African Journal of Biotechnology Vol. 9 (14), pp. 2136-2144, 5 April, 2010
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

Physicochemical characteristics of kernel during fruit maturation of four coconut cultivars (*Cocos nucifera* L.)

Assa Rebecca Rachel[1]*, Konan Konan Jean-Louis[2], Prades Alexia[3], Nemlin Jean[4] and Koffi Ernest[5]

[1]Unité de Formation et de Recherche (UFR) Biosciences, Laboratoire de Biochimie et Sciences des Aliments; Université de Cocody, 22 BP 582 Abidjan 22, Côte d'Ivoire.
[2]CNRA- Station Marc Delorme pour la recherche sur le cocotier de Port- Boüet, 07 BP 13 Abidjan 07, Côte d'Ivoire.
[3]CIRAD, Centre de Coopération Internationale en Recherche Agronomique pour le Développement, UMR Qualisud, F-34398 Montpellier, France.
[4]Centre National de Recherche Agronomique (CNRA) – Station sur la Recherche Technologique, 08 BP 881 Abidjan 08, Côte d'Ivoire.
[5]Unité de Formation et de Recherche (UFR) Biosciences, Laboratoire de Biochimie et Sciences des Aliments ; Université de Cocody, 22 BP 582 Abidjan 22, Côte d'Ivoire.

Accepted 23 October, 2009

Physicochemical characteristics of kernels from four cultivars of coconut were studied with the aim of increasing the value of coconut palm (*Cocos nucifera* L.), the main income of most equatorial coastal farmers. Studies were undertaken on West African Tall (WAT), Malaysian Yellow Dwarf (MYD), Equatorial Guinea Green Dwarf (EGD) and the improved PB121 hybrid, PB121+. Analyses were concerned with kernel weight, thickness, dry matter, oil, proteins and soluble sugars content at six stages (ranks) of nuts maturity. Chromatographic profiles of fatty acids of extracted oils were also determined. The results showed positive interaction between cultivar and maturity stage for all examined parameters. Then, PB121+ nuts, without kernel at the beginning of maturation, had the greatest weight (358.7 g) at rank 26. Kernel thickness was maximum (13.28 mm) in WAT at rank 26 due to nuts complete maturity. Oil content increased until the highest value of 73.01% in WAT at rank 23 before decreasing. Total soluble sugars, essentially non-reducing sugars, were maximum (9.09 g/100 g) in MYD fruits at rank 26. The fatty acids profiles showed an increasing proportion of lauric acid during nuts maturation. These results indicated the possibility of specific utilisations of coconut kernels according to cultivar and maturity stage.

Key words: Coconut, kernel, characteristics, maturity, cultivar.

INTRODUCTION

Coconut palm (*Cocos nucifera* L.) is widely referred to as "the tree of life" because of its endless potential uses (Roberto et al., 1996). Thus, more than 10 millions peasant families of many equatorial coastal countries, with traditional plantations, live off the coconut palm, largely through nuts production (Moore and Batugal, 2004).

At full maturity, coconuts consist of an average of 33% husk, 16% shell, 33% kernel and 18% coconut water (Konan, 1997). Dried mature coconut kernel, known as copra, contains 6% moisture and is one of the main coconut products in producing countries (Roberto et al., 1996).

Dry mature coconut kernel contains an average of 70% lipids (Konan et al., 2008). These lipids are referred to as coconut oil or copra oil, according to the type of extraction, that is, directly from the fresh kernel or from the copra (N'cho and Sangaré, 1997). Copra oil is used in both food-processing (Priscilla et al., 1989) and oleochemical industries (Graille, 1993), contrary to other oils

*Corresponding author. E-mail: assa_rebecca@yahoo.fr. Tel: (225) 07-69-88-51 or (225) 23-46-29-68. Fax: (225) 22-44-03-07 or 22-44-37-24.

which are either exclusively nutritious (soya bean oil) or exclusively non-nutritious (castor oil). Coconut oil, on the other hand, is rich in saturated fatty acids (Berger and Andanar, 1991). Thus, it is qualified as non-nutritious because its consumption is thought to increase the risk of cardiovascular disease (Gurr, 1994). However, despite this, studies conducted in Asian and African populations with cooking traditions based on the use of coconut oil (Conrado, 1994) did not show a predominance of cardiovascular illnesses (Gurr, 1994).

In addition to oil, coconut kernel has various other uses. For example, Priscilla et al. (1989) documented the use of rasped coconut in engineering production. Chee and Choon (1997) examined the possibility of dehydrated coconut milk manufacture and showed that the principal components of dehydrated coconut milk were 63.6% fat, 28.7% sugars and 4.5% proteins.

However, despite the above, few previous studies have examined the differences between kernels of different coconut cultivars. Further, the biochemical features of coconut kernel during nut maturation remain largely unknown, except some old data like those of Balasubramaniam (1976).

Then, in Côte d'Ivoire, an equatorial country, where more than 12000 coastal peasant families live off the coconut palm, nuts are sold whole because of the lack of transformation technologies. Moreover, there remains widespread ignorance over the value of copra, the principal product of mature kernel (Assa et al., 2006). Thus reduce the profitability of coconut palm producers. Revalorization of coconut production is therefore necessary.

Accordingly, the present work was conducted to identify the physicochemical characteristics of kernel from different coconut cultivars, with the aim of increasing the overall value of coconut palm in producing countries.

MATERIALS AND METHODS

Materials

The vegetal material was derived from nuts of four coconut palm cultivars obtained from the Marc Delorme research center of the National Agronomic Research Centre (CNRA) in Côte d'Ivoire. These cultivars were the West African Tall (WAT), Malayan Yellow Dwarf (MYD), Equatorial Guinea Green Dwarf (EGD) and the improved PB121 hybrid; PB121+. Their agronomic features have been studied respectively by De Nucé and Wuidart (1979), De Nucé and Rognon, (1977) and Bourdeix et al., (1992). WAT constitutes the local cultivar in peasant areas of Côte d'Ivoire, MYD and the EGD are dwarf cultivars whose nut features are deemed valuable. However, PB121+, a hybrid of MYD and WAT, is worldwide known.

Methods

Six coconut palms were randomly chosen per cultivar, giving 24 sample palms in total. From these, six bunches at six different stages of maturity (ranks) were harvested. Maturation ranks were as follows: 17, 19, 21, 23, 25 and 26, corresponding respectively to fruits of 5, 7, 9, 11, 13 and 14 months old. Three fruits from each bunch were sampled. Their kernels were homogenized to form a representative sample for analysis. Harvested fruits were sheltered to prevent the effects of sun and rain and analyses were initiated within 24 h after harvesting.

Coconut husks, shell and water were successively removed then the kernel was cut into pieces. The weight of the kernel (WKE) was determined on a Sartorius electronic balance and the thickness of three pieces of kernel (TKE) was measured using a micrometer. Dry matter (DMK) was determined by freeze-drying to -60°C under a pressure of 9 millibars for 48 h. Reducing sugar (RSK) and total sugar (TSK) contents of the kernel were determined by di-nitro-salycilate and phenol-sulphuric methods, respectively (Dubois et al., 1965), with a spectrophotometer (Spectronic Genesis 5). The amount of non-reducing sugar (NSK) was deduced by the difference between the TSK and RSK contents. The total protein content (PRK) was obtained after mineralization using the Kjeldahl method. Both of these results are expressed in grams per 100 g fresh kernel. Oil content (OCK) was determined by extraction using the Soxhlet method according to an ISO 659 norm and was expressed as a relative percentage of the dry matter content. Identification of principal fatty acids in the extracted coconut oil was conducted by gaseous-phase chromatography with nitrogen as the vector gas. The fatty acids content is expressed in grams per 100 g of coconut oil.

Experiments were conducted using the same trees over two successive years; in 2005 and 2006 from February to April. Obtained results were tested for statistical significance using Genstat software (Genstat Discovery, Edition 2). Analysis of variance with two criteria of classification (cultivar and stages of maturity) was performed to a risk of 5% error. Years of harvesting constituted blocs. Differences between averages were compared by the least significant difference at 5% probability. Correlations between analysed parameters were found using to explain theirs mutual effects. Six determinations have done for each sample.

RESULTS

Significant differences ($p < 0.01$) were found for each analysed parameter between cultivars and fruit ranks with a positive interaction between these two factors. But, both two campaigns were not found significant different at 5%.

Physical data of the coconut kernels

WKE and TKE, of all tested cultivars, increased during nut maturation from rank 17 to rank 25, becoming statistically stable at rank 26 (Table 1). The weight of the kernels varied from 0 to 19.7 g at rank 17, becoming maximum at rank 26 with 358.7, 303.8 and 274.6 g for cultivars PB121+, WAT and EGD respectively. In MYD, kernel weight decreased slightly, but not significantly, from 265.2 to 229.7 g between ranks 25 and 26 (Table 1).

TKE varied from 0 to 0.9 mm at rank 17 for all cultivars then increased significantly until rank 25. At this stage, values were 13.11, 11.88, 11.25 and 10.63 mm, respecttively for cultivars WAT, PB121+, EGD and MYD (Table 1). In PB121+, nuts of rank 17 did not have any kernel, while

Table 1. Evolution of coconut kernels weight and thickness during nuts maturation [a].

Cultivars	Ranks	Kernel weight (g)	Kernel thickness (mm)
WAT	17	19.70 ± 9.6	0.90 ± 0.30
	19	141.20 ± 12.6	5.78 ± 0.53
	21	239.30 ± 13.8	10.35± 1.47
	23	270.60 ± 13.4	12.24± 0.50
	25	311.10 ± 22.5	13.11± 2.38
	26	303.80 ± 15.2	13.28± 1.40
MYD	17	14.00 ± 10.21	0.90± 0.54
	19	137.70 ± 24.13	5.74± 0.55
	21	225.50 ± 23.01	8.45± 0.37
	23	262.80 ± 13.20	10.06± 0.41
	25	265.20 ±24.01	10.63± 0.65
	26	229.70 ± 13.01	10.87±0.38
EGD	17	3.30 ± 2.10	0.10± 0.04
	19	110.08 ± 13.03	4.61± 0.53
	21	191.40 ± 12.80	7.73± 0.31
	23	249.00 ± 23.14	10.26± 0.90
	25	277.30 ± 12.09	11.25± 0.40
	26	274.60 ± 18.10	11.31± 0.31
PB121+	17	0	0
	19	50.50 ± 15.10	2.04± 0.40
	21	193.40 ± 14.33	6.40± 0.35
	23	281.10 ± 15.02	9.44± 0.50
	25	349.10± 21.14	11.88± 1.39
	26	358.70 ± 20.04	12.14± 0.45
	LSD	26.4	0.74

[a:] Mean values ± standard error.
LSD: little significant difference.
Each value represents an average of six determinations (n = 6).
WAT : West African Tall.
MYD : Malayan Yellow Dwarf.
EGD : Equatorial Guinea Green Dwarf.
PB121+ : Improved PB121 hybrid.

those of EGD at the same rank weighed 3.3 g and had a thickness of 0.1 mm.

Biochemical data of the coconut kernels

Percentage of DMK increased during nut maturation in all cultivars tested (Figure 1). Between ranks 17 and 25, PB121+ had the lowest value, rising from 0 to 45.16%. However, at rank 26, its value was higher (48.74%) than that of MYD (47.28%), but the difference was not significant. Kernel of WAT fruits had the highest percentage of dry matter at all stages of maturity, evolving from 16.6 to 58.6%.

OCK increased gradually, reaching a peak at rank 23 in WAT and MYD with respective values of 73.01 and 64.16% (Figure 2). In EGD and PB121+, peaks were observed at rank 25 with respective values of 71.24 and 70.94%. At this stage, the OCK of WAT, EGD and PB121+ were statistically identical, but at rank 26 values decreased in all cultivars.

The PCK of each cultivar's fresh kernel are presented in Table 2. They increased from rank 17 to rank 19, reaching values of 10.68, 10.51, 10.42 and 12.86% in WAT, MYD, EGD and PB121+, respectively. This phase was followed by a decrease until rank 26 to respective values of 6.78, 7.2, 6.12 and 6.57% for WAT, MYD, EGD and PB121+.

RSK showed two phases of unequal expanse, successively increasing and decreasing, with a peak of 1.27, 1.03, 1.07 and 1.43% at rank 19 for WAT, MYD, EGD and PB121+, respectively (Table 2). From rank 23, the kernels of WAT and PB121+ showed statistically identical RSK values. The NSK and TSK values showed a similar tendency (Table 2) with two phases, successsively decreasing and increasing. TSK decreased from rank 17 to rank 19 in WAT (2.92%). In MYD and EGD, values from rank 17 decreased until rank 21, reaching

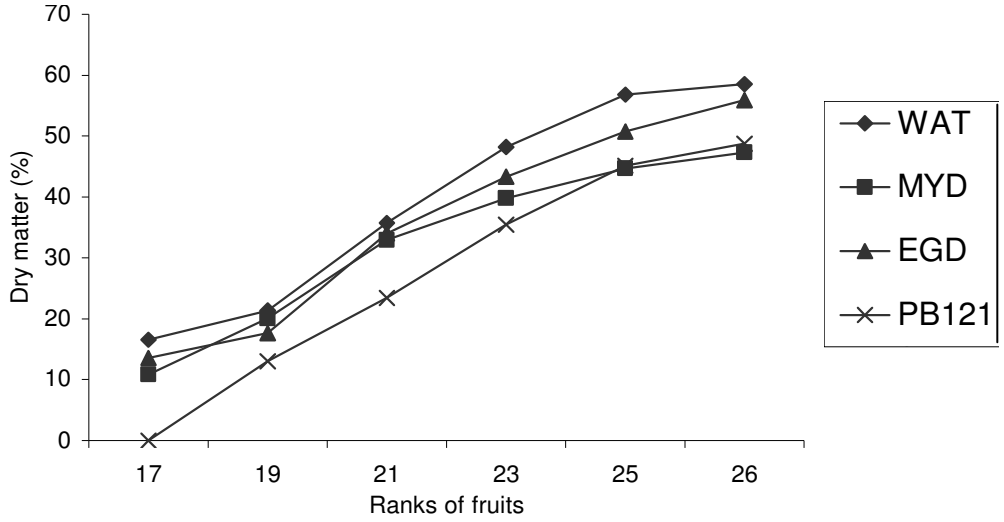

Figure 1. Coconut kernel dry matter (%) evolution during nuts maturation.

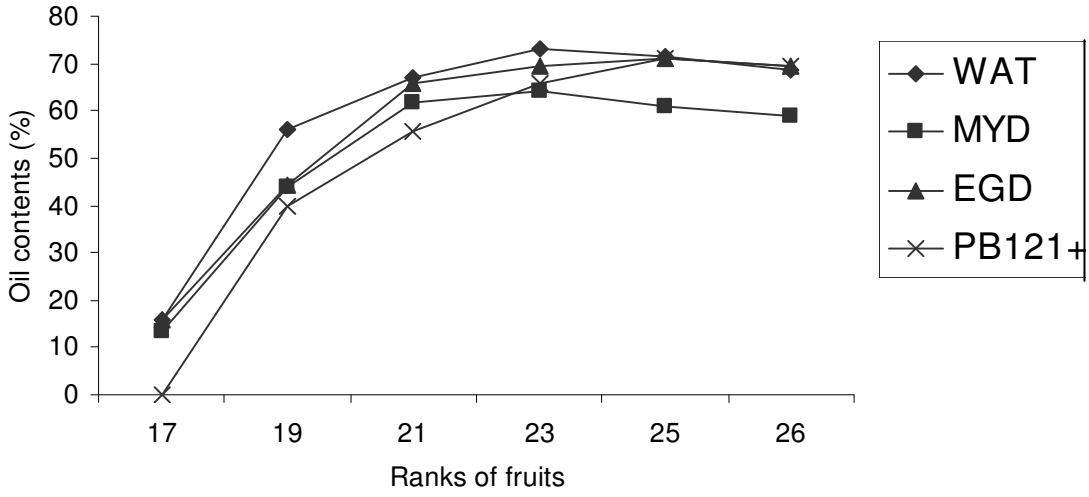

Figure 2. Coconut oil contents evolution during nuts maturation.

5.12 and 3.28%, respectively. This was followed by an increase until rank 26, at which WAT, MYD, EGD and PB121+ had respective amounts of 7.87, 9.09, 5.47 and 4.94%. Whatever the rank, MYD showed the highest values for these two parameters.

Fatty acid chromatographic profiles of the coconut oil revealed identical qualitative components in all cultivars studied (Figures 3). A significant interaction was observed between cultivars and maturation ranks for fatty acid content. Percentages of lauric acid increased during nut maturation from rank 17 until rank 26 in WAT, EGD and PB121+. Respective values varying between 35.0 and 47.82%, 30.76 and 44.15% and 30.50 and 44.37% (Figures 3a, 3c and 3d). In MYD (Figure 3b), the maximum lauric acid content was obtained at rank 21 (42.17 %), before becoming statistically stable at rank 23 (42.04%). After this, it decreased until rank 26 when it reached 40.17%. WAT oil of rank 25 had the highest percentage of lauric acid, but statistically identical with that at ranks 23 and 26.

Proportions of linoleic acid, an essential fatty acid, varied significantly during nut maturation. In MYD, values increased from 2.72 to 5.10%, with the maximum value being obtained at rank 23. Percentages of caproic and vaccenic acid, on the other hand, were much lower in all cultivars and at all stages of maturity, varying respectively from 0.10 to 0.33% in EGD and from 0.11 to 0.15% in PB121+. Chromatographic analyses showed that regardless of the cultivar, unsaturated fatty acids constituted a few part of coconut oil.

Correlations (r) were observed between some of studied parameters (Table 3). Then, positive correlation

Table 2. Total proteins and sugars contents (g/100 g of fresh matter) of kernel during coconuts maturation[a].

Cultivars	Ranks	Total proteins	Reducing sugars	Non reducing sugars	Total soluble sugars
WAT	17	8.18 ± 0.40	0.77 ± 0.17	4.59 ± 0.34	5.36 ± 0.35
	19	10.68 ± 0.47	1.27 ± 0.09	1.65 ±0.30	2.92 ± 0.36
	21	8.77 ± 0.54	0.86 ± 0.15	3.11 ± 0.25	3.97 ± 0.32
	23	7.33 ± 0.43	0.7 ± 0.08	3.86 ± 0.28	4.56 ± 0.25
	25	7.35 ± 0.35	0.47 ± 0.11	7.08 ± 0.30	7.55 ± 0.24
	26	6.78 ± 0.40	0.48 ± 0.07	7.39 ± 0.36	7.87 ± 0.30
MYD	17	8.19 ± 0.43	0.53 ± 0.13	6.33 ± 0.30	6.86 ± 0.33
	19	10.51 ± 0.38	1.03 ± 0.16	4.49 ± 0.34	5.52 ± 0.36
	21	8.62 ± 0.40	0.57 ± 0.11	4.55 ± 0.31	5.12 ± 0.31
	23	8.21 ± 0.50	0.44 ± 0.05	5.12 ± 0.38	5.56 ± 0.28
	25	6.41 ± 0.39	0.21 ± 0.12	8.66 ± 0.36	8.87 ± 0.39
	26	7.2 ± 0.24	0.38 ± 0.10	8.71 ± 0.33	9.09 ± 0.34
EGD	17	7.61 ± 0.31	0.46 ± 0.14	3.96 ± 0.29	4.42 ± 0.29
	19	10.42 ± 0.30	1.07 ± 0.15	3.29 ± 0.36	4.36 ± 0.30
	21	7.91 ± 0.34	0.48 ± 0.13	2.8 ± 0.33	3.28 ± 0.34
	23	7.2 ± 0.25	0.24 ± 0.07	3.66 ± 0.37	3.9 ± 0.29
	25	6.44 ± 0.30	0.32 ± .010	4.87 ± 0.27	5.19 ± 0.22
	26	6.12 ± 0.38	0.17 ± 0.12	5.3 ± 0.30	5.47 ± 0.26
PB121+	17	0	0	0	0
	19	12.86 ± 0.50	1.43 ± 0.16	1.28 ± 0.40	2.71 ± 0.29
	21	10.1 ± 0.47	1.28 ± 0.14	2.55 ± 0.29	3.83 ± 0.27
	23	8.04 ± 0.31	0.7 ±0.05	3.58 ± 0.31	4.28 ± 0.24
	25	6.94 ± 0.39	0.47 ±0.1	3.98 ± 0.23	4.45 ± 0.38
	26	6.57 ± 0.35	0.32 ± 0.09	4.62 ± 0.32	4.94 ± 0.30
	LSD	0.77	0.21	0.74	0.73

[a]: Mean values ± standard error.
LSD: little significant difference.
Each value represents an average of six determinations (n = 6).
WAT : West African Tall.
MYD : Malayan Yellow Dwarf.
EGD : Equatorial Guinea Green Dwarf.
PB121+ : Improved PB121 hybrid.

(r = 0.94) existed between TKE and OCK. Thus, TSK was positively correlated (r = 0.97) with NSK. While negative correlations were observed between PRK and WKE (r = -0.70) and between PRK and OCK (r = -0.77). In all cases, the amount of oil was positively correlated (r = 0.71) to the proportion of lauric acid.

DISCUSSION

Increasing kernel weight was shown to be strongly linked with its thickness. Indeed, when the kernel is establishing, its thickness gradually increases and thus, so too does the weight. At the beginning of maturation, the thin coconut kernel contains much water. It then thickens progressively and becomes hard as a result of intense cellular multiplication (Anonyme, 2006). This continues until rank 25, at which the thickness becomes stable. These findings suggest that morphologic changes, such as variation in kernel thickness, continue until the nut reaches full maturity. Then, fruits of coconut palm reach full maturity between 12 and 13 months after fecundation of the female flower.

The oil content of the kernel increases until rank 25, at which point the quantity of water decreases (Jayaleskmy et al., 1986). Since kernel development requires water, the stability of the oil content beyond rank 25 may indicate that this stage marks complete maturity. The variations observed in the present study in the dry matter, oil and protein content of the kernel during nut maturation are comparable with the data obtained by Balleza and Zenaida (1976).

Positive correlation between the oil content and kernel thickness suggests the implication of some hormones and enzymes in kernel, during nuts maturation, which initiate and enhance the oil synthesis.

Non-reducing sugars constituted the majority of the kernel total soluble sugars. Moreover, these two parameters

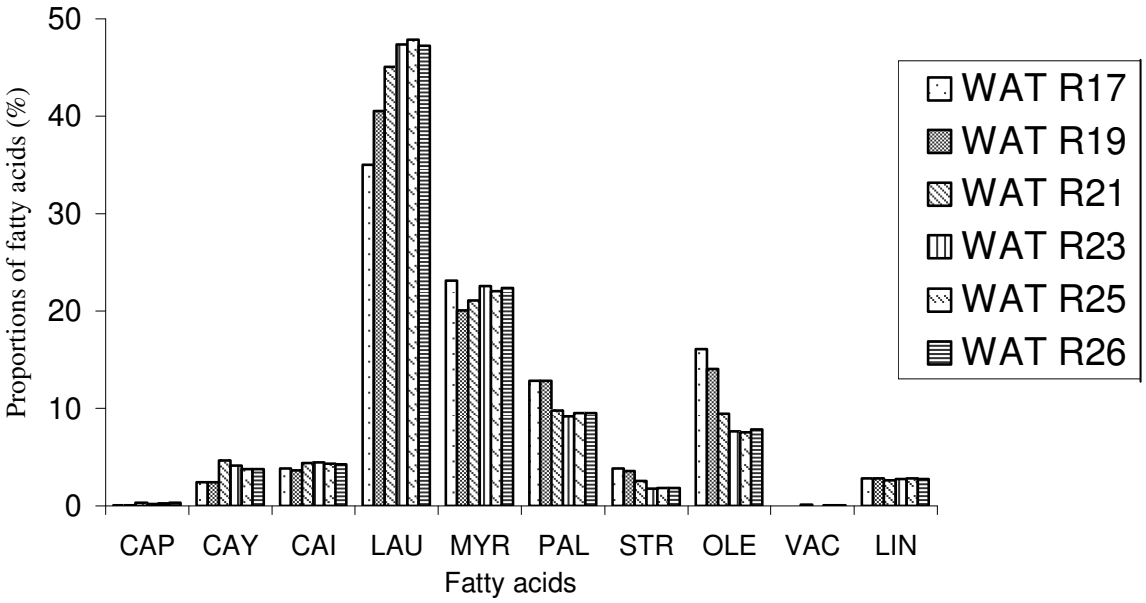

Figure 3a. Chromatographic profiles of coconut oil fatty acids during nut maturation, Cultivar WAT. WAT: West African Tall; MYD: Malayan Yellow Dwarf; EGD: Equatorial Guinea Green Dwarf; PB121+: Improved PB121 hybrid; CAP: caproïc acid; CYP: caprylic acid; CAI: capric acid; LAU: lauric acid; MYR: myristic acid; PAL: palmitic acid; STR: stéaric acid; OLE: oléic acid; VAC: vaccenic acid; LIN: linoléic acid.

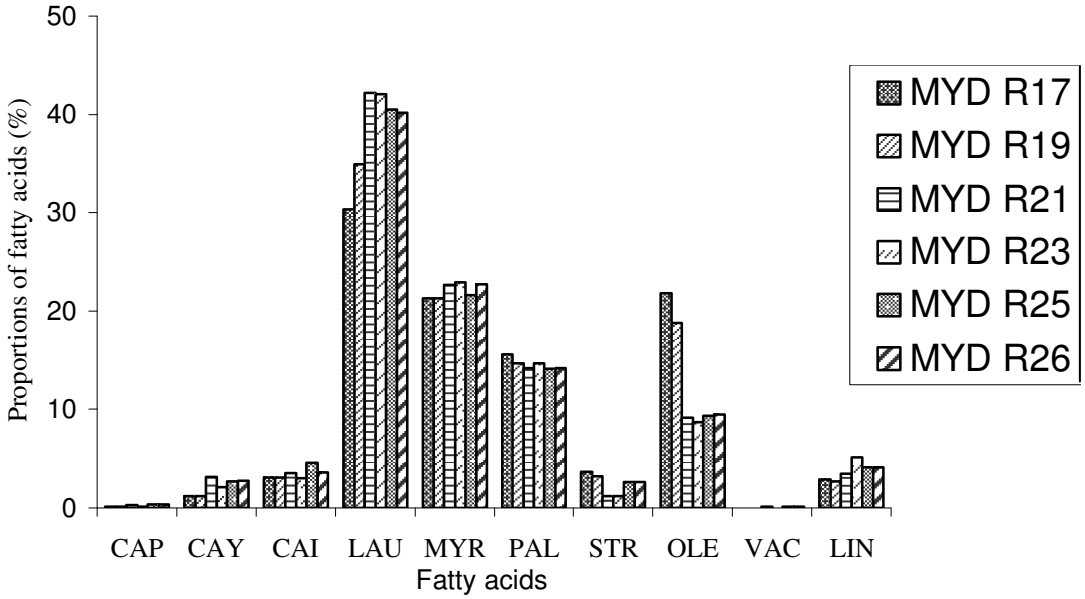

Figure 3b. Chromatographic profiles of coconut oil fatty acids during nut maturation, Cultivar MYD. WAT: West African Tall; MYD: Malayan Yellow Dwarf; EGD: Equatorial Guinea Green Dwarf; PB121+: Improved PB121 hybrid; CAP: caproïc acid; CYP: caprylic acid; CAI: capric acid; LAU: lauric acid; MYR: myristic acid; PAL: palmitic acid; STR: stéaric acid; OLE: oléic acid; VAC: vaccenic acid; LIN: linoléic acid.

showed the same tendency during nut maturation. A highly positive correlation (r = 0.94) was also observed between them. Differences between the kernel sugar content of different cultivars have also been observed by Swetman and Broadbent (1979) in mature whole nuts. Moreover, Balasubramaniam (1976) noticed an increasing concentration of polysaccharides in coconut kernel during maturation.

The saturated fatty acids present in coconut oil are caproic, capric, caprylic, lauric, myristic, palmitic and stearic

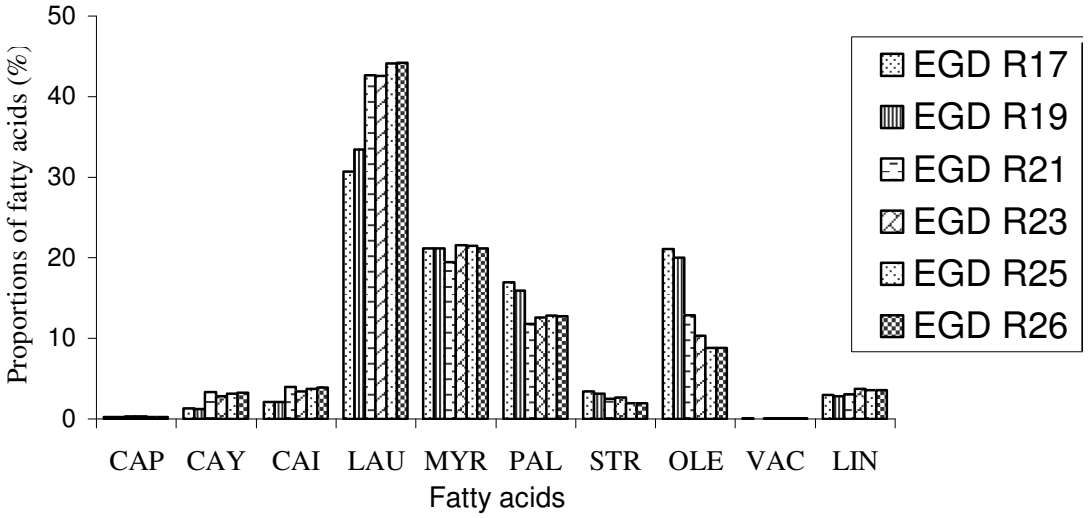

Figure 3c. Chromatographic profiles of coconut oil fatty acids during nut maturation, Cultivar EGD. WAT: West African Tall; MYD: Malayan Yellow Dwarf; EGD: Equatorial Guinea Green Dwarf; PB121+: Improved PB121 hybrid; CAP: caproïc acid; CYP: caprylic acid; CAI: capric acid; LAU: lauric acid; MYR: myristic acid; PAL: palmitic acid; STR: stéaric acid; OLE: oléic acid; VAC: vaccenic acid; LIN: linoléic acid.

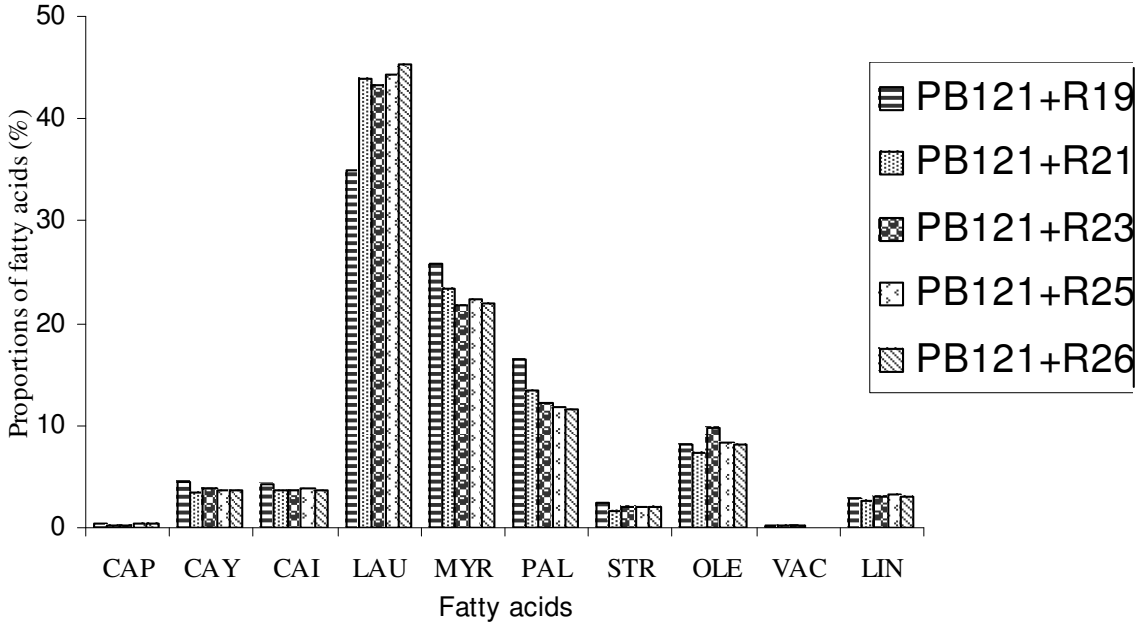

Figure 3d. Chromatographic profiles of coconut oil fatty acids during nut maturation, Cultivar PB121+. WAT: West African Tall; MYD: Malayan Yellow Dwarf; EGD: Equatorial Guinea Green Dwarf; PB121+: Improved PB121 hybrid; CAP: caproïc acid; CYP: caprylic acid; CAI: capric acid; LAU: lauric acid; MYR: myristic acid; PAL: palmitic acid; STR: stéaric acid; OLE: oléic acid; VAC: vaccenic acid; LIN: linoléic acid.

acids, which respectively contain 6, 8, 10, 12, 14, 16 and 18 carbon atoms (Berger and Ong, 1985). Coconut oil contains many saturated fatty acids like those of palmist oil (Kristina et al., 2007). This is an interest for the stability of foods containing coconut oil due to its resistance at oxidation reactions (Tchiégang et al., 2001).

Biochemical mechanisms can explain the biosynthesis of these fatty acids as well as that of unsaturated fatty acids present in the oil. The synthesis of saturated fatty acids starts with the transformation of glucose, which is degraded into pyruvate and acetyl coenzyme A molecules (Rawsthorne, 2002). These molecules are then transported into the mitochondrion where the saturated fatty acids are lengthened by successive additions

Table 3. Correlations between coconut kernel physicochemical parameters (cultivars and ranks mixed).

	WKE	TKE	DMK	OCK	RSK	NSK	TSK	PRK	CAP	CAY	CAI	LAU	MYR	PAL	STR	OLE	VAC	LIN
WKE	1.00																	
TKE	0.94	1.00																
DMK	0.81	0.94	1.00															
OCK	0.79	0.82	0.81	1.00														
RSK	-0.55	-0.63	-0.65	-0.59	1.00													
NSK	0.37	0.51	0.56	0.21	-0.47	1.00												
TSK	0.26	0.41	0.46	0.09	-0.28	0.97	1.00											
PRK	-0.70	-0.77	-0.74	-0.77	0.58	-0.44	-0.35	1.00										
CAP	0.37	0.26	0.26	0.21	-0.12	-0.02	-0.06	-0.24	1.00									
CAY	0.39	0.31	0.34	0.41	-0.09	-0.15	-0.20	-0.24	0.55	1.00								
CAI	0.38	0.34	0.34	0.44	-0.12	-0.19	-0.25	-0.19	0.42	0.92	1.00							
LAU	0.65	0.59	0.58	0.71	-0.22	-0.09	-0.17	-0.19	0.29	0.67	0.77	1.00						
MYR	0.08	0.08	-0.05	-0.12	0.04	0.32	0.36	0.05	-0.26	-0.58	-0.56	-0.11	1.00					
PAL	-0.49	-0.45	-0.43	-0.56	0.14	0.18	0.25	0.13	-0.39	-0.83	-0.89	-0.78	0.52	1.00				
STR	-0.07	-0.10	-0.09	-0.10	0.09	-0.19	-0.18	-0.13	0.31	0.43	0.37	-0.13	-0.75	-0.39	1.00			
OLE	-0.68	-0.61	-0.59	-0.65	0.27	-0.10	-0.03	0.33	-0.33	-0.55	-0.58	-0.88	-0.20	0.50	0.31	1.00		
VAC	-0.83	-0.78	-0.81	-0.93	0.41	-0.40	-0.29	0.38	-0.19	-0.21	-0.39	-0.67	-0.01	0.23	0.16	0.75	1.00	
LIN	0.01	0.10	0.12	0.07	-0.35	0.38	0.33	-0.02	-0.34	-0.71	-0.73	-0.35	0.61	0.62	-0.63	0.11	0.70	1.00

WKE: Weight of the kernel; TKE: thickness of kernel; DMK: dry matter; RSK: Reducing sugar; TSK: total sugar; NSK: non-reducing sugar of the kernel; PRK: the total protein content of kernel; OCK: oil content of the kernel; CAP: caproïc acid; CYP: caprylic acid; CAI: capric acid; LAU: lauric acid; MYR: myristic acid; PAL: palmitic acid; STR: stéaric acid; OLE: oléic acid; VAC: vaccenic acid; LIN: linoléic acid.

of two carbons from malonyl-CoA through acetyl CoA molecules. This explains the gradual increase in lauric acid content during nut maturation, coming from an increase in fatty acids with no more than 12 carbon atoms.

Saturated fatty acids can undergo chemical dehydrogenation reactions which result in unsaturated fatty acids with the same number of carbons. Thus, successive dehydrogenation of stearic acid results first in oleic acid followed by linoleic acid then linolenic acid. But both two fatty acids are essentials so that they cannot be synthesizing by human or animals (Belleville, 2003). Vaccenic acid is an isomer of oleic acid but has more small proportion in coconut oil than in pitaya seed oil (Abdul et al., 2009).

Chromatographic profiles of coconut oil are then different of those of *Vigna angularis* which contain impor-tant proportions of insatured fatty acids (Hiromi et al., 2009).

In need of energy, fatty acids can then be reduced into short chains up to acetyl CoA by the phenomenon known as beta oxidation (Guesnet et al., 2005).

At the genetic level, the different kernel parameters do not seem to be inherited characters during nut maturation. Indeed, the observed features (as oil content) of PB121+ were different from those of its two parents, MYD and WAT. The effects of co-dominance and heterosis might explain the results obtained in the PB121+ hybrid.

The biochemical features of EGD and MYD cultivars kernels, like the sugar content, could be the answer to consumers needs. Prior work also established that these two cultivars contain sweet water (Jackson et al., 2004). According to Assa et al. (2006), this sugary taste is an important criterion for coconut kernel and coconut water consumption. This characteristic could therefore be effectively valorised by farmers and coconut partners.

These results can permit the valorisation of nuts

according to cultivars and maturity stages. Thus, WAT, PB121+ and EGD cultivars, which mature kernels of rank 25 are rich in oil, can be valorised by coconut oil extraction. Moreover, oil of WAT kernels is even better used for soap manufacture because of its high lauric acid content. On the other hand, oil of MYD (especially at rank 23), because of its relative high content of essential fatty acid (linoleic acid) compared to the other cultivars, is highly nutritious. Mature rank 25 kernels of WAT and PB121+, which are thicker and have high dry matter content, could be specifically used in rasp coconut manufacture and coconut candy.

Conclusion

This study was conducted to help diversify the uses of coconut palms and accordingly, increase their profitability. The results showed that the physicochemical features of coconut kernel can effectively serve as identification criteria, being correlated with types of cultivar and/or stages of maturity.

However, for better valorisation, determination of micronutrients content in coconut kernel during nut maturation and verification of kernel transformation technologies in their specific products are perhaps necessary.

In conclusion, the obtained findings will contribute to better valorisation of coconut palm and help in the creation of profitable coconut transformation utilities.

REFERENCES

Abdul A, Jamilah B, Chin-Ping T, Russly A, Roselina K, Chia L (2009). Essential fatty acids of pitaya (dragon fruit) seed oil. Food chem. 114: 561-564.

Anonyme (2006). Fruit ; Encyclopédie en ligne. Website: http://encyclopedia.jrank.org/fo/FRA_GAE/FRUIT_par_le_français_du_fructus.html

Assa RR, Nemlin J, Konan KJL, Prades A, Agbo N, Sié R (2006). Diagnostic de la cocoteraie paysanne du littoral ivoirien. Sci. Nat. 3(2): 113-120.

Balasubramaniam K (1976). Polysaccharides of the kernel of maturing and matured coconuts. J. Food Sci. 41: 1371-1373.

Balleza CF, Zenaida NS (1976). Proximate analysis of the coconut endosperm in progressive stage of development. Philipp. J. Coconut stud. 1(2): 37-42.

Belleville J (2003). Complémentarité et équilibre de l'apport alimentaire en protéines et en lipides. *OCL* 10(1): 31-40.

Berger KG, Andanar WT (1991). The lauric oils, medium chain fatty acids sources.World conference on oleochemicals: into the 21st century/ applewhite TH (ed); AOCS-Champaign: AOCS, pp. 88-93.

Berger KG, Ong SH (1985). Les utilisations industrielles de l'huile de palme et de l'huile de coco. Oléagineux, 40(12): 622-624.

Bourdeix R, N'cho YP, Le Saint JP, Sangaré A (1992). Stratégies de sélection du cocotier (*Cocos nucifera* L.): synthèse des acquis. Oléagineux, 45(8-9): 359-371.

Chee CS, Choon NG (1997). Coconut milk: chemistry and technology. J. Food Sci. Technol. 32: 189- 201.

Conrado SD (1994). Health aspects of coconut oil. Proceedings of the world conference on lauric oils: sources, processing and applications/ applewhite. TH (Ed); AOCS-Champaign: AOCS, pp. 119-125.

De Nucé de L, Rognon F (1977). Les cocotiers Nains à Port-Bouët. 1- Nain Jaune Ghana, Nain Rouge Malais, Nain Vert Guinée Equatoriale, Nain Rouge Cameroun. Oléagineux, 32(8-9): 367-373.

De Nucé de L, Wuidart W (1979). Les cocotiers Grands à Port -Bouët (Côte d'Ivoire) 1-Grand Ouest Africain, Grand de Mozambique, Grand de Polynésie, Grand de Malaisie. Oléagineux, 34(7): 339-347.

Dubois M, Gilles K, Hamilton J, Rebers P, Smith F (1965). Colorimetric methods for determination of sugars and related substances. Anal. Chem. 28: 350-356.

Graille J (1993). Usages alimentaires et oléochimiques du complexe laurique. Oléagineux, 48 (12): 515-525.

Guesnet P, Alessandri JM, Astorg P, Pifferi F, Monique L (2005). Rôles physiologiques majeurs exercés par les acides gras polyinsaturés (AGPI). OCL 12(5): 333-343.

Gurr MI (1994). Nutritional aspects of lauric oils, Proceedings of the world conference on lauric oils: sources, processing and applications/applewhite. TH (ed); AOCS-Champaign: AOCS, pp. 104-109.

Hiromi Y, Yuka T, Naoko Y, Yoshiyuki M (2009). Characteristics of lipids components, fatty acid distributions and triacylglycerol molecular species of adzuki beans (*Vigna angularis*). Food chem. 115: 1424-1429.

Jackson JCA, Gordon G, Wizzard MC, Kayanne R, Rolle R (2004). Changes in the chemical composition of coconut (*Cocos nucifera*) water during maturation of the fruit. J. Sci. Food Agric. 84(9): 1049-1052.

Jayaleskmy A, Arumughan C, Narayanan CS, Mathew AG (1986). Changes in the chemical composition of coconut water during maturation. J. Food Sci. Technol. (23): 203-207.

Konan KJL (1997). Etude de la tolérance à la sécheresse chez le cocotier (*Cocos nucifera* L.): Evaluation de quelques caractères biologiques et physiologiques. Thèse Doct., Université d'Abidjan, Côte d'Ivoire, p. 110.

Konan JL, Konan B, Assa RR, Aboua F, Allou K, Amani G, Sangaré A, N'guetta S (2008). Caractéristiques physico-chimiques de l'amande mature des hybrides de cocotiers grands améliorés (*Cocos nucifera* L.). Agron. Afr. 20: 1-14.

Kristina C, Gretchens S, Jillian D, Margaret D, Emile G, Tracy H, Dan W, Nathan S, Paul H, Ted L (2007). Development, fatty acid composition, and storage of drupes and seeds from the endangered pondberry (*Lindera melissifolia*). Biol. Conserv. 137: 489-496.

Moore C, Batugal P (2004). Banking on the tree of life. In: *Geneflow.* A Publication about the Earth's Genetic Ressources. Ruth D. Raymond (eds.). Rome, Italy. p. 35.

N'cho YP, Sangaré, A (1997). CFC Project on improving the small scale extraction of coconut oil: final report on the aqueous processing in Côte d'Ivoire (sub-objective 1.1), IDEFOR/ DPO Marc Delorme Station, p. 20.

Priscilla CS, Lenore FA, Cesar LG (1989). New technology for the production of deshydrated edible mature coconut meat. Philipp. J. Coconut stud. June, 26-31.

Rawsthorne S (2002). Carbon flux and fatty acid synthesis in plants. Progress Lipids Res. 41: 182-196.

Roberto CG, Werner M, Manfred K (1996). Drying characteristics of copra, quality of copra and coconut oil. Postharvest Biol. Technol. 9: 361-372.

Swetman A, Broadbent J (1979). Sugar content variation of coconuts prior to the manufacture of desiccated coconut in Sri Lanka. Trop. Sci. 21(1): 33-38.

Tchiégang C, Kapchié N, Kapseu C, Parmentier M (2001). Influence du temps, de la température et des conditions de stockage sur le ramollissement des fruits de l'aiélé (Canarium scheinfurthii Engl.). J. Food Eng. 47: 63-66.