

Changes in chemical composition of coconut (*Cocos nucifera*) water during maturation of the fruit

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Abstract: Changes in chemical composition of coconut (*Cocos nucifera*) water, including total and soluble solids, titratable acidity (as citric acid), turbidity, ash, lipids and sugars, were investigated in four varieties of coconuts at four stages of maturity of the fruit. The most significant change was observed in the volume of nut water, which increased during development from 233 to 504 ml, with the greatest quantity found at 9 months. Fat, protein, soluble solids, acidity and turbidity also increased steadily with maturity, while pH and ash showed variation throughout maturation. The interaction of variety and stage of maturity of the fruit appeared to have a significant effect on the chemical composition of the coconut water.

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INTRODUCTION

The coconut (*Cocos nucifera* L) is a perennial plant that generally flowers monthly and takes approximately one year for the fruit (nut) to reach full maturity. The plant bears nuts continuously for up to 60–70 years, 12–13 times a year. Apart from fat, coconuts also provide coconut water, which is bottled and sold on the market in Jamaica. Farmers generally harvest the nut at around 9 months when the jelly is less than 0.5 cm thick, soft and translucent; beyond 9-months, the jelly hardens and the volume of water begins to decrease.¹ There has been very little research on coconut water quality from different varieties in the Caribbean. In the present study, the changes in chemical composition of nut water with maturity of Tall and Dwarf varieties in Jamaica were evaluated.

EXPERIMENTAL

Materials

The Coconut Industry Board of Jamaica supplied coconuts at four stages of maturity over the study period. The nuts selected for this study were sourced from their research farm, at Barton Niles in the parish of St Elizabeth, and also from St Mary in Jamaica. Two numbered trees that had coconuts at all of the stages to be studied were randomly selected. Coconuts at exactly 7, 8, 9 and 10 months after emergence of the

inflorescence (stages 7–10), in duplicate, were used over the study period. The four varieties of coconuts evaluated were: (1) Yellow Dwarf (YD), (2) Green Dwarf (GD), (3) Maypan Tall (MT), and (4) Orange Dwarf (OD).

Chemical composition

Water volume, total and soluble solids, pH, titratable acidity (citric acid), ash, protein, sugars and fat were determined according to standard methods.² Turbidity was determined using the method reported by Campos and Souza.³ All analyses were completed within 48 h of sample receipt.

The volume of water in each nut was measured with a calibrated measuring cylinder. Soluble solids, expressed as °Brix, were measured using a refractometer (Abbe, AO Scientific Instruments, Buffalo, NY, USA, 81150-08, ATC) at 25 °C. The pH of the samples was measured using a digital pH meter (Accumet, Model 59500-04). Titratable acidity was determined by titrating 10 ml of each sample with 0.1 M NaOH solution, using phenolphthalein as indicator and expressed as mg citric acid per 100 ml of sample. Calcination of charred coconut water at 550 °C in a muffle furnace (Barnstead Thermolyne, Iowa, IA, USA) was used to determine the ash content. Protein was determined using a micro-Kjeldahl apparatus (Buchi Analytical, Delaware, USA) and calculated

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using the factor 6.25. Total sugar was expressed as percentage invert sugar. For inversion, 50 ml of clarified coconut water was boiled for exactly 2 min, 15 ml of 5% hydrochloric acid was added: and the resulting solution was then neutralized with sodium bicarbonate. Reducing sugar and non-reducing sugars were also expressed as percentage of invert sugar. Fats were extracted using a Soxhlet apparatus after drying 100ml of each sample at 100 °C for 10–15 h. Turbidity was determined using a spectrophotometer (Unicam 5675 UV/VIS spectrophotometer, Thermo Electron, Waltham, MA, USA) at $\lambda = 610$ nm, relative to distilled water.

Statistical analysis

All analyses were carried out in duplicate and statistical differences as a result of variety and stage of maturity were determined by analysis of variance using the statistical software, SPSS (Chicago, IL, USA) Version 11.⁴ Means were separated by least significant differences (LSD) and the mean square error term determined at the 5% level of probability.

RESULTS AND DISCUSSION

Changes in the volume of coconut water from the four varieties at each stage of maturity are shown in Fig 1A. According to these data, all of the stages of maturity were significantly different from each other, and MT was different from the other varieties ($p < 0.05$).

The findings agree with those of Jayalekshmy *et al*,¹ who concluded that water volume was one of the major characteristics of coconut water that changed with maturity. The volume of water present in the whole nut increased from stages 7 through 9, and then decreased between stages 9 and 10 for all varieties. As the nuts matured, they became larger and thus their water-holding capacity increased. However, between stages 9 and 10, the water volume decreased because the nut water at these stages began to form a ‘jelly’ on its inner portion, which resulted in a reduction in the volume of water present in the nut.¹ This was the general trend for all the varieties, although the stage at which the ‘jelly’ starts to form can be as early as stage 8. The MT variety, which is taller than the other varieties had a much larger size nut overall, producing a larger volume of nut water throughout maturation.

The crude fat content of the nut water samples increased overall as the coconuts became more mature (Fig 1B). As it is the fat portion of the coconut water that comprises the ‘jelly’, this suggests that the closer the coconut gets to the stage of ‘jelly’ formation (that is, more mature), the higher the fat content.⁵ There were no significant differences between the varieties except in the case of YD, which generally had a higher fat content than the other varieties.

Protein content showed a significant increase with maturation for all varieties studied and may be associated with the endosperm development in the nut (Fig 1C). As the endosperm hardened from a

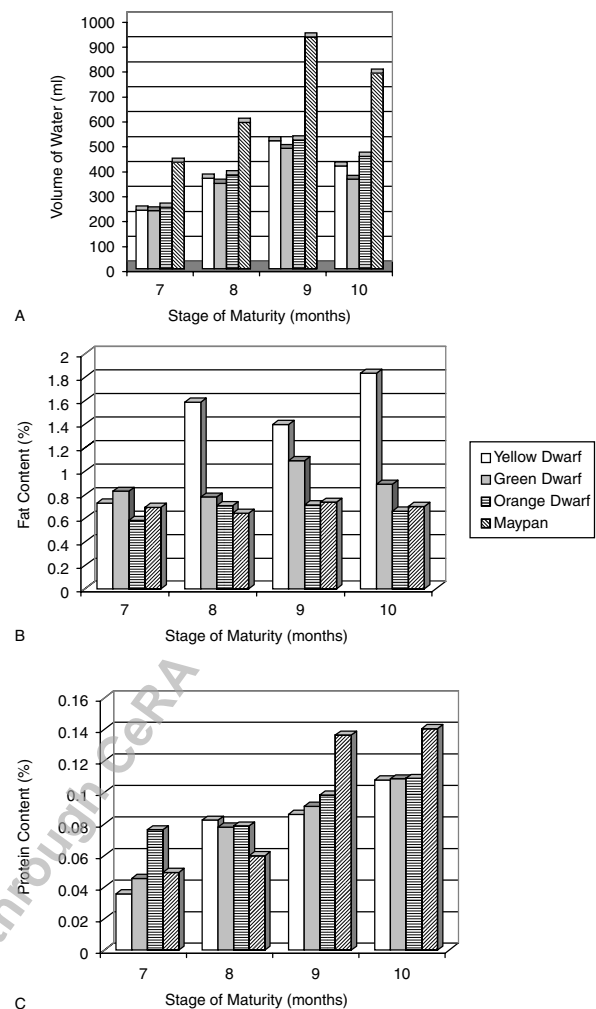


Figure 1. Volume of coconut water (A), fat content (B) and protein content (C) of Yellow Dwarf, Green Dwarf, Orange Dwarf and Maypan varieties at 7–10 months of maturity.

watery ‘jelly’ at stage 7 to the harder ‘white meat’ or kernel at stage 10, protein (possibly storage protein) content increased, which agreed with protein changes with maturity reported by Purselglove.⁶ There were no significant differences observed between the MT and OD varieties and the YD and GD varieties, respectively.

The pH of the samples varied slightly with maturation; overall, the pH of coconut water increased as the coconuts matured from 7 to 10 months (Fig 2A). This trend was not observed for the YD variety. In this case, pH decreased steadily throughout maturity, except at stage 10 when it increased slightly. The findings on increase of pH with maturity supported those of Pue *et al*,⁷ who found that pH increased from 4.7 to 5.58 with maturity in their samples, values within the range of our data. The titratable acidity of the nut samples followed a trend similar to the overall pH changes observed (Fig 2A). Varieties that increased in pH tended to have a Concurrent reduction in titratable acidity. This was particularly observed with OD and MT.

For all varieties, total solids increased overall as the coconuts became more mature (Fig 2B); however

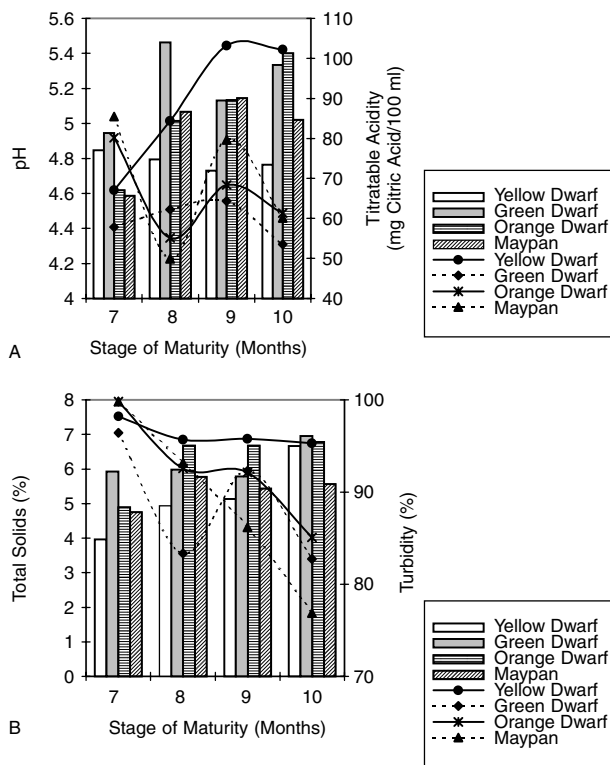


Figure 2. pH (column graph) and titratable acidity (line graph) (A); and total solids (column graph) and turbidity (line graph) (B) of the Yellow Dwarf, Green Dwarf, Orange Dwarf and Maypan varieties at 7–10 months of maturity.

there were no significant differences observed between 8 and 9 months of maturity, particularly for the YD and MT varieties. The total solids is a measure of the dry matter that remained after the moisture was removed from the samples, and is reported to be due to the increased concentrations of ions such as phosphate, sulfate, chloride and fluoride, as coconuts mature.⁷

The samples became more turbid with maturity (Fig 2B), that is, the transmittance decreased further from 100%, which represents the transmittance for clear distilled water. This may be related to the increase in total solids concentration observed with maturation.⁷

The ash content of the coconut water, which represents the overall mineral content, did not show

any significant differences for the GD, OD and MT varieties (Fig 3A). Furthermore, there were no overall significant differences in ash content with maturity of the coconut.

Soluble solids, which are a measure of the sweetness of the coconut water, showed an expected increase overall with maturity (Fig 3B); between stages 9 and 10, however, there was a slight decrease in both the OD and GD varieties. The initial stage of maturity (7 months) was the only one that was significantly different to the others ($p < 0.05$).

This trend was also reflected in the data for sugar content of coconut water from stages 7 to 12 (Table 1). There was a significant increase in total, reducing and non-reducing sugars during maturation. Although there were no significant differences between the varieties themselves, the interaction of maturity and variety had a significant effect ($p < 0.05$) on total and reducing sugar content. The highest total sugar

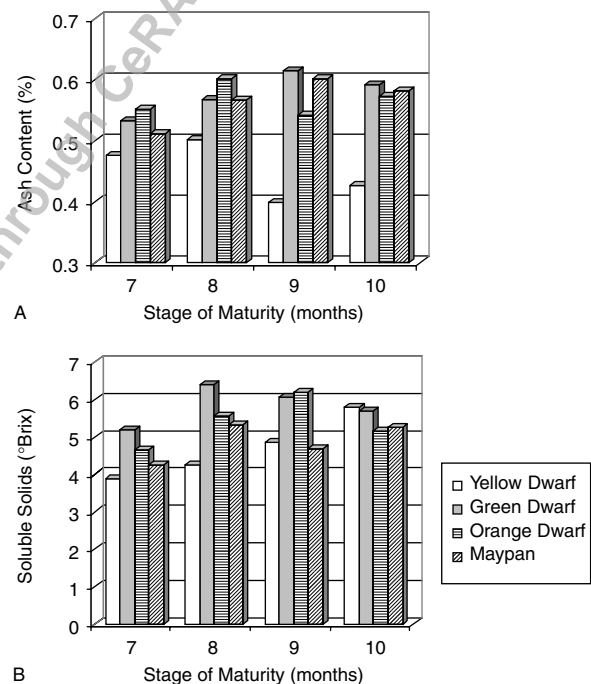


Figure 3. Ash content (A) and soluble solids content (°Brix) (B) of the Yellow Dwarf, Green Dwarf, Orange Dwarf and Maypan varieties at 7–10 months of maturity.

Table 1. Total sugar (TS), reducing sugar (RS) and non-reducing sugar (NR) content (%) of coconut water from Green Dwarf, Orange Dwarf and Maypan varieties at 7–12 months of maturity

Stage	Variety								
	Green Dwarf			Orange Dwarf			Maypan		
	TS	RS	NR	TS	RS	NR	TS	RS	NR
7	3.92 ± 0.58	3.04 ± 1.24	0.86 ± 0.65	4.06 ± 0.23	3.48 ± 0.66	0.67 ± 0.28	4.49 ± 0.51	3.34 ± 0.32	1.14 ± 0.18
8	5.98 ± 0.54	4.54 ± 0.63	1.44 ± 0.09	4.95 ± 0.48	4.41 ± 0.09	0.54 ± 0.58	3.96 ± 0.14	3.02 ± 0.17	0.95 ± 0.06
9	5.11 ± 0.09	4.83 ± 0.23	0.28 ± 0.14	4.51 ± 0.10	4.06 ± 0.09	0.45 ± 0.01	4.09 ± 1.26	3.19 ± 0.91	0.89 ± 0.36
10	4.62 ± 0.31	3.43 ± 0.37	1.19 ± 0.08	4.63 ± 0.89	3.09 ± 0.51	1.54 ± 0.66	3.83 ± 0.23	2.43 ± 0.41	1.39 ± 0.18
11	4.05 ± 0.09	2.72 ± 0.01	1.33 ± 0.11	3.64 ± 0.19	2.31 ± 0.19	1.33 ± 0.001	4.29 ± 0.18	3.22 ± 0.19	1.07 ± 0.01
12	3.29 ± 0.04	1.52 ± 0.36	1.77 ± 0.33	3.33 ± 0.17	1.73 ± 0.23	1.61 ± 0.40	3.77 ± 0.22	2.66 ± 0.22	1.11 ± 0.003

content recorded was 5.98% for the GD variety at stage 8. After stage 8, there was a gradual decrease to stage 12; the lowest was 3.33% for the OD variety at stage 12. In the early stages of maturity, the sugars present were almost entirely reducing sugars, such as glucose and fructose (>75%), but in the latter stages, the non-reducing sugar (sucrose) content increased.

Similar data for the sugar content of coconut water with maturity have been reported by several researchers; they found that sugars, in the form of glucose and fructose, formed an important constituent of the tender coconut water.^{1,3,8,9} In addition, they reported that the concentration of sugars in the water steadily increased from about 1.5% in the early months of maturation, to about 5.0–5.5%, and then slowly decreased to about 2% at the stage of the full maturity of the nut.^{1,3,8,9}

CONCLUSIONS

These findings on changes in chemical composition of coconut water indicate that significant changes occurred during maturity of the fruit. The interaction of variety and maturity of the fruit appeared to affect chemical composition. To optimize the quality of the bottled coconut water, coconuts at the appropriate stage of maturity, that is having maximum water volume and characteristic coconut water flavour, should be utilized. On the basis of these findings,

the optimum stage of maturity for all the cultivars studied appeared to be 9 months after emergence of the inflorescence (stage 9). At this stage, water volume was highest, as was the chemical composition of interest, including non-reducing sugar, soluble solids content and protein content.

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