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Research article

PHYSICOCHEMICAL CHARACTERISTICS OF MATURE KERNEL FROM SIX PROGENIES OF COCONUT (*Cocos nucifera* L.) HYBRID F1 MALAYAN YELLOW DWARF X VANUATU TALL TOLERANT TO LETHAL YELLOWING DISEASE OF GHANA

Françoise N. KODJO[1,2], Konan J.L. KONAN[2], Saraka D.M. YAO[3], Ange B.Z. DEFFAN[4], Eric B. Z. KOFFI[5], Sebastien NIAMKE[1]

[1]Laboratory of Biotechnology, UFR Biosciences, Felix Houphouët-Boigny University, 22 BP 582 Abidjan 22, Côte d'Ivoire

[2]Marc Delorme Research Station, Centre National de Recherche Agronomique (CNRA), 07 BP 13 Abidjan 07, Côte d'Ivoire

[3]UFR Sciences Biologiques, Peleforo Gon Coulibaly University, BP 1328 Korhogo, Côte d'Ivoire

[4]La Mé Research Station, CNRA, 01 BP 989 Abidjan 01, Côte d'Ivoire

[5]UFR Sciences de la Nature, Nangui Abrogoua University, 02 BP 801 Abidjan 02, Côte d'Ivoire

*Corresponding Auteur: Saraka D.M. YAO, UFR Sciences Biologiques, Peleforo Gon Coulibaly University, BP 1328 Korhogo, Côte d'Ivoire 26

ABSTRACT: The physicochemical characteristics of mature kernel extracted from 6 coconut progenies of F1 hybrid MYD x VTT identified in Ghana for their tolerance to Lethal Yellowing (LY) disease were investigated in Côte d'Ivoire environment. Thus, F1 hybrid progenies coded d2, d3, d6, d7, d11 and d15 were characterized from 18 physicochemical traits of kernel extracted from 12 month old nuts. Different expressions of the kernel physicochemical traits were found among these hybrid progenies. Multivariate analyses divided these progenies into three distinct phenotypic clusters. The clusters G1 (d2, d3 and d11) and G2 (d6) were provided an oil rich in myristic (18.93% – 20.71%), stearic (2.26% – 3.29%) and linoleic (3.39% – 3.71%) acids. Especially, d6 progeny from G2 cluster was given a high mineral fraction (6.46 % of ash content) in kernel. The cluster G3 consists of d7 and d15 progenies that provided high total sugars content (4.29%) in mature kernel from which the extracted oil contains low myristic (17.18%), stearic (2%) and linoleic (3.57%) acid contents. Current additional data relate to these progenies could be helpful to coconut breeders in the choices of male parents within Vanuatu Tall (VTT) genitors advisable in crosses with Malayan Yellow Dwarf (MYD) cultivar for improved MYD x VTT hybrid combining together LY disease tolerance, good yields and high attractive technological potentials for industrial processing of mature kernel and oil.

Key words: F1 MYD x VTT coconut progenies, kernel, oil, physicochemical traits, Lethal Yellowing (LY) disease, Côte d'Ivoire

*Corresponding author: Saraka D.M. YAO, [3]UFR Sciences Biologiques, Peleforo Gon Coulibaly University, BP 1328 Korhogo, Côte d'Ivoire E-mail didierys@yahoo.fr (+225) 04 73 79 26

INTRODUCTION

Coconut palm, *Cocos nucifera* L. (Arecaceae), is an important perennial oil crop in the wet tropics. At the level of the international exports, coconut oil extracted from dried mature kernel called coprah is classified in eighth position after the one of the soya, oil palm, colza, sunflower, groundnut, cottonseed and palm kernel (Oilseed, 2006). Several products and by-products derive from coconut palm organs hence its nickname "the tree of life" (Bourdeix *et al.*, 2005) though coprah represents main marketable value from coconut palm cultivation in Côte d'Ivoire.

Coconut is cultivated under area covering 50,000 ha in Côte d'Ivoire (Konan *et al.*, 2006) where over 80% of cultivated coconut lands are located along the coast and it is the main export crop (Assa *et al.*, 2006). However, currently coconut palm is facing relative decline in cultivation, largely due to disrespect of the good agronomic practices, low fertility of the soils, poor quality of the coconut cultivars planted by the farmers and pests and diseases (Yao *et al.*, 2010). Mainly, the economic challenge posed by coconut sector is jeopardized by several pests and diseases. Among the coconut diseases, Lethal Yellowing (LY) is the scariest risk in the world where 1,000 ha of coconut plantations have been destroyed (Arocha-Rosette *et al.*, 2014). Approximately 300 ha of coconut plantations have been devastated in Côte d'Ivoire in Grand-Lahou department (Konan *et al.*, 2013). To stop this pandemic, research works were oriented to genetic control for tolerant hybrids creation that limits pesticides used in pest chemical controls. Therefore, Vanuatu Tall (VTT) cultivar from coconut field genebank of Côte d'Ivoire that was identified tolerant to LY disease in Ghana environment since the 1980s has been crossed with Malayan Yellow Dwarf (MYD) cultivar which present good agronomic abilities to create a first generation of hybrid F1 MYD x VTT progenies (Sangaré *et al.*, 1992; Koffi *et al.*, 2013). Likewise, these progenies from hybrid F1 MYD x VTT created by the Centre National de Recherche Agronomique (CNRA) of Côte d'Ivoire and tested in Ghanaian endemic zone proved to be tolerant to LY disease. Besides, previous researches relate to agro-morphological diversity of some F1 MYD x VTT hybrid progenies cultivated in Côte d'Ivoire environment shown the existence of two clusters according to vegetative and production traits (Koffi *et al.*, 2013). Thus, hybrid d15 progeny forming the first cluster is more robust than the second cluster constituted with other hybrid progenies (Koffi *et al.*, 2013). Besides, important diversity among these progenies following bunch, nut and coprah yields were mentioned (Koffi *et al.*, 2014). However, data about physicochemical characteristics of the mature kernel from these progenies of coconut hybrid F1 MYD x VTT are unknown. Here, we characterize in Côte d'Ivoire environment following some physicochemical traits assessed on mature kernel from six progenies of the hybrid F1 MYD x VTT sampled in both two agro-morphological groups previously reported.

MATERIALS AND METHODS

Plant materials and experimental design

Kernel samples from mature nut aged of 12 months harvested on 24 palms from 6 progenies (4 palms per progeny) of coconut hybrid F1 MYD x VTT coded d2, d3, d6, d7, d11 and d15 were used. These progenies previously studied at agro-morphological diversity level by Koffi *et al.* (2013) were partitioned into two clusters (Table 1). There is the cluster including d15 progeny which is more robust than the ones of the cluster including d2, d3, d6, d7 and d11 (Koffi *et al.*, 2013). Also some production traits such as bunch, nut and coprah yields of these progenies studied by Koffi *et al.* (2014) are shown in Table 1. The progenies of hybrid F1 MYD x VTT studied are half-sib families derived from the crosses following assisted pollination method (Wuidart and Rognon, 1981) between 6 male parent palms of Vanuatu Tall (VTT P09921, VTT P09966, VTT P09958, VTT P09960, VTT P09945 and VTT P09962) with the same female parent Malayan Yellow Dwarf (Table 1). These progenies of hybrid F1 MYD x VTT have been planted in 2002 on plot No. 034 at 5.2 ha with a density of 160 palm ha^{-1}. This plot was located at the Marc Delorme Research Station of the Centre National de Recherche Agronomique (CNRA) in Côte d'Ivoire between 5°14'-5°15' N and 3°54'-3°55' W.

METHODS

Kernel sampling

Four healthy and productive coconut palms were randomly selected per hybrid progeny. Thus, a total of 24 palms were used. Then, a sample of 4 mature nut aged of 12 months harvested on the bunch of rank 25 was collected per palm. A total of 96 mature nuts were studied. Their kernels were homogenized to form a representative sample for laboratory analyses which were performed within 24 h after harvest as recommended by Assa *et al.* (2010).

Assessment of the physicochemical traits of mature kernel

For physical analyses the weight of kernel (KEW) extracted from mature nut was assessed using an electronic scale (Sartorius Inc., Washington, USA). Thus, the proportion of kernel (PKE) per whole nut was calculated. Afterward, kernel thickness (KET) was measured using a micrometer (Outside Micrometer 0-25 mm Inc., New York, USA). Then, dry matter content (DMK) in mature kernel was assessed following oven method at 105°C until constant weight (BIPEA, 1976). Also, ash content in kernel (ASK) was determined with a furnace muffle at 550°C for 24 hours (AOAC, 1980). For chemical analyses the total sugars (TSK) and reducing sugars (RSK) contents in mature kernel were obtained respectively with phenol-sulfuric (Dubois *et al.*, 1965) and Dinitrophenylhydrazine-salicylate (Bernfeld, 1955) methods using a spectrophotometer after ethanosoluble extraction (Agbo *et al.*, 1985). The proteins content (PKE) was determined from Kjeldahl method (BIPEA, 1976) after total nitrogen determination. Oil content (OKE) was determined using Soxhlet method with hexane as solvent according to an ISO 659 norm (AFNOR, 1986). Then fat fraction was characterized by determining the acid, iodine and saponification indices. Identification of principal fatty acids in the extracted coconut oil was conducted by Gaseous-phase Chromatography (GC) with nitrogen as the vector gas.

Statistical analyses of data

The Statistica v.7.1 software (StatSoft Inc., France) was used for all statistical analyses. First, the non-parametric test of Kruskal-Wallis incorporating multiple comparisons of groups at the threshold 5% was used to compare the hybrid progenies following each physicochemical traits of mature kernel. Afterwards, Hierarchical Cluster Analysis (HCA) based on the Ward method was performed to generate a dendrogram which shown relationships between the hybrid progenies studied. At last, Discriminant Analysis (DA) was performed from λ-Wilk test at the threshold 5% to test robustness of the clusters previously established from HCA and reveal kernel physicochemical traits mostly involved in discriminating of hybrid progenies studied.

Table 1. Characteristics of the six progenies of coconut hybrid F1 MYD x VTT

Progeny Codes	Crossing codes (♀ x ♂)	Vegetative and production characteristics of the progenies of hybrid studied	Sample size
d2	MYD x VTT P09921	Low vegetative feature 10 bunch palm^{-1} yea^{-1} 100 nut palm^{-1} yea^{-1} 16.31 kg of coprah palm^{-1} yea^{-1}	4
d3	MYD x VTT P09966	Low vegetative feature 10 bunch palm^{-1} yea^{-1} 90 nut palm^{-1} yea^{-1} 15.45 kg of coprah palm^{-1} year^{-1}	4
d6	MYD x VTT P09958	Low vegetative feature 10 bunch palm^{-1} yea^{-1} 108 nut palm^{-1} yea^{-1} 17.64 kg of coprah palm^{-1} year^{-1}	4
d7	MYD x VTT P09960	Low vegetative feature 10 bunch palm^{-1} yea^{-1} 112 nut palm^{-1} yea^{-1} 17.21 kg of coprah palm^{-1} yea^{-1}	4
d11	MYD x VTT P09945	Low vegetative feature 11 bunch palm^{-1} yea^{-1} 121 nut palm^{-1} yea^{-1} 19.82 kg of coprah palm^{-1} yea^{-1}	4
d15	MYD x VTT P09962	Robust palms 11 bunch palm^{-1}.year^{-1} 113 nut palm^{-1} year^{-1} 18.94 kg of coprah palm^{-1} year^{-1}	4

RESULTS

Weight and thickness of mature kernel

The high significantly averages of mature kernel weight varied from 323.75 to 325 g were recorded in d6 and d11 hybrid progenies respectively. However, d15 hybrid progeny was given the lowest value, i.e. 232.5 g of mature kernel (Table 2). Proportion of kernel weight in relation to total whole nut weight was significantly higher in d15 (25.46%) hybrid progeny (Table 2). Differences between hybrid progenies following mean values of kernel thickness were not significant ($\chi^2_{(5;\ N=24)}$ = 11.003; p =0.051). Kernel thickness values were varied from 11.56 to 13.23 mm among progenies studied (Table 2).

Biochemical characteristics of mature kernel

The dry matter content of mature kernel discriminated significantly ($\chi^2_{(5;\ N=24)}$ = 20.11; p = 0.001) hybrid progenies studied into 3 groups. The first group composed of d6 and d11 hybrid progenies was provided high values of kernel dry matter (59.23%). However, second group represented with only d15 hybrid progeny was produced the lowest value of dry matter content (51.27%). The third group consists of hybrid progenies d2, d3 and d7 was recorded intermediate values of dry matter ranged from 54.83 to 58.6% (Table 3). The mineral fraction represented by the ash content was significantly more abundant in progeny d6 (6.40%) and lower in progenies d11 and d2 where recorded values were 5.01% and 4.92% respectively (Table 3).

Table 2. Weight, proportion and thickness of the mature kernel from six progenies of coconut hybrid F1 MYD x VTT

	Mean ± Standard deviation		
Progeny codes	KEW (g)	PKE (%)	KET (mm)
d2	262.50±25[ab]	21.63±0.57[ab]	11.56±1.24[a]
d3	251.00±0.51[ab]	20.91±0.06[b]	11.19±0.28[a]
d6	323.75±28.68[a]	22.77±1.42[ab]	12.03±0.35[a]
d7	275.00±50[ab]	25.17±3.13[ab]	11.88±0.56[a]
d11	325.00±20.41[a]	23.19±0,78[ab]	11.81±0.08[a]
d15	232.50±23.62[b]	25.46±1.03[a]	13.23±1.47[a]
df	5	5	5
$\chi^2_{(5\,;\,N=24)}$	16.524	15.873	11.003
p	0.005	0.007	0.051

In the same column, the average values indexed by the same letter are statistically equal to 5% probability level; KEW: Weight of the kernel; PKE: Proportion of the kernel; KET: Kernel thickness; df: degree of freedom; $\chi^2_{(5\,;\,N=24)}$: Statistical value of Kruskal-Wallis test; p: probability value associated to Kruskal-Wallis test.

Table 3. Biochemical characteristics of mature kernel from six progenies of coconut hybrid F1 MYD x VTT

	Mean ± Standard deviation					
Progeny Code	**DMK (%)**	**AKE (%)**	**PKE (%)**	**TSK (%)**	**RSK (%)**	**OKE (%)**
d2	54.83±1.52[ab]	4.92±0.03[b]	26.28±0.06[ab]	4.06±0.02[b]	0.32±0.01[ab]	68.65±0.96[ab]
d3	58.61±0.09[ab]	5.01±0.19[ab]	28.70±0.01[a]	4.17±0.01[ab]	0.27±0.01[b]	71.62±0.79[a]
d6	59.23±0.73[a]	6.4±0.09[a]	24.36±0.04[b]	4.15±0.02[ab]	0.36±0.01[ab]	66.92±1.31[ab]
d7	55.60±2.6[ab]	5.25±0.03[ab]	28.01±0.09[ab]	4.35±0.02[a]	0.41±0.01[a]	64.36±1.4[ab]
d11	59.53±0.13[a]	5.01±0.06[b]	23.85±0.03[b]	4.11±0.02[b]	0.28±0.01[b]	61.6±0.08[ab]
d15	51.27±1.08[b]	5.58±0.16[ab]	28.28±0.02[ab]	4.24±0.03[ab]	0.35±0.02[ab]	61.6±0.08[b]
df	5	5	5	5	5	5
$\chi^2_{(5\,;\,N=24)}$:	20.11	20.47	22.40	21.775	20.714	21.711
p	0.001	0.001	<0.001	<0.001	<0.001	<0.001

In the same column the average values indexed by the same letter are statistically equal to 5% probability level; DMK: dry matter content of the kernel; AKE: Ash content of the kernel: PKE: Proteins content of the kernel; TSK: Total sugars content of the kernel; RSK: Reducing sugars content of the kernel; OKE: Oil content of the kernel; df: degree of freedom; $\chi^2_{(5\,;\,N=24)}$: Statistical value of Kruskal-Wallis test; p: probability value associated to Kruskal-Wallis test

The protein contents in kernel of the d6 (24.36%) and d11 (23.85%) hybrid progenies were significantly lower than the ones recorded in d3 (28.7%) progeny (Table 3). Among all studied hybrid progenies only d7 was given significantly higher values of total sugars (4.5%) and reduced sugars (0.41%) (Table 3).

The oil content in mature kernel also structured significantly ($\chi^2_{(5;\,N=24)} = 21.71$; p <0.001) the progenies into 3 clusters. First group was recorded mean values of oil content that was greater than the ones of second and third cluster. The first group includes d3 hybrid progeny (71.62%). The second group consists of hybrid progenies d2, d6 and d7 that given 68.65%, 66.92% and 64.36% oil contents respectively. The third group consists of d11 and d15 hybrid progenies that provided 61.6% of oil content (Table 3).

Biochemical characteristics of oil extracted from mature kernel

Acid, iodine and saponification indices of oil

The acid index values of oil were significantly higher in d11 (5.78 mg g^{-1}) and d15 (5.64 mg g^{-1}) progenies than d7 (4.94 mg.g^{-1}). The d6 hybrid progeny provided significantly the highest value of iodine index (28.88 g/100 g of oil). Higher value of saponification index was recorded in d7 progeny (248.16 mg g^{-1}). The low mean values of saponification index varying from 236.03 to 238.7 mg g^{-1} were found in hybrid progenies d3 and d11 (Table 4).

Table 4. Acid, iodine and saponification indices of the oil extracted from mature kernel of the six progenies of coconut hybrid F1 MYD x VTT

	Mean ± standard deviation		
Progeny codes	Ia (mg g^{-1})	Ii (g/100g)	Is (mg g^{-1})
d2	5.33±0.02[ab]	26.08±0.28[ab]	240.58±1.56[ab]
d3	5.09±0.06[ab]	25.78±0.22[b]	236.03±1.26[b]
d6	5.25±0.05[ab]	28.88±0.77[a]	244.96±1.47[ab]
d7	4.94±0.05[b]	26.66±0.3[ab]	248.7±0.52[a]
d11	5.78±0.15[a]	26.2±0.8[ab]	238.7±1.08[b]
d15	5.64±0.02[a]	26.23±1.19[ab]	245.75±1.49[ab]
df	5	5	5
$\chi^2_{(5\ ;\ N=24)}$	21.843	13.540	21.711
p	<0.001	0.018	<0.001

In the same column the average values indexed by the same letter are statistically equal to 5% probability level; Ia: Acid index; Ii: Iodine index; Is: Saponification index; df: degree of freedom; $\chi^2_{(5\ ;\ N=24)}$: Statistical value of Kruskal-Wallis test; p: probability value associated to Kruskal-Wallis test

Table 5. Main fatty acid contents of coconut oil extracted from mature kernel of the six progenies of hybrid F1 MYD x VTT

	% mean ± standard deviation					
Progeny codes	C12 :0	C14 :0	C16 :0	C18 :0	C18 :1	C18 :2
d2	47.89±0.05[ab]	18.87±0.06[ab]	9.83±0.03[ab]	2.35±0.02[abc]	7.52±0.06[ab]	3.65±0.01[bc]
d3	47.90±0.45[ab]	19.8±0.04[a]	9.67±0.48[ab]	2.71±0.05[ab]	8.04±0.02[ab]	2.59±0.02[c]
d6	48.25±0.12[ab]	20.71±0.36[a]	12.89±0.09[a]	3.29±0.47[a]	6.69±0.02[b]	3.39±0.25[bc]
d7	47.68±0.08[ab]	17.31±0.07[b]	10.16±0.04[a]	1.53±0.02[c]	9.04±0.21[a]	3.94±0.04[bc]
d11	45.23±0.97[b]	18.13±0.38[ab]	8.76±0.34[ab]	1.73±0.03[abc]	7.81±0.02[ab]	4.9±0.16[a]
d15	50.02±0.12[a]	17.06±0.1[b]	7.54±0.15[b]	2.48±0.03[abc]	6.24±0.05[b]	3.21±0.05[b]
df	5	5	5	5	5	5
$\chi^2_{(5\ ;\ N=24)}$	19.030	22.400	21.38	22.402	22.401	22.403
P	0.001	<0.001	<0.001	<0.001	<0.001	<0.001

In the same column the average values indexed by the same letter are statistically equal to 5% probability level; C12: 0 lauric acid content of the oil; C14: 0 myristic acid content of the oil; C16: 0 palmitic acid content of the oil; C18: 0 stearic acid content of the oil; C18: 1 oleic acid content of the oil; C18: 2 linoleic acid content of the oil; df: degree of freedom; $\chi^2_{(5\ ;\ N=24)}$: Statistical value of Kruskal-Wallis test; p: probability value associated to Kruskal-Wallis test

Fatty acid compositions in oil

The GC chromatogram of oil extracted from mature kernel of all studied hybrid progenies was showed 6 main fatty acids such as lauric acid (C12:0), myristic acid (C14:0), palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C18:2). So, these fatty acid contents were discriminated significantly hybrid progenies studied. The highest and lowest fractions of lauric acid were respectively recorded in d15 (50.02%) and d11 (45.23%) hybrid progenies. Meanwhile, hybrid progenies d3 and d6 were provided the highest acid myristic contents varying from 19.8 to 20.71%. The d15 progeny was less rich in palmitic acid (7.54%) and oleic acid (6.24%). In contrast to d7 progeny which exhibited low value of stearic acid content (1.53%) the highest value coming from d6 (3.29%) progeny. Linoleic acid contents ranging from 2.5 to 4.9% were recorded in progenies d3 and d11 where the values were lowest and higher respectively (Table 5).

Structure of the variability of the six F1 MYD x VTT hybrid progenies

The dendrogram derived from Hierarchical Cluster Analysis (HCA) performed with 18 physicochemical traits measured on mature kernel together revealed three phenotypic clusters (Figure 1). Cluster G1 (d2, d3 and d11), cluster G2 (d6) and cluster G3 (d7 and d15) have been revealed at 21 Euclidean distance. The characteristics (mean and standard deviation) of these three clusters within hybrid progenies were presented in table 6.

The difference between these three phenotypic clusters was revealed following λ-Wilk test derived from Discriminant Analysis (DA) which was significant (F = 119.52; p<0.001). To extract from 18 initial physicochemical traits of mature kernel studied, those mainly involved in the differentiation of three phenotypic clusters previously identified by HAC λ-Wilk test from DA were also done.

Thus, only 5 discriminant physicochemical traits of mature kernel, i.e. a percentage of 27.77% of all studied physicochemical traits, were revealed. The hierarchy of these discriminant traits classification was as follows: (i) myristic acid content (C14:0), (ii) linolenic acid content (C18:2), (iii) ash content (ASK), (iv) stearic acid content (C14:0) and (v) total sugar content (TSK) (Table 7).

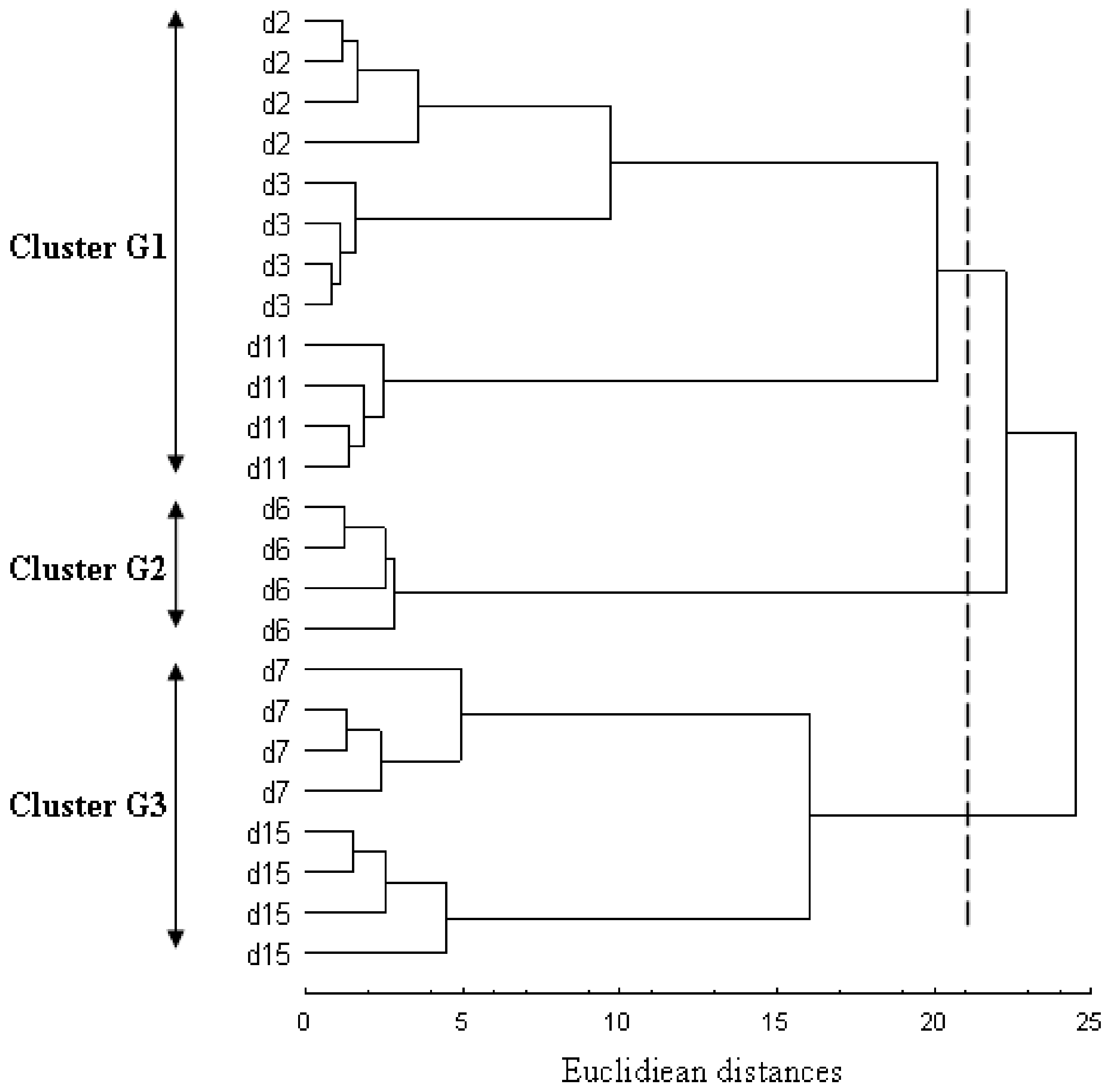

Figure 1. Ward dendrogram performed from 18 physicochemical traits measured of the mature kernel which groups 24 individuals of the six progenies of hybrid F1 MYD x VTT coded d2, d3, d6, d7, d11 and d15

Standardized coefficients of both canonical discriminant functions identified explaining 100% of the total variability were presented in table 7. The first canonical function was the most important and explained until 90.94% of the total variability (Table 7 and Figure 2). This first canonical function was explained by the total sugar content of kernel and the myristic, stearic and linoleic acid contents of oil. The first canonical function opposed the cluster G3 (d7 and d15) with both clusters G1 (d2, d3 and d11) and G2 (d6). Thus, unlike the both clusters G1 and G2, the cluster G3 was produced mature kernel with lower proteins content and an oil rich in myristic, stearic and linoleic acids (Figure 2). The second canonical function which revealed only 9.04% of the total variability was explained by the ash content and allowed to discriminate the clusters G1 and G2. The cluster G1 consists of d2, d3 and d11 progenies was produced kernel whose mineral fractions were less important than the ones of cluster G2 (d6) (Figure 2).

Table 6. Kernel physicochemical characteristics of three clusters identified from HAC within six progenies of F1 hybrid MYD x VTT studied

Trait (SI unit)	Mean ± standard deviation		
	G1 (N=3 ; n = 12)	G2 (N=1 ; n = 4)	G3 (N=2 ; n = 8)
KEW (g)	279.50±37.91	323.75±28.68	253.75±42.74
PKE (%)	21.91±1.11	22.77±1.42	25.31±2.16
KET (mm)	11.52±0.72	12.03±0.35	12.56±1.26
DMK (%)	57.65±2.26	59.23±53.43	53.43±2.96
AKE (%)	4.98±0.11	6.40±0.09	5.42±0.20
PKE (%)	26.27±2.06	24.36±0.04	28.14±0.16
TSK (%)	4.11±0.05	4.15±0.02	4.29±0.06
RSK (%)	0.29±0.02	0.36±0.01	0.38±0.04
OKE (%)	67.29±4.43	66.92±1.31	62.98±1.74
Ia (mg g^{-1})	5.40±0.31	5.25±0.05	5.29±0.37
Ii (g/100g)	26.02±0.49	28.88±0.77	26.45±0.83
Is (mg g^{-1})	238.43±2.27	244.96±1.48	246.95±1.65
C12 :0 (%)	47.01±1.42	48.25±1.25	48.85±1.25
C14 :0 (%)	18.93±0.74	20.71±0.36	17.18±0.15
C16 :0 (%)	9.42±0.58	12.89±0.09	8.85±1.40
C18 :0 (%)	2.26±0.42	3.29±0.47	2±0.50
C18 :1 (%)	7.79±0.22	6.69±0.02	7.64±1.50
C18 :2 (%)	3.71±0.99	3.39±0.02	3.57±0.39

SI: International System; N: number of progeny per cluster; n: number of individuals per progeny; KEW: Weight of the kernel; PKE: Proportion of the kernel; KET: Kernel thickness; DMK: dry matter content of the kernel; AKE: Ash content of the kernel: PKE: Proteins content of the kernel; TSK: Total sugars content of the kernel; RSK: Reducing sugars content of the kernel; OKE: Oil content of the kernel; Ia: Acid index; Ii: Iodine index; Is: Saponification index; C12: 0 lauric acid content of the oil; C14: 0 myristic acid content of the oil; C16: 0 palmitic acid content of the oil; C18: 0 stearic acid content of the oil; C18: 1 oleic acid content of the oil; C18: 2 linoleic acid content of the oil.

Table 7. Discriminant Analysis (DA) based on the physicochemical traits measured on mature kernel from six progenies of coconut hybrid F1 MYD x VTT studied

	Standardized coefficients			λ-Wilk	$F_{(2 ; 12)}$	p	Tolerance	1- Tolerance (R^2)
	Factor 1	Factor 2						
AKE	0.526	0.998*		0.000216	7.099	0.009	0.437	0.563
TSK	-1.162*	0.790		0.000169	4.276	0.040	0.213	0.787
C14 :0	3.964*	-0.293		0.000306	12.557	0.001	0.043	0.957
C18 :0	3.406*	0.563		0.000212	6.877	0.010	0.045	0.955
C18 :2	5.988*	0.347		0.000276	10.760	0.002	0.018	0.982

*Standardized coefficients of the physicochemical traits mostly correlate to canonical axes; AKE: Ash content of the kernel; TSK: Total sugars content of the kernel; C14: 0 myristic acid content of the oil; C18: 0 stearic acid content of the oil; C18: 2 linoleic acid content of the oil.

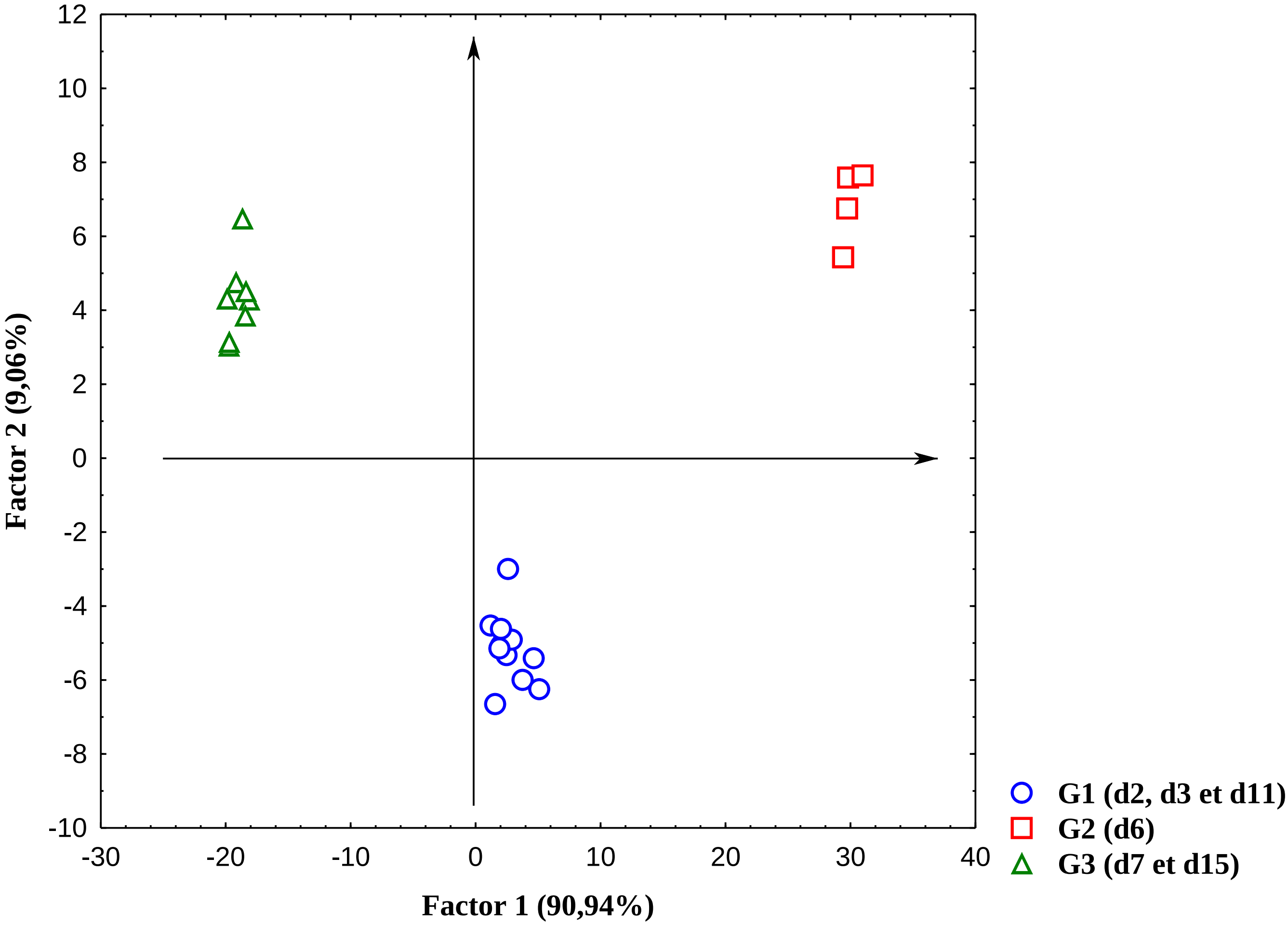

Figure 2. Repartition of the three clusters identified from HCA grouping 24 individuals of the six hybrid F1 MYD x VTT progenies coded d2, d3, d6, d7, d11 and d15 on the first and second canonical factors from Discriminant Analysis (DA)

DISCUSSION

Except kernel thickness character other physicochemical traits observed on mature kernel were differentiated the six progenies of hybrid F1 MYD x VTT studied. These results are supported by those obtained by Assa *et al.* (2010) which reported that the physicochemical features of coconut kernel can effectively serve as identification criteria. Moreover, the genes involve this variability appeared between the progenies d2, d3, d6, d7, d11 and d15 would be essentially due to their six male parents VTT involved in the crosses that are heterozygous since the female parent MYD is homozygous (Konan *et al.*, 2007). Indeed, these authors were reported that Tall coconut populations were diversified with a higher level of heterozygosity than the one recorded in Dwarf populations. Similarly, the morphological and agronomic traits were discriminated F1 MYD x VTT hybrid progenies previously tested by Koffi *et al.* (2013) including the six progenies assessed in this study. Otherwise, variability between these progenies following physicochemical traits of mature kernel could be the tolerance sources of LY disease as reported by Koffi *et al.* (2013).

In this study others findings highlighted that the six progenies of hybrid F1 MYD x VTT have been regrouped into three phenotypic clusters following the physicochemical traits measured on mature kernel. From 18 physicochemical traits of mature kernel studied only 5, i.e. a percentage of 27.77% of these provided sufficient informations to discriminate the three clusters within these progenies. Thus, G1 (d2, d3 and d11) and G2 (d6) clusters were provided an oil rich in saturated fatty acids (myristic and stearic acids) and linoleic acid which is an unsaturated fatty acid. Therefore, the oil extracted from kernel of the progenies d2, d3, d11 and d6 could constitute a source of fatty acids supplier for the food industry because linoleic acid specially is an essential fatty acid that cannot be synthesized by human or animals. Particularly the progeny d6 was presented a high mineral fraction in kernel. Thus, d6 descent kernel would be auspicious in feeding to fill the mineral deficiencies and in industry for food products enrichment in minerals. The cluster G3 consists of d7 and d15 progenies that provided high total sugars content in mature kernel from which the extracted oil contains low myristic acid, stearic acid and linoleic acid contents. Like that, the kernel of d7 and d15 progenies would be appreciated more by the consumers and the industrials because the high sugar content is used as good criteria for kernel appreciation and processing (Assa *et al.*, 2010).

In the present work, F1 MYD x VTT progenies clustering into three groups could reveal two biological realities to consider in hybrid F1 MYD x VTT improvement. Firstly, the structuring of the progenies of hybrid F1 MYD x VTT into three clusters based on physicochemical traits of mature kernel was not similar to that reported by Koffi *et al.* (2013). The non-superposition of the same progenies clustering would be due to the fact that the lists of characters studied in the two studies are different. Indeed, Koffi *et al.* (2013) were used stem, inflorescence, foliar and whole nut traits to characterize these progenies. Therefore, it appears that kernel and oil features from physicochemical traits provide additional inquiries which are not identical to agronomic and morphological characteristics. Henceforth, that must invites breeders to consider technological criteria to refine coconut breeding program.

Secondly, the two clusters of progenies previously found by Koffi *et al.* (2013) could be divided from now on into three clusters according to the biochemical characteristics of mature kernel. Henceforth, these findings offer more possible choice to the coconut breeders to improve simultaneously the weak vegetative vigor and technological potential of these hybrid progenies.

CONCLUSION

These investigations were showed that physicochemical traits measured on kernel and oil extracted from mature nut can be used as criteria for coconut varieties classification. Therefore, three clusters with different potentials of kernel and oil technological processing were found into the six progenies of hybrid F1 MYD x VTT studied. The d7 progeny was classified in the same cluster with d15 progeny which produces high total sugars content in kernel. Mature Kernels from these both progenies would be more appreciated by consumers and industrials. Then, the progenies d2, d3, d6 and d11 could be selected to satisfy the oleo-chemical food industry because their oil is rich in myristic acid, stearic acid and linoleic acid. Only d6 progeny producing high ash content in kernel is advisable as food to satisfy mineral deficiencies and mineral enrichments in food products. When we combine both previously agro-morphological data and current findings about these progenies henceforth we know that d2, d3, d6, d7, d11 and d15 hybrid progenies are endowed together LY disease tolerance, some agronomic performances and attractive technological potentials for kernel and oil industrial processing.

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