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Full Length Research Paper

Physicochemical and biochemical characteristics evaluation of seven improve cassava (*Manihot esculenta* crantz) varieties of Côte d'Ivoire

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A lot of people around the world convert cassava roots into different products according to local customs and preferences. In Côte d'Ivoire, due to its high consumption, cassava is a subject of concern to researchers. For that purpose, seven improved varieties of cassava (with better productivity and resistance to many diseases), were set up by CNRA. Nevertheless, their valorization and popularization need information about physico-chemical, biochemical and sensorial characteristics. So, the aim of this study was to identify the best improved varieties regarding these characteristics. The physico-chemical, biochemical and sensorial characteristics were determined according to several standard methods and then the different data were submitted for statistical analyses. Three clusters of varieties were identified. The first cluster (C1) presented the highest energy value (170.26 Kcal/100 g), carbohydrate (37.65 g/100 g), starch (22.52 g/100 g), dry matter (40.79 g/100 g) and the lowest moisture (59.24 g/100 g) and reducing sugar (0.36 g/100 g). In opposition, the second cluster (C2) registered the lowest energy value (130.12 Kcal/100 g), carbohydrate (25.80 g/100 g), starch (6.12 g/100 g), dry matter (29.59g/100 g) while its moisture (70.41 g/100 g) and reducing sugar (0.91 g/100 g) where the highest. The third cluster (C3) presented values between those of cluster 1 and 2. Sensorial characteristics of all the cassava varieties were accepted. Varieties V4, V54 and V69 of the cluster C1, recorded the best characteristics.

Key words: Valorization, popularization, cassava, characteristics, sensorial, original, cluster.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) constitutes the staple food of nearly a billion people in tropical and subtropical countries (Nartey, 1978; FAO, 2008). The roots provide as much as a third of daily calories (FAO, 2008). They are converted into different products according to local customs and preferences (Cock, 1985; Kawano et al., 1998; Kawano, 2003). Cassava provides a lot of energy to consumers due to the large amount of carbohydrates accumulated in its roots and contributes significantly to the economy of most tropical countries through its processing into various industrial products (Amani et al., 2005; FAO, 2008). In Côte d'Ivoire, a developing country, of the several meals (placali, kongondé, bèdèkouma, gari, etc.) gotten from cassava roots, "attiéke" is the most consumed (Kakou, 2000). In spite of its great importance, cassava is subjected to several problems like diseases, weak yield productivity and low nutritional value.

Many studies have been under-taken in order to resolve these problems. Hence, new cassava varieties were obtained in Côte d'Ivoire by the CNRA (Centre National de Recherche Agronomique) after several crossing between two original varieties V4 (IAC, white color) and V23 (Anango agba, yellow color). They presented higher roots yields and were reported to be

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more resistant to diseases and pest than existing local varieties (N'zué et al., 2001). However, for these new varieties, food composition data which are very important in the field of nutrition and health (Sodjinou, 2006) were unknown. The aim of this study was to identify interesting varieties as far as physico-chemicals, biochemicals and sensorial characteristics are concerned in order to valorize and popularize them. Therefore, physico-chemicals (cyanide, acidity, dry matter, moisture, ash content and pH), biochemicals (fat, protein, vitamin A and C, carotenoid, carbohydrates, total sugar, reducing sugar, starch contents and energy value), as well as sensorial (taste, texture and fiber presence) characteristics of nine cassava varieties was determined.

MATERIAL AND METHODS

Samples preparation

The roots of seven new improved cassava (V51, V52, V53, V54, V55, V69, V71, V73) and two original local varieties V4 (white flesh) and V23 (yellow flesh) of eleven months old were harvested from CNRA experimental plot (Adiopodoumé, Côte d'Ivoire). Fresh roots were washed, pelled manually and cut into small pieces with inox knife. The pieces were abundantly washed and grated finely with a kitchen chopper. The obtained paste were homogenized and stored into part of 250 g in aseptic polyethylene bags at freezing temperature (-18°C) for future analyses. All reagents were of analytical grade.

Physico-chemicals and biochemicals characteristics content

Moisture, dry matter and ash content were determined using the AOAC (1980) methods. The total cyanogens content was carried out by the method of Liebig-Denige (1979) while the pH was directly read with a pH-meter (Roucaire, Metr Ohm 632) and the total titrable acidity evaluated on cassava juice obtained from 40 g of paste.

BIPEA (1976) methods were used to determine fat and protein contents. Vitamins A and carotenoids contents were evaluated using the spectrophotometric method of Rougereau (1981); Vitamin C content was obtained with the method of Tillmanns and Hirsch (1932). Reducing and total sugars were evaluated with the methods of Bernfeld (1955) and Dubois et al. (1956), respectively.

As for carbohydrate and starch contents, they were calculated by difference following expression in Coulibaly (2008):

Carbohydrate content = 100 – (% Moisture + % Ash + % Fat + % Protein)
Starch content = 0.9 (% Carbohydrate – Total sugars).

Energy value was also calculated using the relation describe by Atwater and Rosa (1899).

Sensory analysis of attiéké from each variety

The attiéké of each variety were prepared following the process described by Assanvo (2008) and the sensorial analysis consisted in a hedonic analysis. A panel of 24 assessors (14 females, 10 males aged between 15 and 40 years) were trained following international standards (ISO, 1993) to appreciate the organoleptic characteristics of attiéké obtained. Each assessor received a list of an index card of tasting on which were mentioned evaluating criteria that concern taste, texture, presence or absence of fibers. These criteria were annotated with a score ranged from 1 to 5 with 1 corresponding to very bad, 2 to bad, 3 for acceptable, 4 as good and 5 means very good (Sauvageot, 1980).

Statistical analysis

All analyses were performed in triplicate. The data analysis was conducted using EXELL and XLSTAT version 2007. For physico-chemical and biochemical characteristics, principal component analysis (PCA), hierarchical ascendant classification (HAC) and discriminating factors analysis (DFA) were performed successively. Concerning sensorial data, they were treated by Analyses of Variances (one way ANOVA) in order to detect eventual variation among sensorial annotations; the test of Duncan at 95% confidence level revealed difference among the varieties. All expressed results per 100 g concerned fresh material.

RESULTS

Principal component analysis of cassava varieties physicochemical and biochemical characteristics

Principal component analysis was performed on 16 physicochemical and biochemical characteristics of 9 cassava varieties (V4, V23, V52, V53, V54, V55, V69, V71 and V73). The results revealed that eight principal components could explain all the variances, with the first three explaining 76.97% (data not shown) of the total variance. The first principal component was the most important and represented characteristics such as cyanide, dry matter, moisture, carbohydrate, starch, energy value and reducing sugar. The second component was mainly attributed to the fat content and the acidity, while the third one represented ash content. In summary, a total of 10 characteristics were identified for a fine classification of the 9 varieties (Table 1).

Constitution of cassava varieties cluster

The HAC was performed on the 10 characteristics (cyanide, dry matter, moisture, carbohydrate, starch, energy value, reducing sugar, acidity, fat and ash content) identified by the PCA. The different clusters obtained were confirmed by the DFA.

The nine varieties of cassava were classified in three different clusters C1, C2 and C3. C1 contained varieties V4, V54 and V69; C2 was represented by the varieties V23, V71 and V73 and the cluster C3 was composed of varieties V52, V53 and V55 (Figure 1).

The dissimilarity between these different clusters evaluated by the eucludienne distance was higher between different clusters than within varieties of the same cluster (Table 2). Nevertheless, the distance between, varieties of clusters C1 and C3 were lower than those between these two clusters and the cluster C2 (Figure 2).

Table 1. Cosine squares of the physicochemical and biochemical characteristics of cassava varieties.

Characteristics	PC1	PC2	PC3
Cyanide	0.564	0.009	0.150
Fat	0.283	0.592	0.092
Dry matter	0.874	0.081	0.008
Moisture	0.876	0.079	0.008
Carbohydrate	0.925	0.013	0.024
Starch	0.635	0.037	0.126
Vitamin C	0.079	0.468	0.254
Energy value	0.657	0.289	0.000
Ash	0.006	0.003	0.766
Total sugar	0.146	0.123	0.371
Reducing sugar	0.605	0.289	0.014
Protein	0.210	0.163	0.006
Carotenoid	0.084	0.023	0.495
Vitamin A	0.145	0.264	0.004
pH	0.123	0.483	0.000
Acidity	0.174	0.695	0.002

Physicochemical and biochemical characterization of cassava clusters C1, C2 and C3

According to the result of the DFA, each cluster presented specific characteristic (Table 3). The Cluster C1 recorded the highest dry matter (40.79 g/100 g), carbohydrate (37.66 g/100 g), starch (22.52 g/100 g) and energy value (170.27 Kcal/kg), while its moisture (59.24 g/100 g), acidity (58.64 meq/100 g) and reducing sugar (0.36 g/100 g) were the lowest. The second cluster C2 presented the lowest dry matter, carbohydrate, starch and energy value (29.59, 25.80, 6.12 g and 130.12 Kcal for 100 g, respectively); its reducing sugar, fat and moisture presented the greatest values. Cluster C3 had intermediary value of all the characteristics, excepte for cyanide (8.25 mg/100 g), ash (0.53 g/100 g) and acidity (96.67 meq/100 g) which presented the highest values (Table 3).

Moreover the different clusters (C1, C2 and C3) contained protein (1.64, 1.44 and 1.67 /100 g, respectively), vitamin A (13.07, 16.07 and 13.10 mg/100 g), vitamin C (5.69, 5.42 and 8.70 mg/100 g) and carotenoids (0.15, 0.10 and 0.12 mg/100 g). The test of Duncan showed that there was no significant difference between the three clusters, regarding each characteristic concerned (Table 4).

Sensorial characteristics

The variance analysis performed on sensorial characterristics (taste, texture and fiber) did not reveal significant difference between clusters C1, C2 and C3 (data not shown). Nevertheless, varieties presented variability within and between clusters (Table 5). Concerning the taste, variety V52 (3.7a) was more accepted than the others. It was followed by V69 (3.54ab) and V53 (3.54ab). As for the texture, all varieties of cluster C1 (V4, V54 and V69), V53 from cluster C3 and V73 of cluster C2, registered the best texture (3.75a, 3.42a, 3.83a, 3.71a and 3.43a, respectively). The character fiber content was the best for varieties V4 (4.29a) and V54 (3.96ab) (Table 5).

DISCUSSION

The three clusters C1, C2 and C3 of cassava varieties were highly energetic (130.12 to 170.27 kcal/100 g). This result could be explained by carbohydrate and starch content (Giraud, 1993; Bokanga, 2001) as shown by the correlation on one hand, between the energy values and carbohydrate ($r = +0.878$, $p < 0.05$) and on the other hand, between carbohydrate and starch ($r = +0.713$, $p < 0.05$). This situation could justify the low energy value (130.12 kcal/100 g) of varieties from cluster C2, of which carbohydrate and starch content were the lowest.

In general, energy and carbohydrate values obtained in this study were higher than those given by Bokanga (2001) and Nweke et al. (2002), mainly regarding varieties of cluster C1 and C3. Therefore, these varieties (V4, V52, V53, V54, V55 and V69) could easily assure food and energy security as proposed by FAO (2008); they could also be exploited for various industrial products (more than 300) made with cassava starch (FAO, 2004). Moreover, with their higher dry matter (and lowest moisture content) than those proposed by Meuser and Smolnik (1980), they would present good aptitude for roots long storage (Trèche et al., 1982). According to the same authors, high dry matter of cassava roots could contribute to increase the yield and the texture of derivative product, such as “attiéke”. This idea was confirmed, by the result of sensorial analysis on “attiéké”, mainly for varieties V4, V54 and V69 whose dry matters were the highest and their textures the most accepted by consumers. Concerning varieties of the cluster C2 (V23, V71 and V73) whose moisture and reducing sugar content were relatively high, they tend to be more perishable than the other varieties (Trèche, 1995; Aryee et al., 2006). Nevertheless, they could constitute interesting raw materials for alcohol, lactic bacteria, organic acid (lactic, acetic, formic, etc.) and biofuel industries (FAO, 2008).

As for cyanide content, all the varieties studied were considered neither sweet nor bitter (cyanide content: > 5 mg and < 10 mg/100 g), following the classification of Fortin et al. (1998). In this condition, these varieties might not be consumed crude, but after being cooked or transformed (Barampama, 1992). Indeed, cooking and transformation into derivative products contribute in eliminating or reducing the cyanide content (Nartey,

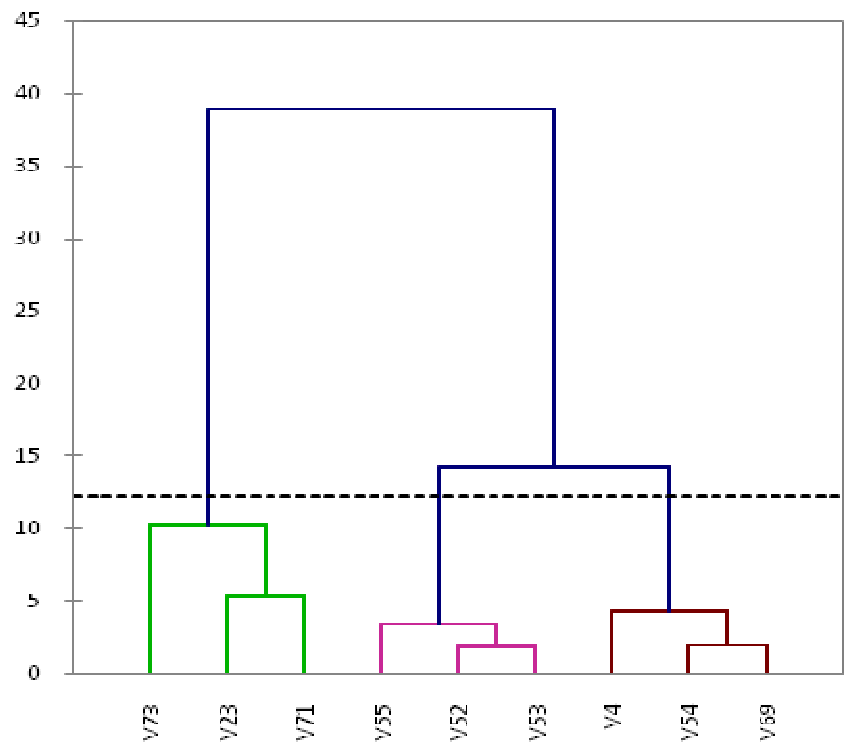

Figure 1. Dendogram of dissimilarity of cassava varieties C1(V4, V54, V69), C2(V73, V23, V71), C3(V55, V52, V53)

Table 2 . Matrice of proximity of varieties.

Varieties	V4	V23	V52	V53	V54	V55	V69	V71
V23	7.139							
V52	3.954	5.433						
V53	4.436	5.696	1.886					
V54	2.178	6.142	2.841	3.646				
V55	4.362	5.948	2.455	2.449	2.808			
V69	3.175	5.983	3.411	4.116	1.964	2.725		
V71	6.212	3.238	3.837	3.677	4.907	4.107	5.209	
V73	7.327	4.653	4.405	4.637	5.519	3.629	4.989	3.765

1978; Amoa-Awua and Jacobson, 1996). So the different varieties of this study could be consume though their acidity were relatively high (58.64 to 96.67 meq/100 g). In fact, the acidity of cassava roots, linked to the presence of organic acids (butyric, acetic, lactic, etc.) contribute not only to lengthen roots and derivative product storage time (Ampe et al., 1994; Brauman et al., 1995; Desmazeaud, 1996), but also in enhancing the well appreciated sourness of some cassava derivative product (placali, attiéké) (Toka et Dago, 2003). This situation should justify why attiéké of varieties V23, V52 and V53, from cluster C2 (acidity: 96.67 meq/100 g), were the most accepted by the consumers concerning their taste.

Yellow colored attiéké were discovered and well appreciated by consumers (data not showed). This color, generally obtained after adding palm oil, could be explained by the high carotenoids content, mainly by beta-caroten (Safo-Katanka et al., 1985). So with these yellow colored varieties, consumers would not only economize on palm oil, but they would also get interesting source of vitamin A, fat and protein, mainly concerning varieties V23, V52, V53, V54, V55, V69, V71 and V73 which were originally yellow.

Conclusion

The nine varieties of cassava of the present study had

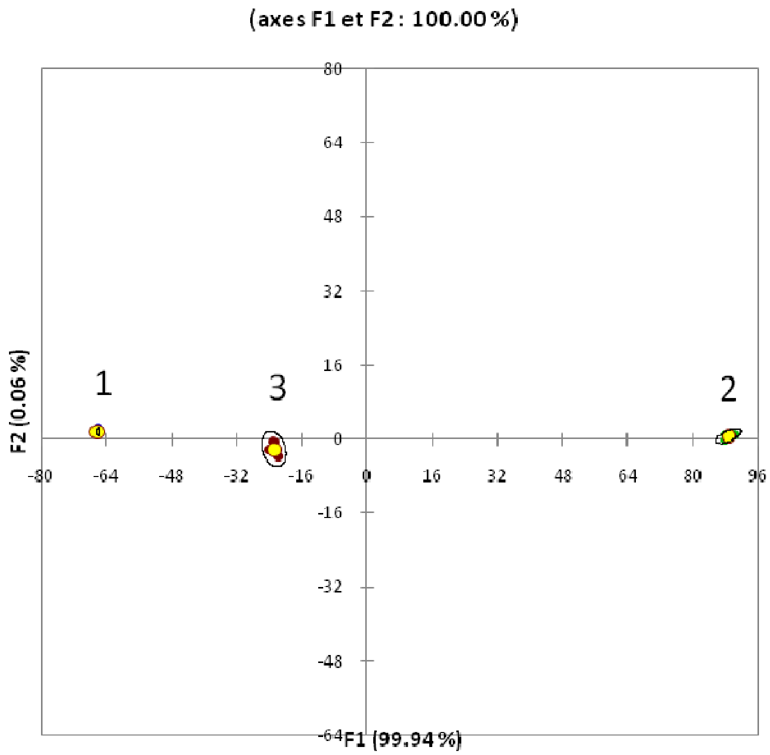

Figure 2. Results of discriminating factors analysis biplot showing the different clusters of varieties of cassava and their dissimilarity.

Table 3. Physicochemical and biochemical characteristic means of different clusters C1, C2 and C3.

Clusters	Cyanide	Fat	Dry matter	Moisture	Carbohydrate	Starch	Energy value	Ash	Reducing sugar	Acidity
1	7.40	1.46	40.79	59.24	37.66	22.52	170.27	0.33	0.36	58.64
2	5.19	2.35	29.59	70.41	25.80	6.12	130.12	0.42	0.91	94.24
3	8.25	0.46	35.72	64.28	33.59	16.68	145.17	0.54	0.50	96.67

Table 4. Protein and vitamin content of the clusters C1, C2 and C3.

Clusters	Protein	Carotenoid	Vitamin A	Vitamin C
1	1.64 ± 0.36 a	0.15 ± 0.12 a	13.07 ± 5.57 a	5.69 ± 1.64 a
2	1.44 ± 0.38 a	0.10 ± 0.00 a	16 .07 ± 3.93 a	5.42 ± 2.47 a
3	1.67 ± 0.28 a	0.12 ± 0.04 a	13.10 ± 2.92 a	8.70 ± 2.40 a

Values followed by the same letter within a column are not significantly different according to Duncan test at 95% confidence level.

Been classified into three clusters C1, C2 and C3, following physicochemical and biochemical characteristics. Cluster C2 contains the original variety V23 and is characterized by the lowest dry matter, energy value, carbohydrate and starch contents, while the moisture and reducing sugar content were the highest. These varieties (V23, V71 and V73) could mainly be exploited for alcohol, organic acids (acetic, butyric, lactic, formic, etc.), lactic bacteria and biofuel production.

Concerning cluster C3, it was exclusively composed of new varieties and present intermediary dry matter, energy value, carbohydrate, starch, moisture and reducing sugar content between those of clusters C2 and C1. With the presence of protein, carotenoids, vitamin A and C, in relatively interesting content, the varieties of this cluster (V52, V53 and V55) could be exploited for house feeding, mainly for varieties V52 and V53 whose taste, texture and fiber content were more acceptable.

Table 5. Sensorial characteristics of “attiéké” from different clusters.

Clusters	Varieties	Taste	Texture	Fiber
	V4	3.46 b	3.75 a	4.29 a
C1	V54	3.08 cd	3.42 a	3.96 ab
	V69	3.54 ab	3.83 a	3.83 abc
	V52	3.7 a	3.17 b	3.62 abc
C3	V53	3.54 ab	3.71 a	3.87 abc
	V55	2.86 e	2.63 d	3.04 c
	V23	3.5 b	3.17 b	3.54 abc
C2	V71	3.2 c	3 c	3.83 abc
	V73	2.95 de	3.43 a	3.5 bc

Values followed by the same letter within a column are not significantly different according to Duncan test at 95% confidence level.

As for cluster C1 which contains the original variety V4, dry matter, energy value, carbohydrate and starch contents were the highest, while the moisture and reducing sugar content showed the lowest values. The roots of such varieties would have a long storage time and the transformation yield should be better. Such varieties could be widely exploited not only for house feeding for their protein, carotenoid and vitamin content, but also in various industries (pharmaceutical, feeding, cosmetic, textile, chemical, etc.) for their dry matter and starch content. Since variety V4 is very appreciated by local consumers, varieties V54 and V69 which presented quite similar characteristics could also be widely accepted by populations.

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