

CHANGES IN THE CHEMICAL COMPOSITION OF NUT WATER AND KERNEL DURING DEVELOPMENT OF COCONUT

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ABSTRACT

Maximum quantity of nut water was observed in six month old nuts. The sugar content of the nut water and kernel were maximum in eight month old nuts. Potassium was the predominant ion in nut water. With gradual decrease in acidity (free fatty acids) of nut water and sugar content of nut water and kernel, there was increase in oil content. The level of different constituents in nut water and kernel and their relative changes were similar in the different genotypes.

INTRODUCTION

Coconut contains two distinct endosperms, one in liquid form called nut water and the other solid form called the kernel. These two endosperms undergo various biochemical changes during the development of the nut. Gonzales (1914) was the first to have studied changes in the ripening coconut. Caray (1921) and Lakshminarayana Rao *et al.* (1956) studied the sugar content of coconut kernel and Child and Nathanael (1950) the sugar content of nut water. The importance of nut water analysis in the diagnosis of nutrient deficiency had been stressed by Ceylon workers (Salgado, 1951). Hence an understanding of the concentration of the nutrient elements in nut water may be helpful as a diagnostic tool.

A detailed study on the changes in the sugar and major nutrient elements content in nut water and kernel was made by Pillai *et al.* (1959). This paper presents the results of an investigation on the changes in the content of sugar, acidity, major and minor elements in nut water and kernel and the change in oil content of kernel at different stages of development of nut from three coconut geno-

types viz. high yielding West Coast Tall and Dwarf \times Tall and Tall \times Dwarf hybrids.

MATERIAL AND METHODS

Nut samples from a fertiliser experiment on three genotypes of coconut viz. high yielding tall, D \times T and T \times D were made use of for the study. All the palms were of the same age and were receiving uniform fertiliser dose. Sampling of nuts was started when they were four months old and then followed upto the twelfth month at bimonthly intervals. Collection of nut samples was done from the same bunch of the palm, throughout the period of study. Three palms from each of the genotypes were selected and at each sampling one nut from each palm was collected. The volume of water inside was measured, and pH and total acidity were determined. The sugar contents were estimated by the method given by Highkin and Frankel (1962) and nitrogen by the Kjeldahl method. Diacid (Nitric acid: Perchloric acid—2:1) digest of the water was prepared and from that P was estimated by the Vanado molybdate yellow colour method, K by using an Eel flame photometer, S by turbidimetry and Ca, Mg, Fe, Mn, Zn and Cu using an atomic absorption spectrophotometer following the standard methods given by Jackson (1967). Fresh weight of kernel and weight of oven dry copra were taken and moisture percent calculated. In the oven dry copra total and reducing sugars, N, P, K, Ca, Mg, S, Fe, Mn, Cu, and Zn were determined in the same way as for nut water. Oil content in copra was estimated by ether percolation method of Kartha *et al.* (1955).

RESULTS AND DISCUSSION

The results of nut water analysis are presented in Table 1 and that of kernel in Table 2.

Nut Water

Volume

The volume of nut water was invariably higher in the sixth month of development of the nut. At this stage the whole cavity of the nut was found to be filled with water. A significant positive correlation between the volume of nut water and the final

Table 1. *Changes in nut water composition during development of coconut*

Geno- type	Age of nut (months)	Vol. of water (ml)	pH	Acidity (KOH/l)	Total sugars (%)	Reducing sugars (%)	N (mg/l)	P (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
W.C. Tall	4	75	3.5	117	0.8	0.78	32	48	1113	206	40	6.5	21.63	91	12.2	0.73
	6	310	4.7	108	3.3	3.0	195	118	5320	578	176	10.1	16.54	82	18.3	0.85
	8	230	5.5	99	5.6	5.4	432	186	7300	994	262	35.4	11.54	49	18.0	0.80
	10	145	5.9	85	3.4	1.6	336	140	3260	312	102	47.8	8.69	31	10.3	0.53
	12	100	6.1	78	1.8	0.3	299	108	3181	269	106	48.0	8.40	30	7.4	0.34
	D×T	4	102	3.1	121	0.7	0.7	42	40	1225	194	42	7.2	22.69	84	12.2
6		460	4.6	111	3.1	3.0	202	120	6014	542	182	10.5	14.89	78	16.8	0.98
8		290	5.2	102	5.1	5.0	486	194	7900	1020	219	33.8	10.68	52	17.0	0.92
10		205	5.5	92	3.1	1.8	348	152	3380	298	108	45.4	6.49	32	10.0	0.64
12		190	5.8	84	2.2	0.3	290	97	3370	262	106	50.1	7.20	33	6.9	0.36
T×D		4	95	3.3	117	0.7	0.7	37	44	1108	212	43	5.8	22.13	99	10.0
	6	315	4.9	107	3.2	3.0	199	131	5120	593	180	9.8	15.82	84	17.1	0.96
	8	320	5.8	101	5.8	5.5	415	192	7326	1045	248	36.4	12.13	45	16.9	0.89*
	10	125	5.9	88	3.5	1.5	332	148	3180	298	114	50.1	7.82	29	11.1	0.64
	12	90	6.0	80	2.1	0.4	295	103	3192	273	112	48.2	7.50	30	7.0	0.30

CHANGES IN COCONUT ENDOSPERM

Table 2. Changes in kernel composition during development of coconut

Age of nut (months)	Fresh weight of kernel (g)	Weight of oven dry copra (g)	Moisture (%)	Total sugars (%)	Reducing sugars (%)	Oil (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
W.C. 8	122	20.5	83.2	8.9	3.80	31.4	0.40	0.070	0.32	0.023	0.069	480	12	19	13.2	5.2
Tall 10	247	84.4	65.2	3.0	0.15	60.9	0.85	0.094	0.85	0.056	0.081	569	27	29	13.1	6.3
12	270	164.2	39.2	1.1	0.04	70.8	0.99	0.207	0.74	0.069	0.024	440	35	38	10.7	7.2
8	211	39.2	81.4	9.2	4.00	29.3	0.45	0.075	0.34	0.019	0.048	421	18	21	12.4	4.9
D x T 10	304	110.1	63.8	2.9	0.10	58.2	0.85	0.099	0.79	0.061	0.071	531	23	32	13.1	5.9
12	319	187.9	41.1	1.5	0.00	70.4	1.14	0.232	0.80	0.054	0.031	592	39	42	11.8	5.8
8	141	28.2	80.0	8.3	3.10	32.4	0.39	0.072	0.40	0.025	0.060	454	14	25	10.8	6.1
T x D 10	195	69.7	64.2	3.1	0.16	60.6	0.78	0.114	0.82	0.052	0.074	504	29	33	11.2	7.7
12	220	133.1	39.5	1.8	0.00	71.2	1.08	0.214	0.78	0.058	0.033	576	36	47	12.4	7.2

copra weight was observed. The 'r' value ranged from 0.79** for 6th month to 0.92** for the 10th month sample. This may be because the volume of water is a measure of the cavity of the nut and hence that of copra weight also. According to Mittal (1974) the quantity of endosperm per seed and dimension of ovular cavity are closely related. The highest quantity of water per nut was observed in D×T palms.

Acidity

The nut water was highly acidic in the beginning, but later the acidity gradually reduced as the nut matured and the pH was about 6 at the fully matured stage. The reduction in acidity of water with maturity of the nut is evident both from pH measurement and titration with standard KOH solution. An observation of Table 2 shows that there was a gradual increase in copra weight and oil per cent coinciding with the reduction in acidity. The reduction in acidity may possibly be due to the removal of free fatty acids, present in nut water, for oil synthesis in kernel.

Sugar content

The sugar concentration in the fourth month was found to be very low. As a consequence of the low sugar concentration, the water at this stage was not sweet. The sugar content gradually increased to a maximum at the eighth month and then decreased. Till the eighth month reducing sugars formed the major portion of the total sugar content, but afterwards non-reducing sugar predominated. The reduction in sugar content was also associated with an increase in the oil percentage of the kernel. According to Pandalai (1958) the fluctuations in quantity and quality of the sugar content in the water and the quantity of water during ripening of the nut has very vital functions in the biosynthesis of fat in kernel. Kartha and Narayanan (1956) reported that fat synthesis starts at the seventh month when the sugar content is maximum and then proceeds and ends at the twelfth month.

Elemental composition

Nitrogen, P, K, Ca and Mg increased upto the eighth month and then decreased. Pillai *et al.* (1959) also studied the major nutrient composition of nut water and got a similar trend. Among

the micronutrients Fe and Mn were highest during the sixth month, remained unchanged upto the eighth month and then decreased; whereas Zn and Cu progressively decreased from sixth month. The highest concentration of all the nutrients, except S, was at the eighth month, the peak period of kernel deposition and oil synthesis. Potassium was the dominant ion in nut water.

Kernel

Earlier reports by Kartha and Narayanan (1956) indicate that kernel deposition starts at the seventh month. But a very thin deposition of kernel was observed even in the sixth month in all the nuts examined. Though, the weight of fresh kernel was maximum during the tenth month, weight of oven dry copra was highest at the twelfth month. Moisture percentage decreased gradually as the nut matured. Maximum copra content per nut was in D×T palms—which could be expected from the volume of the nut cavity also.

The sugar content decreased from about 8.8% in the eighth month to 1.4% in the 12th month. The oil per cent during this period increased from about 31 to 71.

Nitrogen, P, K, Ca, S, Fe and Mn concentrations in kernel steadily increased with maturity, while Mg showed a reverse trend. A similar trend for N, P, K, Ca and Mg was observed by Pillai *et al.* (1959). The increase in sulphur concentration in copra with maturity may be due to its increased need for the synthesis of oil.

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