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COCONUT SAP AS A SOURCE OF SUGAR

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The coconut palm inflorescence sap is used as a source of sugar in this country for ages. In this presentation, the word sugar is used in a broad sense to include all products obtained by concentrating the sap ; they are treacle or coconut honey in the liquid form, jaggery which is a dark solid mass and the crystalline sugar.

Sugar potential in the coconut sap

The fresh coconut sap as it oozes out of the inflorescence is a 15—18 per cent (W/V) solution of sugar in the form of sucrose. A palm yields about a litre of sap per day (Nathanael 1956 ; Jeganathan, 1974). The spathes are tapped throughout the year, leaving a rest period of about two months during drought in February. Assuming the sap to contain 15 percent sugar, the yield per palm annually, in 300 days of tapping, would be 45 kg. of sugar. An acre contains 64 palms. If 60 palms are tapped, the potential for sugar production from coconut would be 2,700 kg. per acre annually. At the present rate of Rs 17.50 a kg. of sugar the income from an acre of coconut, tapped for sugar, would be Rs. 4000/- per month.

Though the economics of producing crystalline sugar from the sap look very lucrative, the industrial production had never been a success in this country. A report (Child, 1956) discusses the problems associated in tapping palms for sugar. A survey done by tapping 200 trees has shown that it is not feasible to attempt production of sugar on a large scale, but could be carried out economically in home units where members of a family participate in the sugar preparation.

The value of the coconut palm as a source of sugar is widely discussed whenever the cane sugar prices increase, but is easily forgotten with time. The Ceylon Institute of Scientific and Industrial Research worked out the Technology for processing with appropriate equipment for small scale production (Ratnasingham, 1967). However, the costing discourages production (Annonymous, 1976). Yet several sugar processing centres were opened in the coconut growing areas and were a failure.

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The Technological problems

The method of obtaining sugary sap from the palms differs from the methods used in the extraction of juice from the other sugar sources, the sugar cane and the beetroot. In the sugar cane and beet, the sap trapped in solid parts of the tree, is extracted in large scale by crushing. The juice could therefore be concentrated by evaporating, soon after extraction. In contrast, the coconut sap oozes dropwise, from the spathe at the rate of a litre per day. The sap is brought down the tree once or twice daily. The long duration of collection gives time for the sap to ferment.

It is known that the changes in the pH of the sap influence the preparation of good jaggery. Methods are described to keep the pH high (Anonymous, 1974) during collection of the sap by adding lime to the collecting pots.

The biochemical changes occurring during the collection of sap are already reported. (Atputharajah *et. al.*, 1981). The initial changes brought about by the lactic acid bacteria and the yeasts, govern the factors that limit the sugar yields or the preparation of quality jaggery. The production of lactic acid by the bacteria causes a drop in pH. The low pH enhances invertase activity converting sucrose to glucose and fructose. It is the inversion, and not the pH, that determines, whether the sap could be used to prepare jaggery, or whether sugar could be crystallised out. It was also found that good jaggery could be prepared from sap at pH 4 having the correct uninverted sugar percentages, the pH being lowered by adding acetic acid.

The effect of inversion on preparation of jaggery

The effect of inversion, expressed as a percentage of the ratio of inverted to total sugars in the sap, on the formation and appearance of jaggery is presented in Table 1. At invert sugar percentages above 8 no good jaggery could be prepared. The concentrates left for solidification form sticky masses or pastes. At low invert sugar percentages the jaggery has more appealing properties, and is less deliquescent. One of the practices adopted in preparing good jaggery is the addition of crystalline cane sugar during concentration to increase the invert sugar percentage.

TABLE 1.

The effect of invert sugar in the sap on the preparation of jaggery

Reducing sugar g./ml. of sap	*Non reducing sugar g./100 ml.*	*Red sugar x100— Total Sugar*	*Appearance of Jaggery*
0.16	17.7	0.9	light brown, hard
0.24	17.7	1.35	brown, hard
0.70	15.3	4.70	light brown, hard
0.80	15.9	5.0	dark brown, soft
0.97	17.3	5.6	dark brown, soft
1.30	15.7	8.3	dark brown, semi solid, sticky
1.60	15.7	10.2	dark brown, paste sticky
2.07	15.20	13.6	dark brown, paste sticky.

The effect of invert sugar on the keeping qualities of jaggery

Apart from the appearance of jaggery the invert sugar ratio also determines the keeping qualities. Figure 1 shows the moisture absorption desorption by jaggery during storage exposed to the atmosphere. At an invert sugar percentage of 2.8 in the jaggery the moisture absorption is low. The moisture content remains below 8 percent up to 4 weeks. The invert sugar percentages up to about 5.5 provide good keeping qualities as the moisture content remains below 10 percent. At higher moisture levels microbes may spoil jaggery.

The effect of inversion on crystallisation of sugar

The yield of crystalline sugar from the coconut sap depends on the amount of inverted sugar in the sap as shown in figure 2. (Samarajeewa and Wijeratne 1979). At 8 percent inverted sugar in the sap the yield drops as low as 50 percent. The time taken for the appearance of crystals in solution too depends on the invert sugar ratio as shown in Figure 2. On this basis the sap containing 8 percent inverted sugar would yield less than 75% of sugar from a litre of sap. If the invert sugar percentage is low the original sucrose content in the sap would have yielded at least 125g per litre at 80 percent efficiency.

Difficulties in large scale production

We had the opportunity of determining the invert sugar percentages in the sap at one of the coconut sugar manufacturing centres, a few years back. The sap prior to boiling contained 8—10 percent invert sugar. In this centre they had taken many precautions such as washing the pots, adding lime and"hal" bark (*Vateria acuminata*) and use of "secret formulae" to minimize inversion. Yet even on theoretical basis the sap would not have yielded more than 75g. of sugar per litre.

It is practically impossible to maintain the required aseptic conditions in obtaining sap on a large scale in this Industry. All the pots have to be properly washed and flame sterilised. The cleaning of pots and addition of chemicals etc., has to be strictly supervised or be done by persons other than the tappers. With the present antiferments used the sap should be brought down the tree early morning and the boiling down should commence soon. It is not possible to carry out the operations involved in sugar prepartion in a 8 hour day shift. We have observed in the sugar centres that the concentration of sap starts by about the mid-day. The sap is more than 10 percent inverted by this time and it does not yield more than 25 percent sugar.

This is why the preparation of coconut sugar should only be tried at a small cottage level and not in large scale production centres.

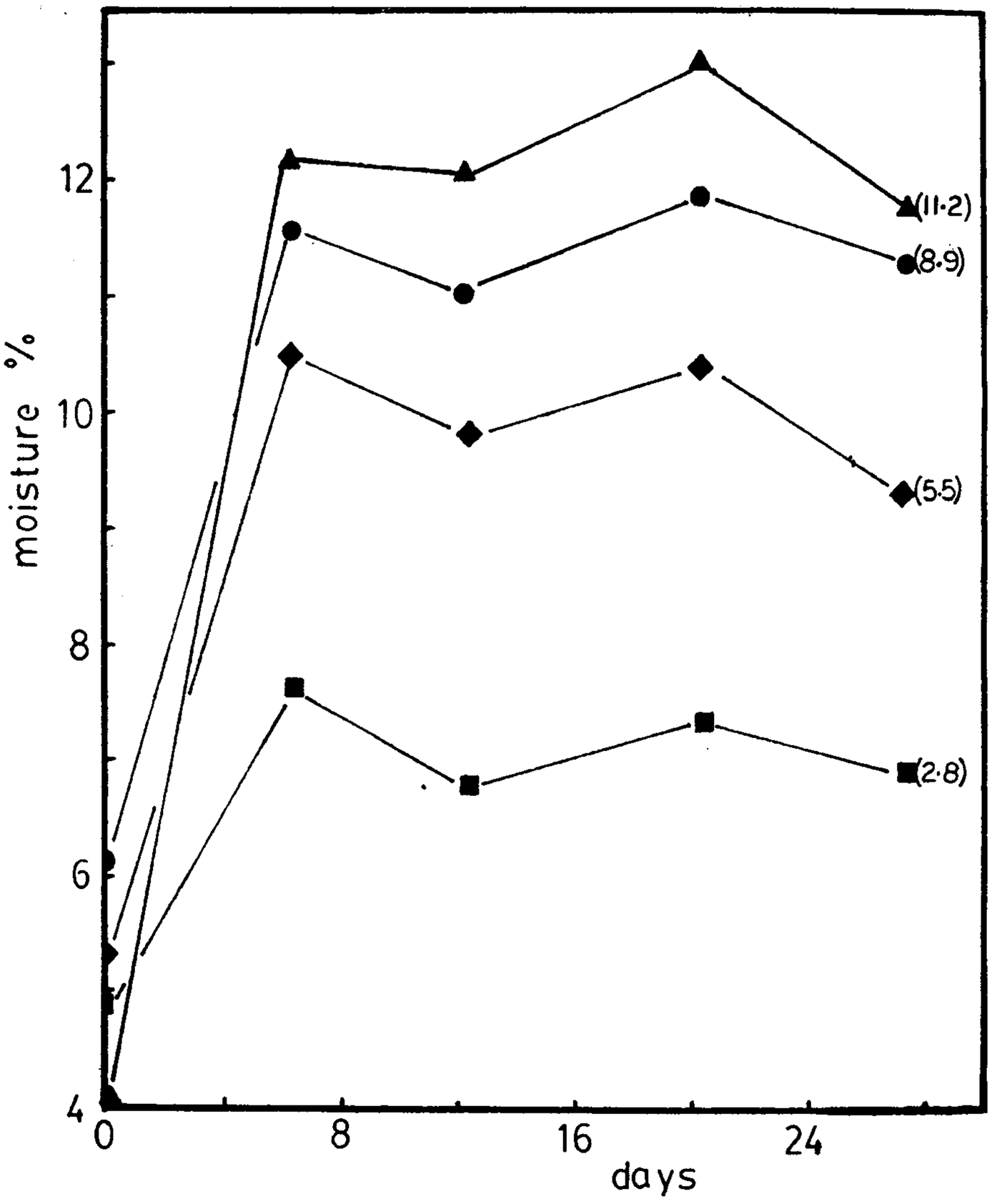

Fig. 1—Moisture absorption by Jaggery at different reducing sugar levels on exposure to atmosphere

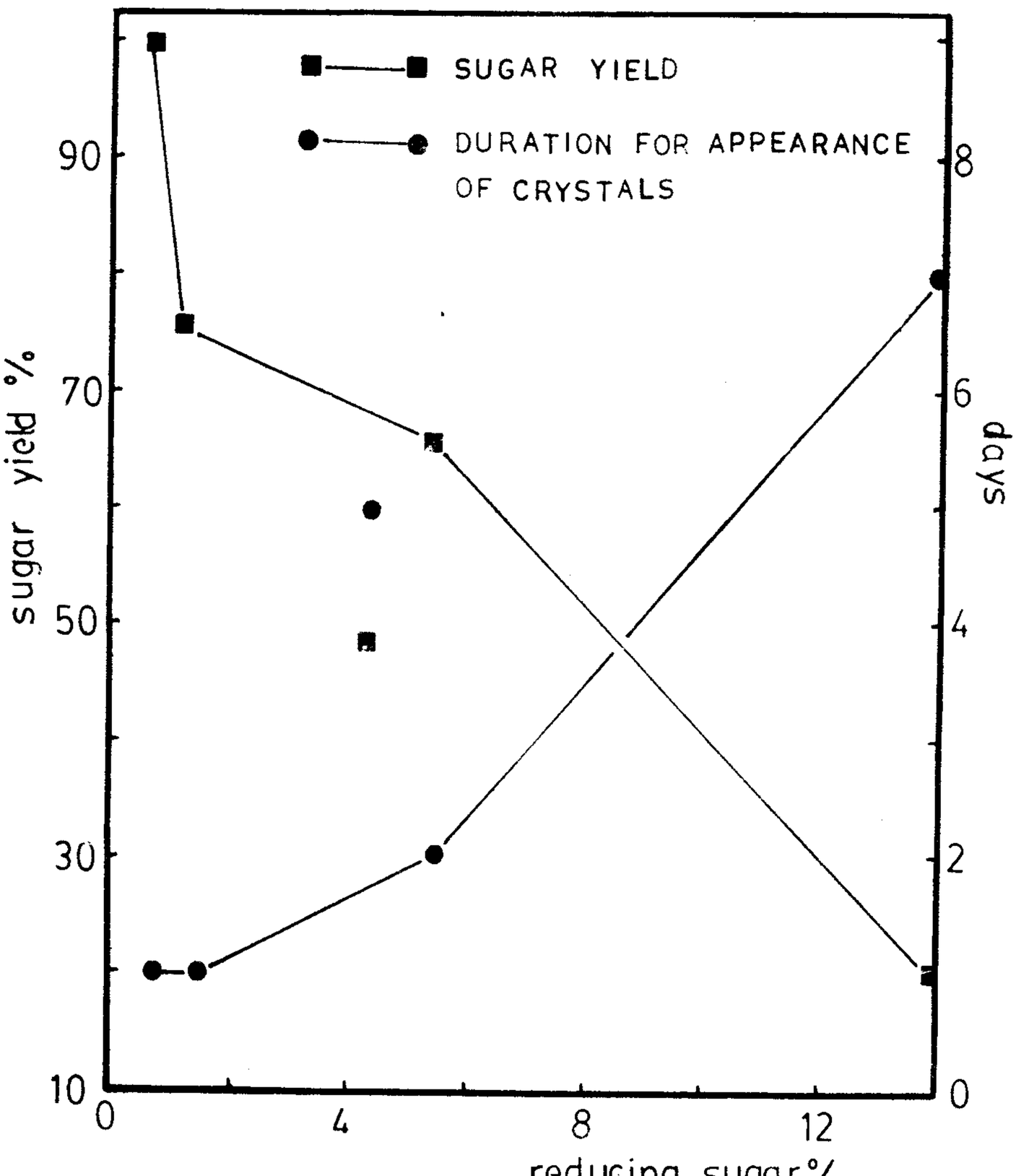

Fig. 2—Dependability of sugar crop yields and time taken for erystallization on the reducing sugar percentage in the sap

Other forms of sugar

In view of the practical difficulties encountered in obtaining fresh sap for the preparation of jaggery and sugar, it appeared more appropriate to look for other means of concentration. The problem in the industry was the difficulty in suppressing the inversion of sugars. Instead we attempted enhancing the inversion to develop a golden syrup. This was done by adding 3 ml. of 4 N Hydrochloric acid per litre of sap and concentrating the sap. The acid was neutralised with 3 ml. of Sodium hydroxide when the boiling temperature was 110°C. The sap was further concentrated to 114°C and viscosity adjusted, if necessary, using gelatine. A comparison of the properties of the coconut golden syrup with that of an imported brand is given in Table 2.

TABLE 2.

Comparison of properties of coconut sap golden syrup with those of commercially available cane suger golden syrup

property	*coconut sap golden syrup*	*cane sugar golden syrup*
Consistency in Brix	77-83	82
$\frac{\text{Invert sugar}}{\text{total sugar}} \times 100$	69-72	60-62
pH	4.7	5.2
Colour	golden yellow (slightly turbid)	golden yellow (clear)
taste	sweet (not acidic) small crystals of sugar appear in the solution	sweet (not acidic) small crystals of sugar appear in the solution

Future Prospects

The aim of the future sugar processing centres should be to prepare two products ; the golden syrup and crystalline sugar depending on the quality of the sap available.

To help the industry in achieving this, a simpe test based on the Fehlings reaction (Lane and Eynon, 1923) was devised. Only a few test tubes pipettes and a spirit lamp are needed to perform the test. Here, a mixture of standard Fehling solution A and B (1.0 ml. each) is heated with 1.0 ml of coconut sap. It could be decided whether the sap is suitable for preparation of crystalline sugar, and what the rough yields would be, depending on the

colour (Table 3). This would avoid the wastage of sap that occurs by attempting to prepare crystalline sugar or jaggery from low yielding highly inverted sap.

TABLE 3.
The relation between colour reaction and the nature of jaggery/sugar yields from sap at different levels of inversion

$\frac{\text{red sugar}}{\text{total sugar}} \times 100\%$	*colour reaction*	*appearance of faggery*	*percentage sugar*	*No. of days taken for appearance of sugar crystals*
0.9	blue	light brown hard	99	1
1.3	green	brown, hard	76	1
5.6	brown	dark brown soft	66	2
4.6	brown	dark brown centre solifified periphony semi solid and sticky	49	5
13.6	brick red	dark brown paste sticky	20	7

The sap was concentrated about an hour after the sugar estimation. The figure does not indicate the actual composition of the sap at the time of concentration.

Our recent experiments have indicated the possiblity of introducing sodium metabisulphite as an antiferment in the preparation of jaggery, and crystalline sugar. It is hoped that all the technical problems faced in the extractions of sugar from sap would be sorted out in the near future so that the coconut could be used as a sugar crop.

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