

THE SUGARS OF COCONUT WATER

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HISTORICAL INTRODUCTION

THE literature contains somewhat conflicting statements on the nature and proportions of the sugars in coconut water.

The earliest analysis to which reference need be made is that of L.L. Van Slyke¹ in 1891. A member of the Yellow Fever Commission in Cuba used the water of unripe coconuts as a bacterial culture medium, and was interested enough to send six unripe coconuts to the John Hopkins University, U.S.A., where they were examined by Van Slyke. Six separate analyses gave a mean value for total solids of 5.00 per cent., of which "glucose" accounted for 3.96 and "cane sugar" for a trace. A ripe coconut (presumably a dry market specimen) was examined for comparison; the water of this contained 8.77 per cent. of total solids, 4.42 per cent. being "cane sugar" with only traces of "glucose."

Thos. Steel in December, 1885, when resident in Fiji had "made a chemical examination of several samples of the 'milk' of green coco-nuts at the stage when used for drinking." He did not however publish his note until 1922². In his unripe nut water he found 3.47 to 4.82 per cent. of "fruit sugar" and 0.53 to 0.61 per cent. of "cane sugar," his results being thus similar to those of Van Slyke.

Note.—Though "fruit sugar" should strictly refer to fructose (or laevulose), yet in this connection Steel probably uses it in a general sense to include both glucose and fructose; the old popular term for glucose itself being "grape sugar" because of its presence in grapes.

The water of ripe nuts from Ceylon as imported into England was found by W. R. Dunstan³ (1906) to contain 2.6 per cent. "sucrose" (cane sugar) and 0.5 per cent. "glucose."

In 1906 appeared a Bulletin of the Department of Agriculture of the Netherlands East Indies containing a paper by E. de Kruyff⁴. This paper was reprinted in a French Journal in the following year, and from either source it has been extensively quoted in books and papers. De Kruyff stated that nut water contains "saccharose" (cane sugar) which becomes inverted* during the maturation of the fruit. This statement is diametrically opposed to previous reports, and all subsequent work has shown it to be erroneous.

Lahille⁵ in 1920 studied the water from varieties grown in Indo-china. He found in full sized but unripe-nuts (at the best drinkable stage) 5.0 to 5.5 per cent. of sugars in the water, of which 4.0 to 4.5 per cent. were reducing sugars.

Note.—In chemical terminology "reduction" means to deprive of oxygen or to add hydrogen to an element or compound. Here reducing sugars refer to glucose and fructose, which can reduce silver and copper salts under alkaline conditions, *e. g.* Fehling's solution.

*Inversion in this context refers to the chemical change whereby cane sugar is converted into glucose (dextrose) and fructose. The term "*invert sugar*" wherever used would refer to a mixture of approximately 50 per cent. glucose and 50 per cent. fructose obtained from cane sugar in this way.

In fully ripe nuts on the other hand, he found that the sugars had fallen to about 2.0 per cent. and was mostly non-reducing sugars.

Apart from de Kruyff, these scattered authors agree in the main that unripe nuts contain about 4 to 5 per cent. of sugars, mostly reducing sugars, and ripe nuts about 2 per cent., mostly non-reducing sugars.

A more complete piece of work published by Gonzalez^{6a} in the Philippines in 1914 seems to be generally overlooked although a summary managed to get twice into the "Tropical Agriculturist" (Ceylon)^{6b}. His results may be summarised in more or less his own words. The ripening of the coconut may be considered in three periods. During the *first* there is an accumulation of invert sugar and amino acids in the water; the meat is absent, the shell and husk are soft and watery. During the *second* period of growth cane sugar appears in the water; during all this time water is being lost from the nut. During the *third* or closing period of ripening, there is a sudden rise in the oil content of the meat; the percentage of invert sugar in the water falls, that of cane sugar increases slightly. The figures for the sugars found by Gonzalez are charted below in Table I and rounded off to the second place of decimals (he unnecessarily gives three places).

TABLE I
SUGARS IN THE RIPENING COCONUT

(Adapted from the results of Gonzalez)

No. of Nut	Description	Thickness of meat cm.	% Reducing Sugars in water	% Sucrose in water	% Total Sugars in water
19	Youngest; green; no meat	—	1.88	0	1.88
18	Next young; green; no meat	—	2.38	0	2.38
17	Green; no meat	—	2.63	0	2.63
16	Green; meat in film, watery when removed	0.08	3.24	0	3.24
15	Green; meat harder than 16	0.10	3.14	0.08	3.22
14	Green; meat harder than 15	0.20	2.52	0.57	3.09
12	Oldest, brown; meat hard	1.20	1.45	0.58	2.03

In the following year, these conclusions were confirmed by Vista⁷, who also studied two germinating nuts and stated that when nuts germinate the percentage of sucrose and invert sugar in the water increase very rapidly.

The last paper which need be noticed is that of Dr. P. M. L. Tammes⁸, who was in charge of a coconut research station in Menados, Celebes. He published in 1940 a paper on the development of the coconut fruit, and included analyses made for him in the chemical Research Laboratory at Buitenzorg. The results quoted by him are similar to those of Gonzalez.

Scope and Methods.—The work of Gonzalez and Tammes adequate as far as it goes did not define very precisely the stages of development of their various samples. The present paper is based on the work carried out by Child and Nathanael⁹ at the Coconut Research Institute (Ceylon) during (1945-1947), when analyses have been carried out on coconut water at successive stages of development from the first-formation of a liquid-containing cavity in the small immature fruit, up to complete maturity.

The coconut palm produces new flowering branches at approximately monthly intervals. From the emergence of the inflorescence to complete maturity of the fruit takes twelve to thirteen months. At any one time, therefore, the palm is carrying twelve or more bunches of fruit at successive stages of development. The method of investigation has been to strip from a palm all the fruits. The volume of water in each nut was measured and on each sample were determined; total solids, sulphated ash and sugars.

In this way all the fruits were examined from two tall palms, one King Coconut (Rath Thambili) palm, and one dwarf palm of Malayan origin.

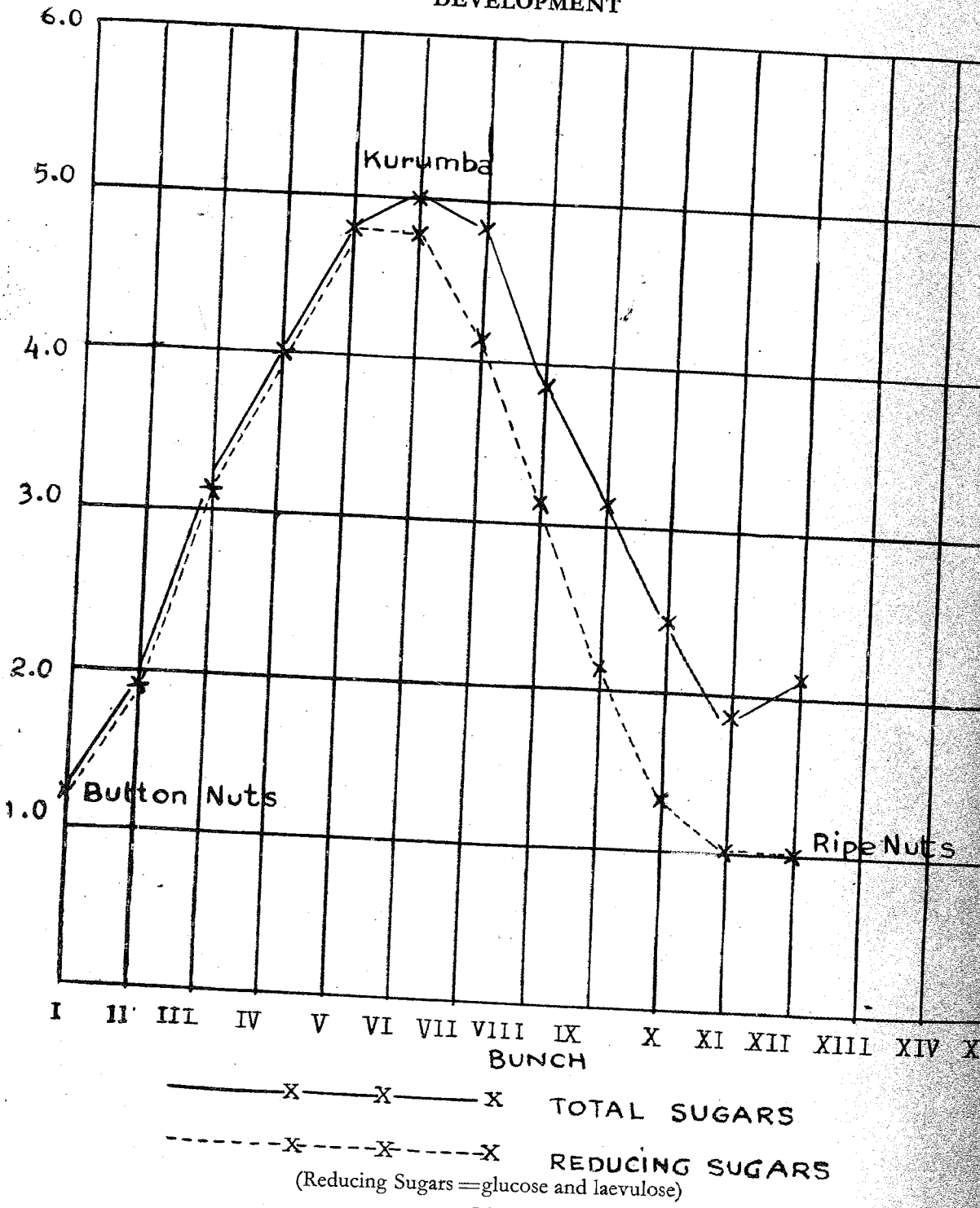
Changes During Germination.—Three hundred ripe nuts were put down in the nursery and twenty removed every fortnight for examination; on these the same determinations were made on the water, viz. total solids, sulphated ash and sugars. As germination proceeds, the cavity of the nut becomes more and more occupied by the developing haustorium (or coconut apple) and practically no water remains by the end of the seventh month after ripe nuts are put in the nursery, at which stage, moreover, the plants are well grown and nearly ready for transplanting. The results obtained however, were not in agreement with those of Vista⁷.

Connecting up the period of twelve to thirteen months, during which the fruit develops to ripeness, with the six to seven months during which germination proceeds until no water remains, we may say that coconut water in a typical nut has a history of about twenty months. We may claim to have followed the changes in the sugars of coconut water during the whole of this period.

Results.—The data which have been published elsewhere⁹ are too voluminous to be quoted here *in extenso*, comprising analytical figures for 53 nuts from tall palm I, 69 nuts from tall palm II, 123 nuts from the King Coconut palm and 51 nuts from the dwarf palm—296 in all, besides data from the samples of germinating nuts. Figure I, however, is a simple graphical representation illustrating the average changes in the nut water of tall palms as grown commercially during progressive stages of development on the tree, and should adequately serve the purpose of this paper. However, it might be mentioned in this connection that the variation found between nuts on the same bunches was not large enough to obscure the changes as ripening proceeds.

It will be seen from the graph that the total sugars in the water of "button nuts" (*i.e.* at a stage after the formation of the water cavity), amount to about 1.0 per cent., and further these are all present in the form of reducing sugars (glucose and laevulose). Though the concentration of total sugars steadily increases to over 4.0 per cent. up to the fifth bunch, yet the composition of sugars in the water remains unchanged; cane sugar (sucrose) being characteristically absent in the water.

FIGURE I
 SUGAR CONTENT IN COCONUT WATER AT PROGRESSIVE STAGES OF
 DEVELOPMENT



The maximum sugar concentration of about 5.0 per cent. is reached at the "Kurumba" stage in the sixth bunch (approximately seven month old fruits), when cane sugar just begins to make its appearance in the water. Quantitatively its concentration is equivalent to the difference between the total and reducing sugars as illustrated in the figure.

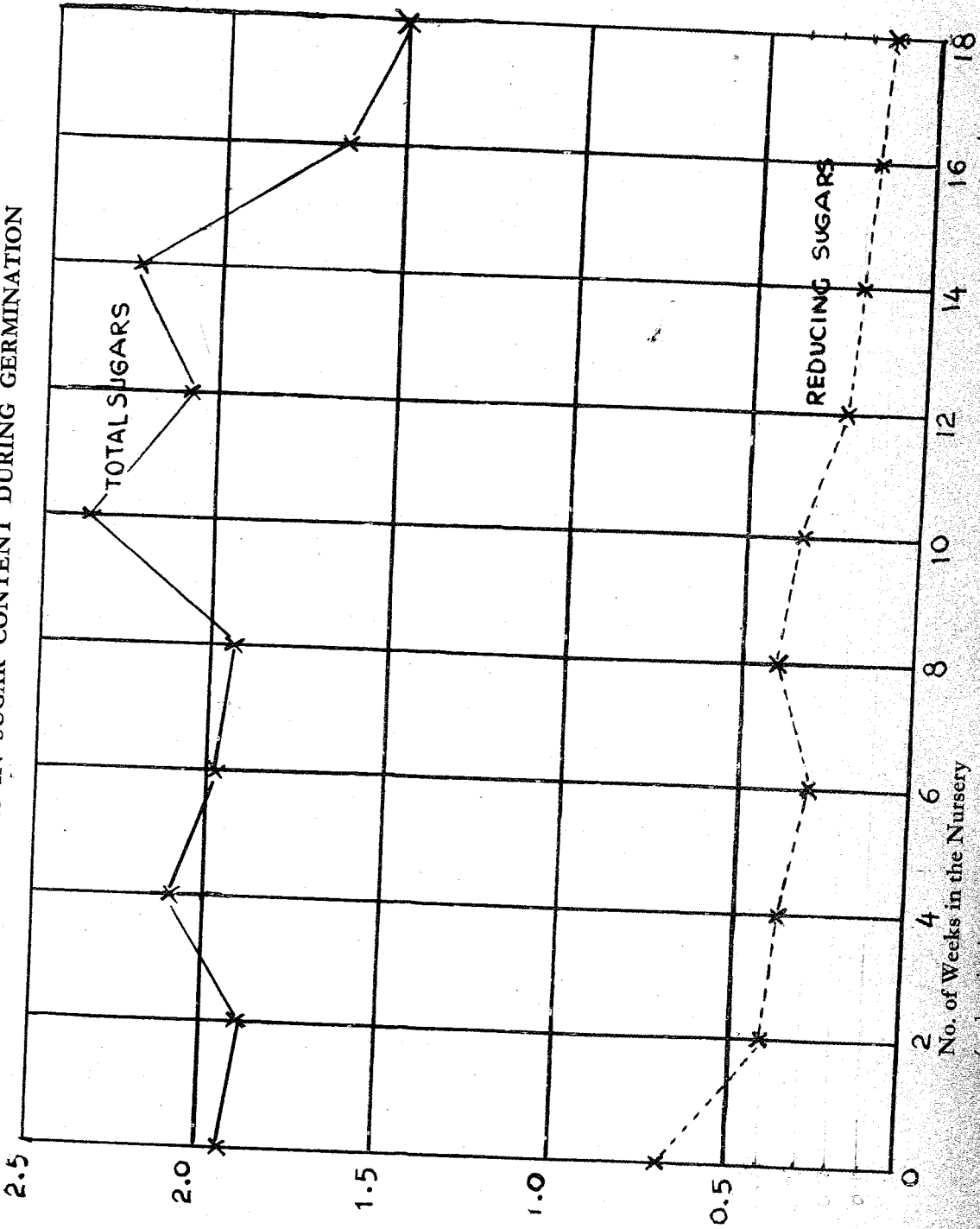
Apart from the question of palatability, the well established belief is that the water from nuts at the "Kurumba" stage is best suited for drinking as a beverage. Our analytical data confirm this theory on the basis of the fact that the glucose content is highest in the Kurumba, and further a fair sized nut at this stage of development should contain the maximum volume of water (500-600 c.c) equivalent to about an ounce of reducing sugars. These sugars account for practically all the organic solids in the water of nuts at and around the "Kurumba" stage.

As ripening proceeds beyond this stage, the total concentration of sugars steadily falls, and non-reducing sugars increasingly make their appearance, till in the ripest bunch (12 to 13 months old), the total sugars are down to about 2 per cent.—approximately half of which is reducing and the rest non-reducing sugars. It was noted in these later stages that there was a considerable proportion of organic material in the water which could not be accounted for by our analyses. Since previous workers too have made the same observation, this could be a subject of further research.

The changes during the early stages of germination are not striking; the concentration of reducing sugars continues to fall, but not until germination is well under way does that of total sugars show any alteration, and they definitely drop below 2.0 per cent. only after about 14 weeks in the nursery. These results are shown below in Figure II, where it will be observed that at the close of the experiment, when the nuts have been kept for 18 weeks in the nursery the total sugars in the water have dropped to 1.5%—containing only a trace of reducing sugars; the rest being entirely non-reducing.

No striking rise in sugar concentration during germination, as that reported by Vista⁷ has been observed in these investigations.

FIGURE II
CHANGES IN SUGAR CONTENT DURING GERMINATION



It was found in this study on the sugars in coconut water, that the general results were similar for all the three varieties of *Cocos nucifera* L. studied—except that in the water of dwarf nuts very small amounts of non-reducing sugars were present in the earlier stages. Also, the concentrations of sugars were somewhat higher in the water of King Coconut palms, than in that of ordinary tall palms. In the specimen examined the concentration of sugars reached 5.6 per cent. at the maximum, and at this, the average sugar content per nut worked out to 29.4 grams.

Nature of the Sugars.—In reviewing the literature, the results of the various authors have been recorded in more or less their own words. Strictly speaking however, all of the results should have been presented as “reducing sugars calculated as invert sugar” and “non-reducing sugars calculated as sucrose,” in the same manner as results of the present work have been expressed. It is reasonably certain however, that the sugars present are actually glucose, laevulose and sucrose only, and other sugars of similar constitution are probably absent in water from nuts of the various stages of ripeness considered in this paper.

E. M. Caray¹⁰ did a careful qualitative examination; he worked up a large volume of water from 150 nuts, and definitely isolated these three sugars. Our results too are consistent with the presence of the same three sugars. It is therefore legitimate to infer that wherever reference has been made to “reducing sugars” in the text—glucose and laevulose alone are implied, and similarly “non-reducing sugars” refer to the presence of cane sugar alone in the water.

Conclusion

Coconut water doubtlessly plays an important role in the ripening of the fruit and during its subsequent germination. The fact that its composition changes during these processes is perhaps sufficient evidence in support of its vital functions in the developing and germinating coconut.

The present work has proved to be of interest in view of certain contradictory statements made by some previous workers on the nature of the sugars in coconut water, and also the exaggerated claims made by enthusiasts regarding its food value.

On sifting all the data in hand, we now have fairly reliable information on the composition of the sugars and the various changes which occur in the water of coconuts from their infancy to senescence and also during germination—a history covering a period of nearly twenty months. As regards the nutritive value of coconut water though it is by no means a source of all the major food constituents—fat, protein and carbohydrate, yet at the “Kurumba” stage it can be regarded as an excellent beverage containing a fair amount of easily available sugars. The ripe nuts however are only a meagre source of such carbohydrates which are so valuable in animal nutrition.

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