

Full Length Research Paper

An evaluation of the proximate and elemental compositions of some yam tuber parts during storage

Seydou Konan*, Kablan Achi Bédié and Felix Boda

Laboratoire de Biochimie et Technologie des aliments. Université d'Abobo-Adjamé 02 BP 801, Abidjan, Côte d'Ivoire.

Accepted 22 May, 2015

Some biochemical parameters of different parts of two varieties of edible yams tuber "Florida" (*Dioscorea alata*) and "Krenglé" (*Dioscorea cayenensis-rotundata* complex) were monitored during storage. The statistical analyses related to analysis of variance (ANOVA) and to principal component analysis (PCA) carried out on these eleven variables showed that the proximate and mineral composition of different parts of yam tuber were significantly different at 0.05 level between them and during the storage. Indeed, the dry matters, the reducing and total sugars contents increased significantly ($P \leq 0.05$) during the conservation from month 0 to month 6 and varied from one tuber part to another. The dry matter content was highest in the proximal parts, while the reducing and total sugar contents were higher in the distal parts. The total phenolic compounds and all the studied minerals decreased significantly ($P \leq 0.05$) during the conservation and varied from one tuber part to another. Contrary to these variables, the lipids and the crude protein contents didn't vary significantly at 0.05 level from a tuber part to another one during the storage period which last six months.

Key words: *Dioscorea* spp, yam, tuber part, proximate composition, minerals.

INTRODUCTION

The edible tubers of yams (*Dioscorea* spp.) are important staple food for millions of people in tropical countries especially in West Africa (Martine and Mario, 1991). Yams are annual or perennial tuber-bearing and climbing plants with over 600 species in which only few are cultivated for food and medicine (IITA, 2006). The most cultivated species in Côte d'Ivoire are *Dioscorea alata* L and *Dioscorea cayenensis-rotundata* complex. They are the most economically important of all cultivated species since they give the highest yields (Doumbia et al., 2006). The tubers of various species of *Dioscorea* spp constitute one of the stable carbohydrate foods for the people in many tropical countries (Akissoe et al., 2003). Many different forms and cultivars of the edible yam species are available in different areas and it is likely that they differ in composition and nutritional values (Bhandari et al., 2003). Indeed, fresh yams are difficult to store and are subject to deterioration during storage (Afoakwa and Sefa-Dedeh, 2001). Seen their importance in the human food and their difficult post crops conservation, several

works were carried out on their whole tubers and were reported in the literature concerning the biochemical properties and the post harvest storage, for example: application of thermodynamics for storage of yams whole tubers (Osuji, 1985); Proximate Analysis and Some Antinutritional Factor Constituents of Jamaican Yams (Marie et al., 2005); Physicochemical changes occurring during post-harvest hardening of trifoliate yam tubers (Medoua et al., 2005) and change in nutritional properties of yam tubers during storage (Sahoré et al., 2007). We have recently conducted studies on composition and minerals changes in different parts of "Bètè-bètè" variety from *Dioscorea alata* species and "Kangba" variety from *Dioscorea cayenensis-rotundata* species (Dje et al., 2010). Results showed that dry matters, reducing sugars and total sugars contents increased significantly during storage and varied from a tuber part to another one. Dry matter content was elevated in the proximal parts, while reducing sugars and total sugars contents are high in the distal parts. The highest content of total phenolic compounds was found in proximal parts of tubers. It varied from a tuber part to another one and decreased significantly during storage. With the exception of Ni, a significant loss of minerals (Ca, Mg and Zn) was noticed

*Corresponding author : E-mail: seydou12_konan@gmail.com.

in different parts of yams tubers after six months. On the other hand lipids and crude proteins contents didn't vary significantly on the threshold of 5% during storage whatever the variety and the part of the tuber was.

To the best of our knowledge, no study has so far been carried out to determine the physicochemical differences existing between different yam tuber parts and the influence of different tuber parts storage on physicochemical properties of resulting flours. Besides, the consumers would like the proximal and median parts more than the distal parts. The objective of this study was to evaluate the proximate and elemental compositions of yam different tuber parts of two other varieties ("Krenglè" and "Florido") during storage for up to 6 months.

MATERIALS AND METHODS

Sampling

Two varieties of yams, *Dioscorea cayenensis rotundata* complex ("Krenglè" variety) and *D. alata* ("Florido" variety), were used in the present study. The tubers of these yams varieties were about 44.07 ± 4.46 cm. They were harvested at maturity from fields in the centre of Côte d'Ivoire. They were immediately transported in a heap aired store and stored under prevailing tropical ambient conditions ($26.56^\circ\text{C} \pm 3^\circ\text{C}$ and $82\% \pm 5\%$ relative humidity) for a period of 6 months.

Preparation of yam flour

One tuber of each yam variety was randomly picked every two months during storage for up to six (6) months. The tubers were washed, then cut in three equal parts, giving three lots of yams made of the proximal parts (head of tuber), the median parts (middle of tuber) and the distal parts (tail of tuber). Four hundred grams (400 g) of each yam lot were peeled, cut into small slices ($3 \times 3 \times 3$ cm thickness), then washed with distilled water. They were dried at 45°C during 48 h. The dried yam slices were further ground in a grinder and sieved with a $90 \mu\text{m}$ sieve to obtain yam flour. The gotten flours were used for the analyses.

Proximate analysis

The dry matters contents were determined by drying in an oven at 105°C during 24 hours to constant weight (AOAC, 1990). Crude protein contents were calculated from nitrogen contents ($\text{N} \times 6.25$) obtained using the Kjeldahl method by AOAC (1990). The lipid contents were determined by continuous extraction in a Soxhlet apparatus for 8 hours using hexane as solvent (AOAC, 1990). The ashes contents were determined by incinerating in a furnace at 550°C (AOAC, 1990). The method described by Dubois et al. (1956) was used for the total sugars content analysis and the reducing sugars content according to the method of Bernfeld (1955) using 3,5 dinitrosalicylic acids (DNS).

Total phenolic compounds

The contents of total phenolic compounds were assessed by the spectrophotometric method described by Swain and Hillis (1959) using the Folin-Ciocalteu.

Mineral composition

The contents of calcium, magnesium, zinc and nickel were quantitatively determined from the digest using strong acids and the atomic absorption spectrophotometer with appropriate hollow cathode lamps. Accuracy was assessed by analyzing the samples in triplicate (AOAC, 1990).

Statistical analysis

All analyses were performed in triplicates. Results were expressed by means of \pm SD. Statistical significance was established using Analysis of Variance (ANOVA) models to estimate the effect of storage period on biochemical composition of yam different tuber parts. Means were separated according to Duncan's multiple range analysis ($P \leq 0.05$), with the help of the software XLSTAT 7.5.2 and SPSS 16.0. Principal components analyses (PCA) were carried out on the biochemical characteristics of yam different tuber parts.

RESULTS

Proximate composition

The proximate composition of proximal part (PP), median part (MP) and distal part (DP) of "kangba" and "bètè-bètè" varieties of yam belonging respectively to *Dioscorea alata* and *Dioscorea cayenensis-rotundata* species are summarised in Table 1 and 2.

Dry matter content of yam tuber different parts varied meaningfully ($P \leq 0.05$) from one part to another at the beginning of the conservation (month 0) and during post-crops storage, whatever the variety is. It is more elevated in the proximal part of yam with amounts ranged from 45.36% (month 0) to 64.95% (month 6) for "Krenglè" and from 36.90% (month 0) to 72.88% (month 6) for "Florido".

Ash content differed significantly ($P \leq 0.05$) from one tuber part to another during the same storage period, whatever the variety is. In general, the highest content was found in yam distal part whatever the variety is, with the contents ranged from 2.51% dry weight (dw) (month 0) to 2.95% dw (month 6) and from 2.85% (month 0) to 3.20% dw (month 6) respectively for "Florido" and "krenglè". Distal part of "krenglè" variety showed the highest content.

Crude protein content of yam tubers different part didn't vary significantly ($P \leq 0.05$) from one part to another during the post crops conservation. Crude protein of "Krenglè" was ranged from 8.00% dw (month 0) to 7.54% dw (month 6) and from 7.88% dw (month 0) to 7.44% dw respectively for the proximal and distal parts. Concerning "Florido" variety, protein content ranged from 8.00% dw (month 0) to 7.52% dw (month 6) and from 7.88% dw (month 0) to 7.33% dw respectively for the proximal and distal parts. In general, the proximal part had a slightly higher protein than the other parts (median and distal).

The mean lipid content of yam tuber different parts were found to be 0.20% dw. The lipid content didn't vary meaningfully ($P \leq 0.05$) from a tuber part to another

Table 1: Proximate composition of flours from different parts of the "Krenglè" variety tubers during the post harvest storage

Parameters	Variety	Krenglè			
	Storage Time/Yam Part	Month 0	Month 2	Month 4	Month 6
Dry matters (%)	PP	45.36 ± 0.03(m)	59.31 ± 0.41(j)	61.84 ± 0.53(hi)	64.95 ± 0.82(g)
	MP	41.41 ± 0.16(n)	56.46 ± 0.42(k)	59.79 ± 0.60(j)	61.08 ± 0.11(i)
	DP	37.97 ± 0.64(o)	52.85 ± 0.52(l)	56.62 ± 0.56(k)	60.20 ± 0.48(j)
Ashes (% dw)	PP	2.55 ± 0.05(efgh)	1.73 ± 0.03(m)	1.64 ± 0.07(m)	2.60 ± 0.02(e f g)
	MP	2.25 ± 0.05(jk)	2.68 ± 0.02(d e f)	2.37 ± 0.01(h i j)	2.70 ± 0.01(c d e)
	DP	2.85 ± 0.01(bcd)	3.18 ± 0.01(a)	2.67 ± 0.01(d e f)	3.20 ± 0.15(a)
Crude Proteins (% dw)	PP	8.00 ± 0.31(a)	7.88 ± 0.25(a b)	7.77 ± 0.35(a b)	7.54 ± 0.22(a b)
	MP	7.90 ± 0.34(ab)	7.75 ± 0.38(a b)	7.73 ± 0.34(a b)	7.52 ± 0.28(a b)
	DP	7.88 ± 0.38(ab)	7.63 ± 0.25(a b)	7.63 ± 0.38(a b)	7.44 ± 0.25(a b)
Lipids (% dw)	PP	0.20 ± 0.01(a)	0.20 ± 0.01(a)	0.21 ± 0.03(a)	0.21 ± 0.02(a)
	MP	0.18 ± 0.01(a)	0.20 ± 0.02(a)	0.21 ± 0.01(a)	0.20 ± 0.02(a)
	DP	0.18 ± 0.03(b)	0.20 ± 0.01(a)	0.21 ± 0.03(a)	0.21 ± 0.03(a)
Total sugars (g/100 g dw)	PP	3.19 ± 0.20(jk)	4.79 ± 0.20(g)	6.52 ± 0.38(d)	7.25 ± 0.24(c)
	MP	2.40 ± 0.03(n)	4.23 ± 0.15(h)	5.79 ± 0.12(e)	6.43 ± 0.06(d)
	DP	3.38 ± 0.23(ij)	5.55 ± 0.04(e f)	7.30 ± 0.10(c)	8.17 ± 0.43(b)
Reducing sugars (g/100 g dw)	PP	0.65 ± 0.04(k)	0.90 ± 0.02(h)	1.02 ± 0.01(e)	1.16 ± 0.01(c)
	MP	0.61 ± 0.03(l)	0.86 ± 0.01(i)	0.95 ± 0.01(g)	1.03 ± 0.02(e)
	DP	0.77 ± 0.04(j)	0.97 ± 0.01(f g)	1.07 ± 0.01(d)	1.32 ± 0.01(a)

-The obtained values are averages ± standard deviation of triplicate determination

-On the columns and lines of each parameter, the averages affected of no common letter are significantly different between them on the threshold of 5% according to the test of Duncan

-PP: proximal part; MP: median part; DP: distal part; dw: dry weight

between the total and reducing sugar contents of the yam tuber different parts. Thus, they varied significantly on the threshold of 5% from one tuber part to another during the storage. In general, the total and reducing sugar contents were higher in the distal part of yam tubers whatever the variety is, with values ranging from 3.38 g/100 g dw (month 0) to 8.17 g/100 g dw (month 6) and from 0.77 g/100 g dw (month 0) to 1.32 g/100 g dw (month 6) for "Krenglè" variety. "Florido" variety showed

total and reducing sugar varying from 3.51 g/100 g dw (month 0) to 9.10 g/100 g dw (month 6) and from 0.91 g/100 g dw (month 0) to 1.34 g/100 g dw (month 6). Besides, yam tuber of "Florido" variety had highest amount of total and reducing sugars.

The total phenolic compounds

The table 3 showed the total phenolic compounds

Table 2: Proximate composition of flours from different parts of the "Florida" variety tubers during the post harvest storage

Parameters	Variety	Krenglè			
	Storage Time/Yam Part	Month 0	Month 2	Month 4	Month 6
Dry matters (%)	PP	36.90 ± 0.60(p)	66.99 ± 0.28(e)	70.90 ± 0.53(b)	72.88 ± 0.60(a)
	MP	35.46 ± 0.18(q)	65.06 ± 0.59(g)	68.01 ± 0.54(d)	69.81 ± 0.53(c)
	DP	34.30 ± 0.79(r)	62.18 ± 0.60(h)	66.00 ± 0.48(f)	67.16 ± 0.64(de)
Ashes (% dw)	PP	2.05±0.05(l)	1.92±0.01(l)	2.04±0.02(l)	2.93±0.07(bc)
	MP	2.31±0.02(ij)	2.61±0.01(efg)	2.46±0.01(ghi)	2.07±0.20(kl)
	DP	2.51±0.02(fgh)	2.67±0.01(def)	2.97±0.01(b)	2.95±0.02(b)
Crude Proteins (% dw)	PP	8.00 ± 0.25(a)	7.81 ± 0.32(ab)	7.69 ± 0.19(ab)	7.52 ± 0.04(ab)
	MP	7.90 ± 0.34(ab)	7.69 ± 0.44(ab)	7.69 ± 0.38(ab)	7.38 ± 0.50(ab)
	DP	7.88 ± 0.25(ab)	7.69 ± 0.31(ab)	7.63 ± 0.38(ab)	7.33 ± 0.35(b)
Lipids (% dw)	PP	0.17 ± 0.02(a)	0.20 ± 0.01(a)	0.21 ± 0.03(a)	0.21 ± 0.03(a)
	MP	0.19 ± 0.01(a)	0.19 ± 0.04(a)	0.21 ± 0.03(a)	0.20 ± 0.04(a)
	DP	0.17 ± 0.04(a)	0.20 ± 0.04(a)	0.21 ± 0.04(a)	0.20 ± 0.03(a)
Total sugars (g/100 g dw)	PP	2.78 ± 0.08(lm)	3.74 ± 0.29(i)	5.37 ± 0.24(f)	7.67 ± 0.32(c)
	MP	2.48 ± 0.10(mn)	2.94 ± 0.16(kl)	4.57 ± 0.05(gh)	6.46 ± 0.20(d)
	DP	3.51 ± 0.13(ij)	4.63 ± 0.33(g)	5.53 ± 0.16(ef)	9.10 ± 0.35(a)
Reducing sugars (g/100 g dw)	PP	0.87 ± 0.001(hi)	0.96 ± 0.02(g)	1.01 ± 0.01(ef)	1.23 ± 0.02(b)
	MP	0.86 ± 0.01(i)	0.94 ± 0.01(g)	0.98 ± 0.01(fg)	1.25 ± 0.03(b)
	DP	0.90 ± 0.01(h)	0.97 ± 0.02(g)	1.03 ± 0.02(e)	1.34 ± 0.03(a)

-The obtained values are averages ± standard deviation of triplicate determination

-On the columns and lines of each parameter, the averages affected of no common letter are significantly different between them on the threshold of 5% according to the test of Duncan -PP: proximal part; MP: median part; DP: distal part; dw: dry weight

Table 3: Total phenolic compound (mg/100 g dry weight) of flours from different parts of "Krenglè"

	Variety	Krenglè				Florida			
	Storage Time/Yam Part	Month 0	Month 2	Month 4	Month 6	Month 0	Month 2	Month 4	Month 6
Total phenolic compounds (mg/100 g dw)	PP	288.89 ± 3.35(a)	217.33 ± 3.69(bc)	119.77 ± 4.87(gh)	50.34 ± 3.09(jklm)	243.00 ± 3.98(b)	189.67 ± 5.82(cd)	119.67 ± 4.74(gh)	38.44 ± 293(klmn)
	MP	266.78 ± 2.91(b)	162.33 ± 2.38(def)	91.56 ± 4.30(hj)	39.67 ± 1.69(klmn)	230.22 ± 5.87(b)	128.48 ± 5.81(fg)	72.67 ± 3.91(ijk)	22.67 ± 0.84(mn)
	DP	211.33 ± 2.47(bc)	151.66 ± 3.42(efg)	76.56 ± 3.04(ij)	36.11 ± 1.11(lmn)	185.11 ± 4.54(cde)	159.56 ± 5.00(def)	70.78 ± 3.98(ijkl)	12.21 ± 0.58(n)

-The obtained values are averages ± standard deviation of triplicate determination

-On the columns and lines of each parameter, the averages affected of no common letter are significantly different between them on the threshold of 5% according to the test of Duncan

-PP: proximal part; MP: median part; DP: distal part; dw: dry weight

Table 4 : Mineral composition of flours deriving from the fresh yam tubers different parts during the post harvest conservation

Minerals	Variety	Krenglè				Florido			
	Storage Time/Yam Part	Month 0	Month 2	Month 4	Month 6	Month 0	Month 2	Month 4	Month 6
Zinc (mg/100g dw)	PP	2.08 ± 0.14 (c)	1.31 ± 0.05 (e)	0.99 ± 0.04 (hi)	0.73 ± 0.04 (lm)	1.45 ± 0.09 (d)	1.21 ± 0.04 (f)	0.81 ± 0.05 (kl)	0.63 ± 0.07 (no)
	MP	1.50 ± 0.07 (d)	1.13 ± 0.04 (g)	0.72 ± 0.10 (lm)	0.60 ± 0.03 (n)	1.24 ± 0.12 (ef)	0.91 ± 0.05 (ij)	0.70 ± 0.06 (m)	0.50 ± 0.04 (o)
	DP	2.99 ± 0.04 (a)	1.24 ± 0.06 (e f)	1.00 ± 0.04 (h)	0.72 ± 0.14 (lm)	2.80 ± 0.09 (b)	1.23 ± 0.03 (ef)	0.84 ± 0.10 (jk)	0.73 ± 0.13 (lm)
Magnesium (mg/100g dw)	PP	37.88 ± 0.02 (a)	28.51 ± 0.34 (n)	29.50 ± 0.13 (m)	29.17 ± 0.21 (m)	53.65 ± 0.14 (c)	40.23 ± 0.35 (gh)	41.33 ± 0.33 (f)	40.34 ± 0.37 (g)
	MP	35.87 ± 0.08 (j)	26.74 ± 0.18 (o)	26.93 ± 0.31 (o)	25.35 ± 0.26 (p)	51.38 ± 0.08 (g)	38.15 ± 0.26 (i)	41.71 ± 0.30 (f)	39.79 ± 0.24 (h)
	DP	38.33 ± 0.14 (i)	30.46 ± 0.33 (l)	33.17 ± 0.20 (k)	30.27 ± 0.18 (l)	57.32 ± 0.09 (b)	47.77 ± 0.96 (e)	47.89 ± 0.27 (e)	47.62 ± 0.33 (e)
Calcium (mg/100g dw)	PP	25.38 ± 0.07 (i)	22.32 ± 0.07 (m)	34.38 ± 0.07 (c)	23.33 ± 0.10 (j)	32.82 ± 0.05 (d)	22.61 ± 0.09 (l)	25.69 ± 0.12 (g)	19.22 ± 0.10 (q)
	MP	16.08 ± 0.13 (t)	12.33 ± 0.09 (v)	18.53 ± 0.09 (r)	14.44 ± 0.11 (u)	23.25 ± 0.08 (j)	21.77 ± 0.13 (n)	18.10 ± 0.08 (s)	17.94 ± 0.13 (s)
	DP	25.68 ± 0.09 (h)	22.84 ± 0.10 (k)	35.29 ± 0.12 (b)	21.55 ± 0.09 (o)	38.49 ± 0.10 (a)	31.42 ± 0.10 (e)	30.89 ± 0.11 (f)	20.35 ± 0.06 (p)
Nickel (mg/100g dw)	PP	0.45 ± 0.05 (i j)	1.04 ± 0.11 (a)	0.42 ± 0.10 (jk)	0.42 ± 0.14 (j)	0.44 ± 0.03 (ij)	0.97 ± 0.04 (a)	0.34 ± 0.02 (gh)	0.66 ± 0.10 (ef)
	MP	0.53 ± 0.05 (h)	0.89 ± 0.04 (b)	0.73 ± 0.03 (de)	0.80 ± 0.06 (cd)	0.81 ± 0.14 (c)	0.60 ± 0.05 (fg)	0.51 ± 0.08 (hi)	0.35 ± 0.08 (kl)
	DP	0.73 ± 0.06 (d e)	0.35 ± 0.03 (k l)	0.32 ± 0.13 (l)	0.44 ± 0.21 (ij)	0.98 ± 0.09 (c)	0.53 ± 0.12 (gh)	0.74 ± 0.04 (cd)	0.63 ± 0.06 (f)

-The obtained values are averages ± standard deviation of triplicate determination

-On the columns and lines of each common parameter of "Krenglè" and "Florido" varieties, the averages affected of no common letter are significantly different between them on the threshold of 5% according to the test of Duncan

-PP: proximal part; MP: median part; DP: distal part; dw: dry weight

content of "Krenglè" and "Florido" different parts during storage. The total phenolic compound of yam distal and median parts didn't vary meaningfully ($P \leq 0.05$) during the storage. Indeed, the proximal parts had higher phenolic compounds than the other tuber parts whatever the variety is, with the contents varying from 288.89 mg/100 g dw (month 0) to 50.34 mg/100 g dw (month 6) and from 243.00 mg/100 g dw (month 0) to 38.44 mg/100 g dw (month 6) respectively for "Krenglè" and "Florido".

Mineral composition

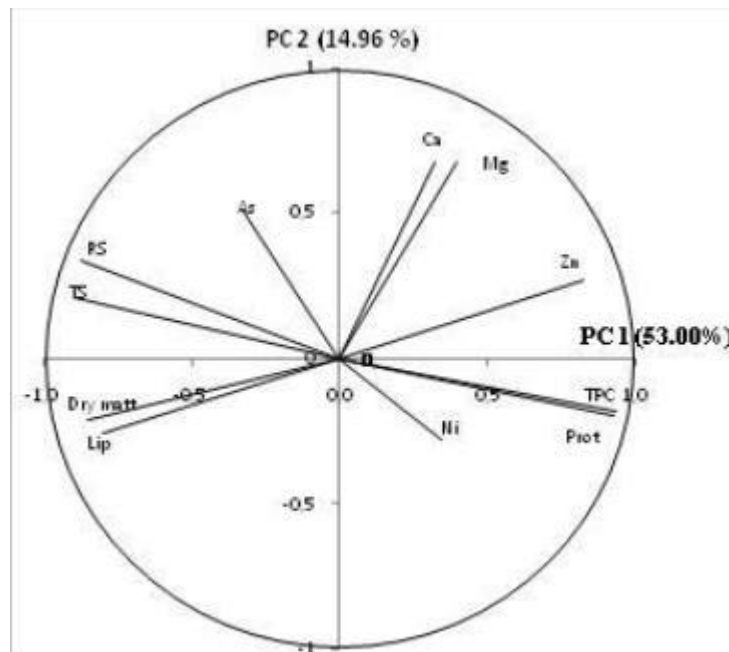
Table 4 summarizes the mineral composition the studied

varieties. All decreased significantly ($P \leq 0.05$) during storage whatever the variety is. Indeed, they differed significantly ($P \leq 0.05$) from one part to another, excepting zinc content in the proximal and distal parts for the two varieties of yam. Ca, Zn, Mg and Ni were highest in the distal parts of tubers during the conservation period. Calcium content ranged from 25.68 mg/100 g dw (month 0) to 21.55 mg/100 g dw (month 6) and from 38.49 mg/100 g dw (month 0) to 20.35 mg/100 g dw (month 6) respectively for "Krenglè" and "Florido". Magnesium content varied from 38.33 mg/100 g dw (month 0) to 30.27 mg/100 g dw (month 6) and from 57.32 mg/100 g dw (month 0) to 47.62 mg/100 g dw

Table 5: Pearson correlation coefficient for physicochemical parameters of different parts of some yam tubers

Variables	RS	TS	As	TCP	Zn	Mg	Ca	Ni	Prot	Lip	Dry matt
RS	1.00										
TS	0.88	1.00									
AS	0.32	0.36	1.00								
TCP	-0.90	-0.86	-0.38	1.00							
Zn	-0.64	-0.59	-0.01	0.71	1.00						
Mg	-0.06	-0.34	0.03	0.23	0.33	1.00					
Ca	-0.07	-0.09	-0.07	0.20	0.42	0.49	1.00				
Ni	-0.24	-0.30	-0.17	0.25	0.30	0.09	-0.15	1.00			
Prot	-0.90	-0.86	-0.47	0.93	0.68	0.22	0.31	0.29	1.00		
Lip	0.54	0.68	0.12	-0.63	-0.71	-0.51	-0.22	-0.28	-0.57	1.00	
Dry matt	0.67	0.64	0.03	-0.74	-0.78	-0.32	-0.31	-0.18	-0.71	0.80	1.00

NB : in thick, the significant correlation values on the threshold of 5%
 TS, Total sugars ; RS, reducing sugars ; TPC, Total phenolic compounds ;
 Lip , lipids; As, ashes; Prot, proteins; Zn, zinc; Mg, magnesium; Ca, calcium;
 Ni, nickel; D matt, Dry matters.



TPC: total phenolic compounds ; TS: total sugar; RS: reducing sugar ; Ni: nickel ; Lip: Lipid ; Mg: magnesium ; Zn: zinc ; Prot, protein ; Ash: ashes ; Ca: calcium ; D mat, dry matter ; PC: principal component.

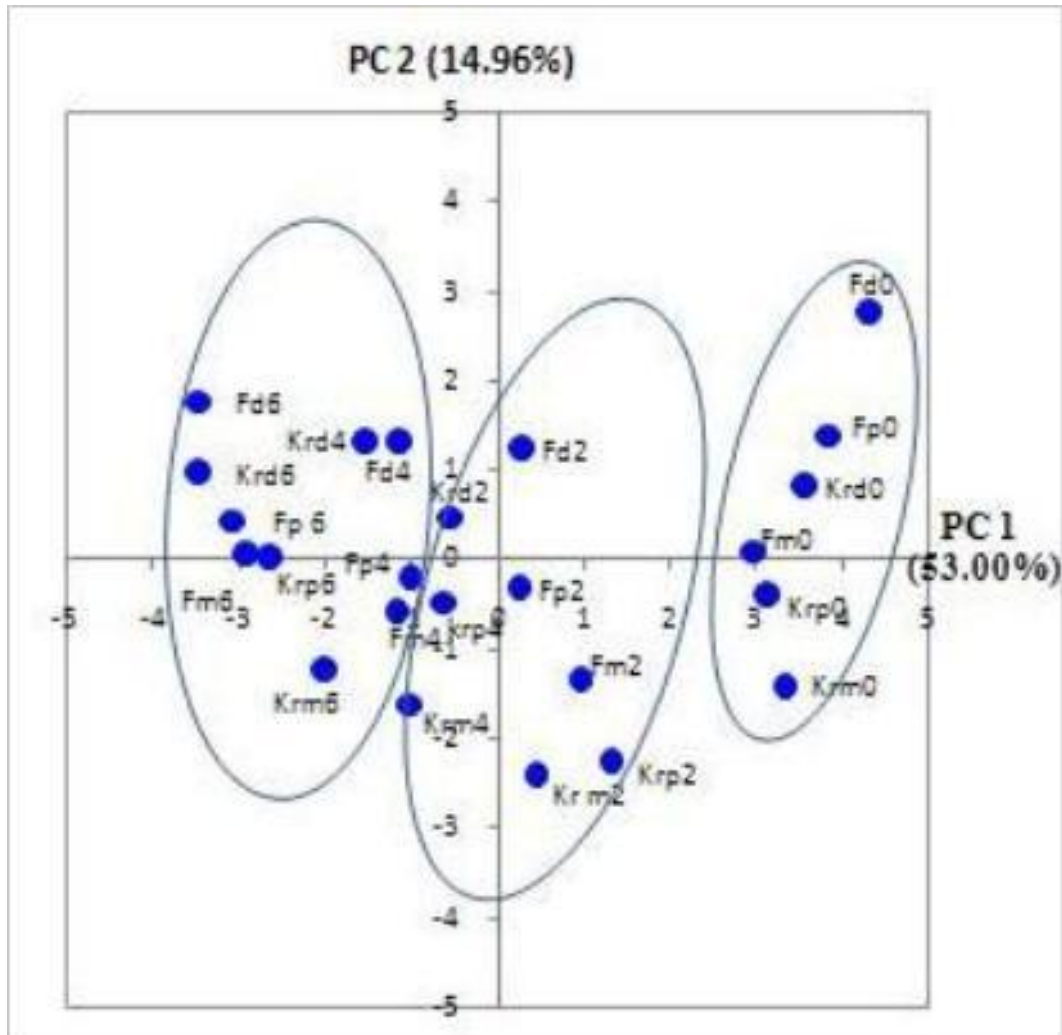
Figure 1 : Circle of correlation of the physicochemical properties of some yams tubers different parts on axes 1 and 2

mg/100g dw to 0.80 mg/100g dw, for “florido” in proximal part varying from 0.44 mg/100g dw to 0.66 mg/100g d

Principal component analysis

The principal component analysis of yam tuber different parts of "Florido" and "Kangba" varieties related to the eleven physicochemical parameters permitted to show two axes explaining the essential variability that were axis 1 and 2. These axes expressed 67.96% of the total variability observed, with 53.00% and 14.96% respectively for axis 1 and 2. The circle of correlation (Figure 1) revealed three groups of enough distinct physicochemical variables. Zinc (Zn), total phenolic compounds (TPC) and the proteins (Prot) contributed to 14.70%, 14.94% and 14.82% to formation of the axis 1. This axis well highlighted these variables. The ashes (As), calcium (Ca) and magnesium (Mg) constituting the second group expressed in the order of 15.52%, 27.52% and 27.63% on the axis 2. This axis is a good indicator of the composition in mineral matters of different samples of yam tubers. The total sugars (TS.), the reducing sugars (RS), the Lipids (Lip) and the dry matters (Dry matt) centered on the first principal component of which they expressed 13.79%, 13.12%, 10.98% and 12.34%. Otherwise the matrix of correlation (Table 5) showed that the proteins, total phenolic compound and zinc contents were correlated positively between them. This variable group correlated negatively at 0.05 level with the variables group constituted by reducing sugars, total sugars, lipids and dry matters contents that were correlated positively at the 0.05 level. The ash contents

(month 6). A slight increase of nickel content was observe for "Krenglè" in median part ranging from 0.53



Kr: "Krenglè"; F: "Florido"; p, proximal; m: median; d: distal; (0), (2), (4) et (6): storage time (months); PC: principal component

Figure 2: Sample plot of principal components 1 and 2 of different parts of some yams tubers

were not correlated with the calcium and magnesium that were correlated positively ($R = 0.49$) between them. The principal component analysis permitted to regroup the yam tuber different parts of "Krenglè" and "Florido" varieties at the beginning of storage month 0 (Figure 2). They were in the positive part of the axis 1, of which they expressed the essential of the variability, contrary to the proximal, median and distal parts of these varieties at the storage time month 4 and 6. These positions explained the difference of physicochemical parameters between the yam tuber different parts at the month 0 and those to the month 6 concerning the total phenolic compound, protein and zinc contents on the one hand and the reducing and total sugar, the lipid and dry matter contents on the other hand. The graph also showed that the three parts of "krenglè" and "Florido" varieties at the month 2 and 4 discriminated in the negative part of the axis 2

according to the intermediate contents of different parameters studied.

DISCUSSION

Proximate composition

Dry matter increased significantly ($P \leq 0.05$) in the different parts of tubers during the post-harvest storage. Indeed, this increase could be explained by the reduction of moisture during the storage period (Sahoré et al., 2007). "Florido" and "Krenglè" showed one 14.62% and 29.19% lost of moisture after 3 months of storage. These values were higher than those recorded by Trèche and Agbor-Egbe (1996) who reported moisture loss of about 8.6% within 110 days after harvesting of the yellow

cultivars of *D. dumetorum*. The very important loss of water in the tubers during the storage could be entailed by the setting up of the germination process that need a strong increase of the respiratory intensity and perspiration acceleration (Trèche, 1989). The raised of dry mater observed in the tubers proximal parts could be attributed to the fact that they were formerly formed and constituted of more aged tissues than those of the median and distal parts (Trèche, 1989).

Concerning the ash contents of yam tuber different parts, our results were closed to the reports of Amani and Kamenan (2003) who found 3.3% dw, 3.4% dw, 2.0% dw and 2.9% dw respectively for dw "Florido", "Bètè-Bètè", "Kponan" and "Krenglè". They were contrary to those obtained by Medoua et al. (2005) who reported a significantly ($P \leq 0.05$) increase of ash contents in the tuber of the yellow cultivars of *D. dumetorum* after 56 days of storage. Otherwise, the elevated content in the distal parts could be bound to the fact that these newly formed parts were fixed to soil. Distal part constitutes the primordial source of mineral matters accumulation from which the median and proximal parts were provided.

The protein contents of yam tuber different parts didn't differ significantly at the level 5% during the post-harvest storage. The slight decrease of protein contents could only result from a reduction of the proteic synthesis capacity as well as a weak proteolysis initiated by the proteases (Kumar and Kwnols, 1993a). The products of deterioration provided a source of energy and metabolic skeletons for germination (Michaud et al., 1994). The gotten values were similar to reported values varying from 9.3% to 8.6% for *Dioscorea dumetorum*, from 7.1% to 6.4% for *Dioscorea cayenensis* and 7.7% to 6.5% for *Dioscorea rotundata* on the whole yam tubers during 19 weeks of conservation (Trèche and Guion, 1979).

The mean of lipid contents of yam tuber different parts didn't differ significantly on the threshold of 5% during the postharvest conservation. Low lipid contents obtained in the yam flours were in accordance with previous studies. Our results were slightly lower than the 0.35-0.38% noted for white and yellow cultivars of *Dioscorea dumetorum*, (Afoakwa and Sefa-Dedeh, 2001). These values were similar to that recorded by Yi-Chung et al. (2006) on the yam whole tubers who found the rate of 0.20% dw for *Dioscorea batata* ("Hualien" cultivar). The gotten weak contents testified that the yam tuber different parts were poor in lipids. This assertion was supported by Osagie and Opute (1981a) who indicated that it didn't seem to have sensitive modification of the lipids content in the tubers during conservation.

The total and reducing sugar contents of yam tuber different parts increased meaningfully ($P \leq 0.05$) during the storage. Indeed, these increasing levels of sugars in the tubers with storage time were suspected to be brought by the breakdown and subsequent hydrolysis of starches into sugars after harvesting (Afoakwa and Sefa-Dedeh, 2001). Similar trends have been recorded by

Trèche and Agbor-Egbe (1996), who reported the most predominant changes occurring in yam tubers after harvest, when stored in non-freezing environment below 40-45°C. The total sugar average contents of the yam tuber different parts during conservation were similar to those recorded by Trèche (1989) on the whole yam tubers, who found contents ranging from 4.3 g/100 g dw to 7.6 g/100 g dw, from 5.1 g/100 g dw to 5.6 g/100 g dw and from 2.8 g/100 g dw to 4.5 g/100 g dw respectively for *Dioscorea cayenensis* ("Bafang" cultivar), *Dioscorea rotundata* ("Bafut" cultivar) and *Dioscorea dumetorum* ("Jakiri" cultivar) during 19 weeks of conservation to 28°C. Otherwise, the variation of the total and reducing sugar contents suggested an unequal distribution of enzymes activities in the yam different parts (Diopoh and Kamenan, 1981).

Total phenolic compounds

Phenolic compounds of yam tuber different parts decreased significantly ($P \leq 0.05$) during the storage. The capacity of a plant species to resist the attack of the bugs and microorganisms is often correlated with the phenolic compounds contents (Rees and Harborne, 1985; Nathalie and Jean-Paul, 2006). It would also justify why the distal part must here be more vulnerable to the mentioned attacks than the proximal part during the storage. Our results were very higher than those published by Marie et al. (2005) who reported the rate of 79.3mg/kg for "st Vincent" cultivar belonging to *Dioscorea alata*. Phenolic compounds were also responsible for the bitterness and astringency associated with many foods.

However, the phenol contents didn't differentiate between wild and edible varieties. The very high levels of phenolic compounds of the proximal part compared to the other parts could explain the rapid browning of the tuber when cut or damaged (Bravo, 1998).

Mineral composition

Calcium contents were lower than those recorded by Bell and Favier (1981) in yam whole tubers of *Dioscorea dumetorum* who reported 41.8 mg/100 g dw and 52.4 mg/100 g dw, respectively. Besides, these values were higher than those recorded by Sahoré and Amani (2005) in yam whole tubers of *Dioscorea dumetorum* and *Dioscorea bulbifera* who noted 5.3 mg/100 g fresh weight (fw) and 5.0 mg/100 g fw, respectively. As for the magnesium contents, our results were higher than those mentioned by Sahoré and Amani (2005) in yam whole tubers of *Dioscorea hirtiflora* and *Dioscorea bulbifera* who reported 23.1 mg/100 g fw and 22.4 mg/100 g dw for these two species. Otherwise, the general minerals content reduction that was magnesium, calcium and zinc during the postharvest conservation would be caused by

their transfer towards the bud for the metabolic process entailed by the germination (Coleman, 2000).

CONCLUSION

This study showed the effects of post-harvest storage on some biochemical parameters in different parts of yam tuber. Proximal composition like total and reducing sugar, and dry matters increased during storage while minerals (Zn, Ca, Mg) and total phenolic compounds significantly decrease. With the exception of lipids and to a lesser extent proteins, the parameters studied varied in the distal, median and proximal parts. Unlike most previous studies have focused on the whole tuber, this work highlights the variability of the chemical composition in different parts of the tuber during storage.

REFERENCES

- Afoakwa EO, Sefa-Dedeh S (2001). Chemical composition and quality changes occurring in *Dioscorea dumetorum* Pax tubers after harvest. *Food Chem.* 75: 85-91.
- Akissoe N, Hounhoui J, Mestres C, Nago M (2003). How blanching and drying affect the colour and functional characteristics of yam (*Dioscorea cayenensis-rotundata*) flour. *Food Chem.* 82: 257-264.
- Amani NG, Kamenan A (2003). Potentialités nutritionnelles et technologiques traditionnelles de transformation des denrées amylacées en Côte d'Ivoire. In : 2^{ème} Atelier international: Voies alimentaires d'amélioration des situations nutritionnelles en Afrique de l'Ouest: le rôle des technologues alimentaires et des nutritionnistes (Ouagadougou 23-28 Novembre). Institut de recherche pour le développement, Wageningen University, FAO.
- AOAC (1990). Official Methods of Analysis. 15th Ed. Association of Official Analytical Chemists, Washington DC.
- Bell A, Favier JC (1981). Influence des transformations technologiques traditionnelles sur la valeur nutritive de l'igname (*Dioscorea spp*) au Cameroun. *Rev. Sci. et Tech. (Sci Santé)*. N°1-2: 135-150.
- Bernfeld P (1955). Amylase α and β . *Methods in enzymology* 1.S. P. Colswick and N.O.K., Ed. Academic Press Inc, New-York. 149-154.
- Bhandari MR, Kawabata J, Kasai T (2003). Nutritional evaluation of wild yam (*Dioscorea spp.*) tubers of Nepal. *Food Chem.* 80: 619-623.
- BRAVO L (1998). Polyphenols: Chemistry dietary sources, metabolism and nutritional significance. *Nut. Rev.* 56: 317-333. Coleman WK (2000). Physiological ageing of potato tubers: a review. *Ann. of Appl. Biol.* 137: 189-191.
- Diopoh J, Kamenan A (1981). Distribution de l'amylase, de la phosphorylase et de la phosphatase acide dans quelques dioscoracées (Igname) de Côte d'Ivoire. *Physiol. Vég.* 19: 401-405.
- Doumbia S, Touré M, Mahyao A (2006). Commercialisation de l'igname en Côte d'Ivoire : Etat actuel et perspectives d'évaluation. *Cah. d'Etude et de Rech. Francoph. / Agric.* 3: 273-277.
- Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F (1956). Colorimetric method for determination of sugars and related substances. *Anal. Chem.* 28: 350-356.
- IITA (2006). Yam. Research Review. International Institute of Tropical Agriculture, Ibadan, Nigeria. Pp.1-4.
- Kumar GNM, Knowles NR (1993a). Age of potato seed-tuber influences protein synthesis during sprouting. *Physiol. Plant.* 89 (2): 262-270.
- Marie AM, Felix OO, Angela SL, Helen NA (2005). Proximate Analysis and Some Antinutritional Factor Constituents in Selected Varieties of Jamaican Yams (*Dioscorea* and *Rajana spp*). *Plant Foods for Hum. Nut.* 60: 93-98.
- Martine J, Mario C (1991). In vitro tuberization in *Dioscorea alata* L. "Brazo fuerte" and "Florida" and *D. Abyssinica* Hoch. *Plant cell, Tis. and Org. cult.* 26: 147-152.
- Medoua GN, Mbome IL, Agbor-Egbe T, Mbofung CMF (2005). Physicochemical changes occurring during post-harvest hardening of trifoliolate yam (*Dioscorea dumetorum*) tubers. *Food Chem.* 90: 597-601.
- Michaud D, Nguyen-Quoc B, Bernier-Vadnais N, Faye L, Yelle S (1994). Cysteine proteinase forms in sprouting potato tuber. *Physiol Plant.* 90: 497-503.
- Nathalie B, Jean-Paul C. (2006): Méthode rapide d'évaluation du contenu en composés phénoliques des organes d'un arbre forestier. *Cah. des Tech. de l'Inra.* 79-82.
- Osagie AU, Opute FI (1981a). Major lipid constituents of *Dioscorea rotundata* tuber during growth and maturation. *J. of Exp. Bot.* 32: 737-740.
- Osuji GO (1985). Application de la thermodynamique à la conservation des tubercules. In : Plantes- racines tropicales. Culture et emplois en Afrique, Terry ER, Doku EV, Arene OB, Mahungu NG, éd. IDRC-Zif, Ottawa, Canada. 145-148.
- Rees S, Harbone G (1985). The role of sesquiterpene lactones and phenolics in the chemical defence of the chicory plant. *Phytochem.* 24: 2225-2231.
- Sahoré D, Amani NG (2005). Composition of wild yams of Côte d'Ivoire. *Trop. Sci.* 45 (3): 110-113.
- Sahoré DA, Nemlin GJ, Kamenan A (2007). Changes in nutritional properties of yam (*Dioscorea spp*), plantain (*Musa spp*) and cassava (*Manihot esculenta*) during storage. *Trop. Sci.* 47 (2) 81-88.
- Swain T, Hillis WE (1959). The phenolic constituents of *Prunes domestica* L. The quantitative analysis of phenolic constituents. *J. of the Sci. of Food and Agric.* 10: 63-68.
- Trèche S (1989). Potentialités nutritionnelles des ignames (*Dioscorea spp.*) cultivées au Cameroun. Vol. I : Texte. Vol. II: annexes. Thèse, Ed. de l'ORSTOM, Collection Etudes et Thèses, Paris, 595 p.
- Trèche S, Agbor E (1996). Composition chimique des ignames consommées au Cameroun. *Rev. Sci. et Tech. (Sci. Santé)*. 2: 23-44.