analyses, a sample of dilute alcohol was obtained, 8.54 per cent. alcohol w/v (at 30°C). This had: furfural < 0.05, aldehydes 9.7, higher alcohols 10.1 parts per 100 litres of spirit.

acid. We have in several trials never found "matured" coconut water greatly to exceed this figure even when the water is kept longer, but Lahille (*loc. cit.*, p. 24) records one sample which after eleven days contained 0.89 gms. per 100 c.c. as acetic acid.

Such acid coconut water has been used for rubber coagulation in times of shortage of acetic or formic acids due to war emergencies (7). According to the Rubber Research Institute of Malaya the acid water from one coconut will coagulate $\frac{3}{4}$ lb. of rubber (8). Transport of such a dilute solution is not economic, but during war periods fermented coconut water has been used in Ceylon for coagulating rubber in those areas where coconuts and rubber are grown on adjoining lands. (9, 10).

Mannitol.—A sample of coconut water was sent from Ceylon to the Imperial Institute in 1904, preserved (as it was supposed) in a sealed tin with the addition of chloroform. Dunstan (*loc. cit.*) found this sample to contain 4.0 per cent. of total solids, of which 1.8 per cent. was mannitol. A very old record by Bizio (11) gives an analysis of coconut water as 5 per cent. total solids, of which 3.825 per cent. was mannitol.

We have been able to separate mannitol quite easily from very stale coconut water, but not from fresh water. Moreover there is no unequivocal report of the occurrence of mannitol in undoubtedly fresh coconut water. At the same time all the analytical figures of which we are aware, including our own, fail to identify the 1 to 2 per cent. of organic solids other than sugars, and the subject clearly needs further investigation.

It is very difficult to preserve coconut water unchanged for any length of time; we have found chloroform and toluene quite inadequate. It seems likely that mannitol is not a normal constituent of coconut water, but is formed by bacterial reduction of glucose during putrefaction of the water on keeping. Our analytical figures in Table I show that the percentage of non-saccharine organic material increases during spontaneous fermentation, *i.e.*, the fermentable sugars present undergo side reactions other than conversion to alcohol and carbon dioxide; we consider it most probable that reduction to mannitol is one of these.

Disposal of Coconut Water on Estates.—On some Ceylon estates the water is collected in a brick-lined sump and given to cattle (12). It must be given fresh. When first fed it has a purgative effect, probably due to potash salts, but cattle become accustomed to it. Lahille (*loc. cit.*, p. 16) recommends feeding the water to cattle in Indochina.

Lahille also calls attention to the desirability of conserving the water for the sake of the potash it contains. He recommends collecting the water, adding slaked lime or calcium phosphate to form a sludge which is applied directly as a fertilizer to coconut palms. The water from 1000 nuts contains about $\frac{1}{2}$ lb. K_2O .

Another plan would be to use the water for sprinkling compost heaps, which would become thereby enriched with potash, a constituent in which composts intended for manuring coconut palms are sometimes deficient.

Disposal of Water in Desiccated Coconut Factories.—In desiccated coconut factories, the accumulated washing water (which also contains the nut water) is run into settling tanks. The scum which rises is collected, and

when boiled down and pressed, yields a low grade oil, known as "drain oil" and a press cake with high fertilizer value (13). The oil almost certainly arises from the 'milk' squeezed out from the kernels during paring and not from the nut water (14). We have extracted several samples of ripe nut water with ether and have never obtained more than traces of oil, unless the nuts were partly germinated. When germination starts, the walls of the oil-containing cells begin to break down with release of free oil. Partly germinated nuts are not, however, accepted in desiccated coconut manufacture.

It is possible that the sugar, salts and small amount of nitrogenous matter of the nut water provide a substrate for the growth of moulds and other organisms in the settling tanks which form the substance of the scum. This rises to the surface bringing with it the suspended oil. The press cake from the "drain oil", contains a fairly high percentage of nitrogen (15).

Coconut Water as a Culture Medium.—Under field laboratory conditions in the tropics coconut water has been used as a culture medium for bacteriological work, for example by the U.S. Yellow Fever Commission in Cuba in 1890. (16). Lahille (*loc. cit.*, pp. 20-24) refers to this use, pointing out that coconut water as it comes fresh from the nut is sterile.

SUMMARY.

1. Average analytical figures for waste coconut water are recorded. From these it is concluded that the material is not a possible economic source of sugar.
2. From a preliminary study of the spontaneous fermentation of coconut water, it is concluded that it is not a promising source of alcohol.
3. Reference is made to the use of the stale acetified water as an emergency rubber coagulant.
4. The useful disposal of coconut water from copra curing on estates, and in desiccated coconut factories, is discussed.
5. Fresh sterile coconut water has been used as a laboratory culture medium.

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