

Changes in the composition of coconut kernel (*Cocos nucifera* L.) with maturity and season of fertilization in selected cultivars/hybrids

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Abstract

(*Cocos nucifera*) has an oil yield of about 65% and is perhaps the richest material for vegetable oil extraction. The solid endosperm, kernel, undergoes biochemical changes as it matures during its 12-month growth period after fertilization. The objective of this work was to study these changes in the coconut endosperm in relation to the maturity of the nut and season of fertilization in five selected cultivars/hybrids of coconut. Freshly fertilized bunches of coconut cultivars/hybrids, WCT, LCT x GBGD, COD x WCT, WCT x GBGD and LCT x COD palms, were tagged in three seasons: post-monsoon, pre-monsoon and monsoon. The nuts were harvested at different maturity stages: 7, 8, 10 and 12 months after fertilization. The dried kernel or copra was analyzed for its oil content, total soluble sugar, reducing sugar, starch, protein and fiber contents. Nuts that fertilize in the post monsoon season were found to have higher oil and carbohydrate contents, but lesser kernel protein content than nuts that fertilize at other seasons. Among the varieties studied, COD x WCT had higher levels of carbohydrates and proteins in the kernel. Other promising varieties are WCT x GBGD for its higher carbohydrate content and LCT x GBGD for its higher protein content.

Key words: *Cocos nucifera*, coconut, kernel, copra, metabolites

Introduction

Coconut (*Cocos nucifera*) is the most useful of tropical palms. It is mainly cultivated in the humid tropics for the nuts from which are obtained copra, coconut oil and coconut fiber. It is one of the most important sources of vegetable oil in the world. Copra, the main product of the palm, which has an oil yield of about 65%, is perhaps the richest material for vegetable oil extraction.

The solid endosperm undergoes biochemical changes as it matures during its 12-month growth period after fertilization. An understanding of these changes would be useful for not only the scientists and nutritionists but also the farmers, to determine the specific end use to which the nut can be put to. The objective of this study was to look into the biochemical changes of the coconut endosperm in relation to the maturity of the nut and season of fertilization in five selected cultivars/hybrids of coconut.

Materials and Methods

Material: Freshly fertilized bunches of WCT, LCT x GBGD, COD x WCT, WCT x GBGD and LCT x COD palms, ten years of age, were tagged in three seasons: post-monsoon (November 1998), pre-monsoon (May 1999) and monsoon (August 1999). The nuts were harvested at 7, 8, 10 and 12 months after fertilization. Three replicates of each treatment, each a composite of two nuts, were analyzed for the nut water volume, kernel moisture, oil and kernel metabolites – total soluble carbohydrates, reducing sugars, starch, total protein and fiber contents.

Metabolites: Spectrophotometric quantification of total soluble carbohydrates was done by the phenol-sulfuric acid method (Dubois *et al.*, 1956), starch by the anthrone method (Hodge and Hofreiter, 1962), reducing sugar by the Nelson-Somogyi method (Somogyi, 1952). Protein was quantified by Lowry's method (Lowry *et*

al., 1951) and crude fiber was determined gravimetrically by the method of Maynard (1970).

Results and Discussion

Oil content: Table 1 gives the oil content (in percentage) of the maturing kernels of different varieties of coconut. The oil content of nuts tagged in the pre-monsoon and monsoon seasons was on par, while that of nuts tagged in the post-monsoon season was significantly higher. Oil content was least in LCT x COD and maximum in LCT x GBGD, followed by WCT. The contents in WCT x GBGD and COD x WCT were on par. The difference in oil contents of nuts differing in maturity was significant at both 5 and 1% levels.

Table 1. Oil content (%) in coconut of different varieties and maturity stages, tagged in different seasons

Variety	Maturity (Months)	Season of tagging Post-monsoon	Pre-monsoon	Monsoon
WCT	7	48.5	45.5	45.8
	8	60.0	57.4	45.5
	10	63.6	61.5	71.1
	12	69.5	71.8	72.2
LCT x GBGD	7	57.1	52.2	43.2
	8	59.2	64.1	51.6
	10	62.0	65.0	64.0
	12	67.8	72.1	67.2
COD x WCT	7	55.3	49.2	40.0
	8	58.0	53.9	47.5
	10	65.8	59.1	65.3
	12	69.3	70.5	66.4
WCT x GBGD	7	54.0	33.7	51.0
	8	61.6	43.7	55.6
	10	63.0	64.0	63.7
	12	65.7	64.7	68.1
LCT x COD	7	55.3	24.7	34.0
	8	58.5	46.0	51.2
	10	64.0	68.9	61.8
	12	67.6	68.4	64.4

CD_{0.05}: Season = 0.77; Variety = 0.99; Maturity = 1.01

Nut water volume and Kernel moisture: The nut water volume decreased with increasing nut maturity as is already known. In nuts tagged in pre-monsoon it was significantly higher than those tagged in the other seasons. Though nut water volume is a highly variable factor, it was recorded in the five cvs/hybrids, and consistent trends were observed. Irrespective of season or maturity, WCT had significantly greater nut water volume, followed by LCT x COD; LCT x GBGD had the least. The solid endosperm moisture content also decreased with increasing nut maturity; it was more in nuts tagged in monsoon, while the nuts tagged in the other two seasons were on par. LCT x COD had significantly higher kernel moisture content than the other four varieties (Table 2).

Both nut water volume and kernel moisture is already known, were found to decrease with increasing nut maturity, and this observation corroborates with the reports of Sierra and Velasco (1976) which states that the dissolved constituents of the water, with reported growth promoting activity are an essential component in the ripening of the solid endosperm. The present study also indicates an increase in total soluble carbohydrates and non-reducing sugars in the kernel up to the 10th month, the nut water probably acting as the vehicle for these metabolites. LCT x COD was found to have higher levels of both, compared to the other varieties.

Carbohydrates: Nuts tagged in the post monsoon season had the maximum total soluble carbohydrates and starch content. WCT x GBGD and LCT x COD had greater soluble carbohydrate content followed by COD x WCT. All varieties, in spite of quantitative differences followed the same trend, viz., increase in soluble carbohydrates with nut maturity, to a maximum in the 10th month, after which it fell significantly in the 12th month. WCT x GBGD and COD x WCT had greater starch content compared to the other varieties. All the varieties were found to demonstrate a significant reduction in starch content as the nut matured. The concentration of reducing sugars was more in the nuts tagged in monsoon, followed by the nuts tagged in post monsoon season. Of the five cultivars/hybrids, LCT x COD had the highest reducing sugar concentration, while LCT x GBGD had the least, irrespective of the other variables. In nuts of all the varieties, tagged at different seasons, reducing sugar was maximum in the 7th month, after which it decreased to a minimum by the 10th month, it increased again by the 12th month (Table 3).

The inverse relationship seen in the trends of total soluble carbohydrates and the reducing sugars, also reflects on the corresponding increase in non-reducing sugars by the 10th month. It can be concluded that for maximum carbohydrate content, the 10th month kernel is the best. Starch content was found to significantly drop from the 7th to 12th month nuts, as it contributes to the total soluble carbohydrate pool, by its breakdown. That the nuts tagged in the post monsoon season were found to have the greatest amounts of total soluble carbohydrates and starch coincides with better water and nutrient availability to the palm in this season. WCT x GBGD and COD x WCT were the varieties that consistently showed higher total soluble carbohydrates and starch content compared to the other three cultivars/hybrids.

Protein and fiber content: Nuts tagged in pre monsoon season had greater protein content, followed

Table 2. Nut water volume (NWW) (mL) and kernel moisture (%) in coconut of different varieties and maturity stages, tagged in different seasons

Variety	Maturity (Months)	Post monsoon		Pre monsoon		Monsoon	
		NWW	Moisture	NWW	Moisture	NWW	Moisture
WCT	7	420.33	71.73	454.33	78.64	355.33	77.29
	8	347.00	67.98	428.33	67.42	273.33	72.62
	10	247.67	50.32	205.33	38.59	172.00	48.03
	12	162.33	35.76	207.33	36.60	147.33	42.15
LCT x GBGD	7	205.33	78.54	324.33	82.96	220.33	78.84
	8	158.00	64.97	255.00	69.52	205.00	67.92
	10	128.33	49.37	149.67	39.11	150.67	46.89
	12	48.33	35.56	50.33	35.06	62.67	41.22
COD x WCT	7	266.67	80.08	343.33	81.28	276.33	81.56
	8	223.33	67.91	270.67	70.75	202.00	71.86
	10	142.67	46.60	204.00	42.08	136.67	52.58
	12	128.67	37.12	130.00	35.17	130.33	42.74
WCT x GBGD	7	230.33	67.90	415.00	85.24	279.33	75.46
	8	221.67	72.50	329.33	73.52	241.00	66.98
	10	135.33	56.54	232.00	49.84	171.67	57.56
	12	126.00	34.55	160.67	34.67	128.33	42.99
LCT x COD	7	346.33	79.03	500.67	88.27	363.33	79.41
	8	257.33	70.51	343.67	68.26	213.67	73.40
	10	239.67	59.73	190.00	43.93	238.33	54.60
	12	163.00	40.89	156.67	37.24	186.67	46.90
CD _{0.05}	Season	7.83	1.36				
	Variety	10.10	1.76				
	Maturity	8.29	1.21				

by those tagged in monsoon. LCT x GBGD and COD x WCT had the maximum protein content followed by WCT, irrespective of other variables. In all these varieties,

there was a significant decrease in protein content as the nut matured. The decrease in protein content with nut maturity reflects on its utilization for cell division and

Table 3. Carbohydrates - Total soluble carbohydrates (TSC) (mg g⁻¹ dry weight), Starch (mg g⁻¹ dry weight) and Reducing sugars (RS) (mg g⁻¹ dry weight) - in coconut of different varieties and maturity stages, tagged in different seasons

Variety	Maturity (Months)	Post monsoon			Pre monsoon			Monsoon		
		TSC	Starch	RS	TSC	Starch	RS	TSC	Starch	RS
WCT	7	174.87	185.49	10.45	169.65	128.10	7.38	159.13	96.64	15.24
	8	227.21	137.10	3.32	169.14	69.06	5.97	190.74	106.77	7.62
	10	328.47	96.99	2.97	244.68	68.20	3.50	283.96	60.51	2.47
	12	287.05	73.89	3.52	199.67	58.60	4.15	195.83	39.35	6.37
LCT x GBGD	7	203.93	173.22	8.76	142.84	106.40	4.79	146.57	116.35	20.49
	8	231.00	123.35	6.14	160.55	63.80	2.96	175.62	92.17	6.85
	10	324.66	111.24	2.56	233.24	56.48	2.10	284.17	84.39	3.01
	12	265.03	73.86	4.00	182.34	49.03	2.98	218.51	43.97	5.24
COD x WCT	7	251.06	236.12	16.54	150.14	103.25	7.49	150.07	113.15	23.48
	8	237.96	134.25	8.93	190.27	68.62	5.71	197.63	111.61	10.36
	10	407.70	98.71	2.46	241.38	63.27	2.69	301.12	69.49	2.60
	12	301.41	82.89	5.11	196.41	57.02	4.80	209.79	47.63	4.89
WCT x GBGD	7	235.28	202.00	12.13	198.23	164.36	11.39	178.12	106.39	16.90
	8	266.68	127.64	7.38	196.03	102.56	6.92	191.04	87.18	8.82
	10	461.74	122.70	4.58	234.70	84.83	3.26	264.97	47.62	2.23
	12	366.72	84.61	7.11	209.39	52.61	3.68	204.08	44.31	6.49
LCT x COD	7	259.83	157.56	13.04	205.60	116.14	22.07	153.10	119.36	25.33
	8	265.94	134.97	10.54	217.66	82.78	5.97	208.59	103.24	9.75
	10	354.77	102.73	5.86	244.19	76.87	3.70	225.03	57.11	4.01
	12	342.21	85.03	7.39	231.42	59.14	5.06	218.72	46.31	5.67
CD _{0.05}	Season	6.73	8.06	0.40						
	Variety	8.69	6.71	0.51						
	Maturity	8.80	7.63	0.52						

proliferation in the maturing of the kernel. As oil and sugars are the main constituents of the mature kernel, the decrease in protein fraction could be attributed to the synthesis of both. LCT x GBGD and COD x WCT had higher protein contents than the other cultivars/hybrids.

varieties studied, COD x WCT had higher levels of carbohydrates and proteins in the kernel. Other promising varieties are WCT x GBGD for its higher carbohydrate content and LCT x GBGD for its higher protein content. Knowledge of the nutrient profile of the coconut

Table 4. Protein (mg g⁻¹ dry weight) and fiber (% dry weight) content in coconut of different varieties and maturity stages, tagged in different seasons

Variety	Maturity (Months)	Post monsoon		Pre monsoon		Monsoon	
		Protein	Fiber	Protein	Fiber	Protein	Fiber
WCT	7	80.75	15.67	122.36	15.17	77.92	12.90
	8	76.03	27.07	101.87	19.67	73.97	14.00
	10	46.67	29.80	79.31	20.43	68.82	16.10
	12	26.54	33.63	54.18	21.00	58.45	19.23
LCT x GBGD	7	90.70	17.80	110.67	13.50	89.52	11.47
	8	84.95	25.70	93.14	13.63	88.88	13.73
	10	38.13	25.90	68.62	15.97	76.12	19.47
	12	20.43	35.90	62.51	16.33	72.01	25.33
COD x WCT	7	80.68	15.67	108.76	17.37	95.75	12.40
	8	79.30	22.93	104.27	21.80	81.75	13.60
	10	31.27	26.40	74.19	22.70	79.62	21.77
	12	27.08	41.23	58.45	23.93	67.99	23.47
WCT x GBGD	7	80.60	16.30	103.47	9.63	75.21	11.83
	8	74.86	26.60	102.48	16.03	71.98	15.13
	10	39.05	27.20	80.04	21.00	59.34	19.00
	12	23.93	27.73	51.16	22.76	53.63	26.30
LCT x COD	7	84.83	12.83	85.42	11.93	81.90	10.03
	8	75.73	21.40	78.30	13.10	75.90	11.67
	10	43.09	23.33	72.42	21.60	74.15	17.57
	12	25.96	28.73	66.79	21.27	62.42	19.47
CD _{0.05}	Season	1.66	0.65				
	Variety	2.14	0.84				
	Maturity	2.21	0.80				

Nuts tagged in post monsoon season had greater fiber content in the solid endosperm than the rest. Maximum fiber content was noticed in COD x WCT, least in LCT x COD, the rest being on par. All varieties were found to follow the same trend of increase in fiber content as the kernel matured (Table 4). Fiber content, an essential ingredient of a healthy diet due to the roughage it provides, was found to increase as the kernel matured by twice its normal content from the 7th to the 12th months. So in cuisines as those of Kerala, where the mature kernel, and not the oil alone, is also used for culinary purposes, coconut is a good source of fiber in the diet. Balleza and Sierra (1976), who observed the same trend, are of the opinion that as the solid endosperm matures, more of the sugars are transformed into cellulose.

In conclusion, nuts that fertilize in the post monsoon season were found to have a higher oil and carbohydrate content, but lesser kernel protein content than nuts that fertilize at other seasons. Among the

endosperm in relation to maturity, variety and season of fertilization is thus useful in determining its end use.

References

- Balleza, C. F. and Sierra Z. N. 1976. Proximate analysis of the coconut endosperm in progressive stages of development. *Phil. J. Coco. Studies. I (2):* 37-43.
- Dubois, M. K. A., Gilles, J. K., Hamilton, P. A., Rebers, and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. *Anal. Chem. 26:* 350.
- Hodge, J. E., Hofreiter, B. T. 1962. *In* : Methods in carbohydrate chemistry. Whistler, R. L., Be Miller J. N. (eds) Academic Press, New York.
- Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. J. 1951. Protein measurement with Folin-phenol reagent. *J. Biol. Chem. 193:* 265-276.
- Maynard, A. J. (eds) 1970. Methods in food analysis. Academic Press, New York, pp 176.
- Sierra, Z. N. and Velasco, J. R. 1976. Studies on the growth factor of coconut water – Isolation of the growth promoting activity. *Phil. J. Coco. Studies. II(2):*11-18.
- Somogyi, M. 1952. Notes on sugar determination. *J Biol. Chem. 200:* 245.