Advance Journal of Food Science and Technology 2(3): 178-183, 2010
ISSN: 2042-4876

Submitted Date: May 03, 2010 Accepted Date: May 21, 2010 Published Date: May 30, 2010

Monitoring of Some Biochemical Parameters of Two Yam Species (*Dioscorea* Spp) Tubers Parts During Post-Harvest Storage

M. Kouakou Dje, S. Dabonne, S. Tagro Guehi and L. Patrice Kouame
Laboratory of Biochemistry and Food Technology, University of Abobo-Adjamé,
02 BP 801, Abidjan, Côte d'Ivoire

Abstract: Yams tubers of "Bètè-bètè" variety from *Dioscorea alata* species and "Kangba" variety from *Dioscorea cayenensis-rotundata* species were kept for six (6) months after harvest in an aired storage (26.56±3ºC; 82±5% RH). Some biochemical parameters of different parts of tubers were analyzed during the post-harvest preservation. Dry matters, reducing sugars and total sugars contents increased significantly ($p \le 0.05$) during preservation from the month 0 to the month 6 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 ($p \le 0.05$) during storage. With the exception of Ni, a significant loss of mineral (Ca, Mg and Zn) was noticed 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 what ever the variety and the part of the tuber was.

Key words: *Dioscorea alata*, *Dioscorea cayenensis-rotundata*, post-harvest, preservation, proximate composition, tuber parts

INTRODUCTION

Yam (*Dioscorea* spp) is an economically important food in many tropical countries particularly in West Africa, south Asia and Caribbean, where it also has a social and cultural importance (Manuel *et al.*, 2005). It is an important food for about 300 millions people through the world (Ettien *et al.*, 2009). Total world production of yam is estimated to 40 millions tons per year (FAO, 2006). More than 90% of this production occurs in west Africa (Attaie *et al.*, 1988).

In Côte d'Ivoire, yam is cultivated and consumed in the center and the north-east but in a leaser quantity in the south and the west. Total production is about 3 million tons per year. The most important species in Côte d'Ivoire, are *Dioscorea cayenensis-rotundata* complex and *Dioscorea alata*, (Ondo *et al.*, 2009). Yam is an excellent source of starch, which provides calorific energy (Coursey, 1973). It also provides proteic contribution three times superior than the one of cassava and sweet potato (Bourret-Cortedellas, 1973). Yam has a seasonal production that makes mandatory its storage for use as food or seed. After harvest, tubers enter into dormancy. Once the dormancy is broken, sprouting occurs and prolonged storage is no longer possible. Moreover, yam like other root and tuber crops such as cassava and taro, suffers from post-harvest losses estimated at 30% (Doumbia, 1990) caused partly by external agents, such as insects, rodents and moulds. The mode of most widespread storage in Côte d'Ivoire is the preservation in hurdles. The others traditional storage modes of are made in heap, in mounds and in straw hut. The storage time of yam under fresh shape is five (5) months and even on a longer time according to Osagie (1992).

Most of the elaborated biochemical compositions of yam only give nourishing elements content of the whole tuber. Works done by Ferguson *et al.* (1980), Trèche *et al.* (1982), Amani *et al.* (1993), Lebot *et al.* (2005) and Sahoré *et al.* (2007) showed the physicochemical properties of some yam whole tubers from *Dioscorea alata* and *Dioscorea cayenensis-rotundata* species.

According to Degras, (1986) yam tuber can only be divided in three parts: the proximal part, median and the distal one. Data related to the biochemical composition of the tubers different parts during the post-harvest conservation are little known. Hence the objective of this study was to determine the difference in some biochemical properties of yams tubers parts during post-harvest storage.

MATERIALS AND METHODS

Plant material: Varieties "Bètè-Bètè" from *Dioscorea alata* and "Kangba" from *Dioscorea cayenensis-rotundata*

Corresponding Author: S. Dabonne, Laboratory of Biochemistry and Food Technology, University of Abobo-Adjamé, 02 BP 801, Abidjan, Côte d'Ivoire

species were selected in the Center of Côte d'Ivoire. Tubers of about 44.07±4.46 cm were harvested in August 2008 in fields of villages named Douibo, Bomizambo and Koubi. They were transported to the Laboratory of Biochemistry and Food Technology of university of Abobo-Adjamé (Côte d'Ivoire) where study was conducted. Yam tubers were stored for six month (from August 2008 to January 2010) in a heap aired store in which the temperature and the Relative Humidity (RH) rate are respectively 26.56±3ºC and 82±5%.

Sample preparation: Every two (2) months during storage period (six months), four (4) tubers of each variety was randomly picked. The chosen tubers were cut in three equal parts giving for each variety three lots of yam pieces constituted of the proximal parts (head of tuber), the median (middle of the tuber) parts and the distal parts (tail of tuber). Tubers parts of each lot were peeled, cut in small slices (4x4x4 cm^3) and washed with distilled water. Five hundred (500) g of slices in each lot were dried at 45ºC during 48 h. The dried slices were ground and pass through sieve (90 μm size). The obtained flour was kept for analysis.

Proximate analysis: Dry matters were determined by drying in an oven at 105ºC during 24 h to constant weight (AOAC, 1990). Crude protein was calculated from nitrogen (Nx6.25) obtained using the Kjeldahl method by AOAC (1990). Lipids were determined by continuous extraction in a Soxhlet apparatus for 8 h using hexane as solvent (AOAC, 1990). Ash was determined by incinerating in a furnace at 550ºC (AOAC, 1990). Method described by Dubois *et al.* (1956) was used to determine total sugars while reducing sugars were analyzed according to the method of Bernfeld (1955) using 3.5 dinitrosalycilic acids (DNS).

Total phenolics: The total phenolics were determined according to the spectrophotometric method described by Swain and Hillis (1959) using the Folin-Ciocalteu.

Mineral analysis: Calcium, magnesium, zinc and nickel were quantitatively determined from the digest using strong acids and the atomic absorption spectrophotometer with appropriate hollow cathode lamps (AOAC, 1990).

Statistical analysis: All analyses were performed in triplicates. Results were expressed by means of ± SD. Statistical significance was established using Analysis of Variance (ANOVA) models to estimate the effect of storage period on biochemical composition of different parts of yam tubers. Means were separated according to Duncan's multiple range analysis ($p \leq 0.05$), with the help of the software Statistica (StatSoft Inc, Tulsa USA Headquarters).

RESULTS AND DISCUSSION

Proximate composition: Table 1 and 2 give the proximate composition of Proximal Part (PP), Median Part (MP) and Distal Part (DP) of "kangba" and "bètè-bètè" tubers during post harvest storage.

The highest dry matter at month 0 was found to be 35.07 and 45.59% for proximal parts of "Bètè-Bètè" and "Kangba". It increased signicantly ($p \leq 0.05$) during storage till 71.49% for "Bètè-Bètè" and 63.98% for "Kangba" at month 6. Dry matter was significantly ($p \leq 0.05$) different from a part to another one during preservation. Proximal part of "Bètè-Bètè" showed the highest dry matter at the end of storage period. Dry matter increasing was due to the loss of water by tubers during storage. This phenomenon was caused by the setting up of the germination process that requires a strong increase of the respiratory intensity and perspiration acceleration. High level of dry matter in proximal parts of both "Bètè-Bètè" and "Kangba" could be explained by the presence of old tissues in this part of the tuber (Trèche, 1989).

Concerning total sugars, the highest values obtained at month 0 were 3.26 g/100 g of dry weigh (dw) and 3.62 g/100 g dw respectively for distal parts of "Kangba" and "Bètè-Bètè". After six months, distal parts still showed highest and significant increased amount with 5.79 g/100g dw and 8.76 g/100 g dw for "Kangba" and "Bètè-Bètè". Distal parts also contained the most elevated reducing sugars with 0.91 g/100 g dw and of 0.84 g/100 g dw at the beginning of the storage. A significant increase of reducing sugars was observed during storage giving 1.26 g/100 g dw and of 1.37 g/100 g dw respectively for "Kangba" and "Bètè-Bètè". Amount of reducing sugars obtained was closed to those recorded by Ketiku and Oyenuga (1973) for *Dioscorea rotundata* Poir, "Efuru" variety, respectively 0.72, 0.78 and 1.20 dw g/100 g for the proximal, median and distal parts of the tubers. Total and reducing sugars increasing could be attributed to hydrolysis of starch by the amylolytic enzymes present in the tuber (Diopoh and Kamenan, 1981). Distal parts contained the most elevated rate of total and reducing sugar after six months storage.

Protein content ranging from 7.90 to 7.94% did not vary significantly ($p \leq 0.05$) from a tuber part to another at month 0, whatever the yam variety is. A slight fall of protein is observed during storage, giving 6.88% as the lowest content in "bété-bété" distal part after six months. Similar protein content was observed by Trèche and Guion (1979). He also noticed a little decrease from 7.1 to 6.4% for the whole tuber of *Dioscorea cayenensis* after 19 weeks of storage. The slight decrease of protein content during storage could be the result of reduction of the proteic synthesis capacity as well as a weak proteolysis initiated by the proteases (Kumar and Knowles, 1993). There was a homogeneous repartition of

Table 1 : Proximate composition of different parts of "kangba" yam tubers during post harvest storage

	Variety	Kangba			
		Storage time			
Parameters	Yam part	Month 0	Month 2	Month 4	Month 6
Dry matters(%)	PP	45.59±0.98(e)	58.92±0.25(i)	61.31±0.46(j)	63.98±0.40(l)
	MP	40.75±0.74(d)	54.71±0.26(g)	59.38±0.86(i)	62.65±0.69(k)
	DP	38.28±0.59(c)	52.95±0.70(f)	55.28±0.74(g h)	60.75±0.47(j)
Ash(% dw)	PP	1.51±0.01(b c)	1.42±0.03(b)	1.29±0.03(a)	1.60±0.07(c d)
	MP	1.90±0.10(f g)	1.53±0.03(b c)	1.80±0.01(e f)	1.85±0.01(f g)
	DP	1.70±0.01(d e)	1.63±0.01(c d)	1.98±0.04(g h)	2.00±0.02(g h)
Proteins(% dw)	PP	7.94±0.31(f)	7.90±0.35(e f)	7.75±0.13(d e f)	7.19±0.31(a b c d)
	MP	7.94±0.44(f)	7.88±0.32(e f)	7.52±0.26(b c d e f)	7.08±0.16(a b c)
	DP	7.94±0.38(f)	7.81± 0.31(e f)	7.50±0.25(b c d e f)	7.00±0.13(a b)
Lipids(% dw)	PP	0.18±0.01(a)	0.20±0.03(a)	0.21±0.01(a)	0.21±0.01(a)
	MP	0.19±0.02(a)	0.19±0.01(a)	0.21±0.02(a)	0.21±0.03(a)
	DP	0.18±0.02(a)	0.20±0.02(a)	0.21±0.01(a)	0.21±0.01(a)
Total sugars	PP	3.19±0.43(c)	3.87±0.20(e f)	4.30±0.05(f g h i j)	5.05±0.18(l m)
(g/100 g dw)	MP	3.02±0.40(b c)	3.74±0.46(d e)	4.16±0.07(e f g h i)	4.38±0.20(g h i j)
	DP	3.26±0.13(c)	4.08±0.03(e f g h)	4.77±0.06(j k l)	5.79±0.40(n)
Reducing sugars	PP	0.87±0.01(d e)	0.92±0.01(g h)	0.96±0.02(i)	1.18±0.03(l)
(g/100 g dw)	MP	0.83±0.01(c)	0.90±0.01(f g h)	0.93±0.01(h)	1.12±0.01(k)
	DP	0.91±0.01(g h)	0.96±0.01(i)	1.08±0.02(j)	1.26±0.03(m)

PP: proximal part; MP: median part; DP: distal part; dw: dry weight
Each value is an average of three replicate
Values are mean±standard deviation
Means not sharing a similar letter in a line are significantly different $p \leq 0.05$ as assessed by the test of Duncan

Table 2 : Proximate composition of different parts of "bètè-bètè" yam tubers during post harvest storage

	Variety	Bètè-bètè			
		Storage time			
Parameters	Yam part	Month 0	Month 2	Month 4	Month 6
Dry matters(% dw)	PP	35.07±0.65(b)	66.45±0.41(n)	67.97±0.58(o)	71.49±0.65(q)
	MP	34.52±0.84(b)	64.05±0.49(l)	65.35±0.17(m)	69.09±0.61(p)
	DP	30.98±0.52(a)	56.15±0.62(h)	61.29±0.35(j)	64.56±0.69(l m)
Ashes(% dw)	PP	2.60±0.10(j k)	2.04±0.04(h)	2.20±0.01(i)	2.70±0.01(k l)
	MP	3.00±0.10(n o)	2.25±0.02(i)	2.30±0.02(i)	2.50±0.02(j)
	DP	3.07±0.15(o)	2.55±0.07(j)	2.91±0.01(m n)	2.83±0.02(l m)
Crude Proteins(% dw)	PP	7.94±0.28(f)	7.75±0.38(d e f)	7.65±0.19(c d e f)	7.56±0.13(b c d e f)
	MP	7.92±0.35(f)	7.70±0.44(d e f)	7.52±0.22(b c d e f)	7.31±062(a b c d e)
	DP	7.90±0.09(e f)	7.52±0.38(b c d e f)	7.52±0.25(b c d e f)	6.88±0.32(a)
Lipids(% dw)	PP	0.18±0.01(a)	0.20±0.01(a)	0.20±0.01(a)	0.21±0.03(a)
	MP	0.19±0.01(a)	0.20±0.02(a)	0.20±0.02(a)	0.20±0.03(a)
	DP	0.18±0.02(a)	0.20±0.01(a)	0.21 ±0.03(a)	0.21±0.06(a)
Total sugars	PP	2.55±0.07(a)	3.99±0.13(e f g)	4.97±0.13(k l m)	7.67±0.20(p)
(g/100 g dw)	MP	2.26±0.30(a)	3.34±0.15(c d)	4.56±0.20(I j k)	6.46±0.35(o)
	DP	3.62±0.30(a b)	4.50±0.30(h i j k)	5.22±0.06(m)	9.10±0.62(q)
Reducing sugars	PP	0.73±0.02(a)	0.89±0.01(e f g)	1.30±0.03(n o)	1.33±0.01(o)
(g/100 g dw)	MP	0.77±0.01(b)	0.87±0.03(e f)	1.25±0.01(m)	1.29±0.02(n)
	DP	0.84±0.03(c d)	0.92±0.02(h)	1.32±0.02(n o)	1.37±0.02(p)

PP: proximal part; MP: median part; DP: distal part; dw: dry weight
Each value is an average of three replicate
Values are mean±standard deviation
Means not sharing a similar letter in a line are significantly different $p \leq 0.05$ as assessed by the test of Duncan

protein in the two varieties of yam tuber. Post harvest storage did not significantly affect protein what ever the part and the variety of yam were.

Lipids average only represented about 0.20% of the dry matter and didn't vary significantly on the threshold of 5% from a tuber part to another one, whatever the variety was at month 0 and during post harvest conservation. The gotten values were in agreement with those of the whole tuber reported by Trèche *et al.* (1982) on *Dioscorea cayenensis* and *Dioscorea rotundata* ranging from 0.15 to 0.30% and from 0.20 to 0.25%. They were lower if compared to 0.70 and 1.10% record by Amani and Kamenan (2003) for "Florido" and "Kponan". Yam tubers parts were poor in lipids as supported by Osagie and Opute (1981) who also don't observe sensitive modification of the lipids content in the tubers during conservation.

The highest contents of ash were observed in distal parts with 2.00% for "Kangba" and 3.07% for "Bètè-Bètè". Ash content of "Bètè-Bètè" tuber parts was higher than those of "Kangba". Present findings were closed to the values ranging from 2.60 to 3.10% and 2.60 to 3.0%

Table 3 : Total phenolic compounds of different parts of "bètè-bètè" and "kangba" yam tubers during post harvest storage

	Varieties,	Kangba,				Bètè-bètè			
		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	330.11±3.28 (k)	259.89±5.94 (h i j)	153.11±2.22 (d)	63.12±2.95 (b)	263.67±3.46 (i j)	213.44±2.66 (e f)	112.67±3.28 (c)	50.22±3.83 (b)
	MP	281.44±5.93 (j)	219.11±4.36 (f)	148.33±3.19 (d)	55.17±3.19 (b)	241.00±3.39 (g h)	161.67±4.90 (d)	93.89±4.11 (c)	46.11±2.45 (b)
	DP	247.00± 1.1 (h i)	196.00±3.98 (e)	144.99±2.88 (d)	54.44±2.88 (b)	222.44±2.22 (f g)	146.44±344 (d)	67.22±3.97 (b)	23.00±1.22 (a)

PP: proximal part; MP: median part; DP: distal part; dw: dry weight
Each value is an average of three replicate
Values are mean±standard deviation
Means not sharing a similar letter in a line are significantly different $p \leq 0.05$ as assessed by the test of Duncan

Table 4 : Mineral composition of different parts of "bètè-bètè" and "kangba" yam tubers during post harvest storage

	Varieties	Kangba				Bètè-bètè			
		Storage time							
Minerals	Yam part	Month 0	Month 2	Month 4	Month 6	Month 0	Month 2	Month 4	Month 6
Zinc									
(mg/100g dw)	PP	1.90±0.15 (k)	1.40±0.13 (i)	0.85±0.08 (f)	0.80±0.11 (e f)	1.32±0.03 (h)	1.09±0.03 (g)	0.68±0.05 (c d)	0.63±0.03 (b c)
	MP	1.43±0.11 (i)	1.04±0.12 (g)	0.83±0.13 (f)	0.61±0.03 (b)	1.04±0.06 (g)	0.73±0.15 (d e)	0.62±0.03 (b c)	0.44±0.12 (a)
	DP	1.61±0.08 (j)	1.04±0.08 (g)	0.75±0.03 (d e)	0.63±0.06 (b c)	1.42±0.07 (i)	1.07±0.03 (g)	0.82±0.13 (f)	0 .79±0.05 (e f)
Magnesium									
(mg/100g dw)	PP	58.17±0.10 (p)	39.71±0.09 (e)	46.10±0.40 (i)	37.49±0.26 (d)	61.51±0.14 (q)	43.12±0.27 (g)	57.37±0.23 (o)	45.50±0.24 (h)
	MP	52.63±0.12 (m)	32.26±0.15 (a)	36.49±0.35 (c)	31.83±0.70 (a)	49.52±0.13 (l)	36.95±0.33 (c)	46.96±0.20 (j)	39.62±0.21 (e)
	DP	64.22±0.07 (r)	45.12±0.20 (h)	53.54±0.39 (n)	41.44±0.18 (f)	47.64±0.11 (k)	36.73±0.33 (c)	43.33±0.25 (g)	34.32±0.20 (b)
Calcium									
(mg/100g dw)	PP	12.43±0,10 (i)	12.32±0.11 (i)	8.34±0,08 (e)	7.47±0.08 (d)	27.30±0.16 (p)	16.77±0.16 (m)	16.91±0.14 (m)	5.11±0.04 (b)
	MP	10.04±0.10 (g)	11.03±0.07 (h)	3.57.±0,11 (a)	5.58±0.16 (c)	22.82±0.13 (o)	13.54±0.11 (k)	10.86±0.13 (h)	5.15±0.09 (b)
	DP	16.05±0.08 (l)	13.19±0.15 (j)	9.35±0,08 (f)	8.35±0.08 (e)	27.48±0.09 (q)	17.30±0.12 (n)	17.47±0.06 (n)	7.55±0.08 (d)
Nickel									
(mg/100g dw)	PP	0.51±0.02 (e f)	0.77±0.21 (j k)	0.95±0.04 (o)	0.83±0.22 (l)	0.87±0.04 (m n)	0.89±0.12 (n)	0.49±0.03 (e)	0.11±0.06 (a)
	MP	0.48±0.07 (d e)	0.54±0.13 (f)	0.84±0.11 (l m)	0.74±0.13 (j)	0.47±0.08 (d)	0.75±0.03 (j)	0.65±0.07 (h)	0.79±0.05 (k)
	DP	0.38±0.08 (c)	0.70±0.04 (i)	0.70±0.03 (i)	0.52±0.06 (f)	0.27±0.02 (b)	0.73±0.04 (i j)	0.59±0.03 (g)	0.66±0.03 (h)

PP: proximal part; MP: median part; DP: distal part; dw: dry weight
Each value is an average of three replicate
Values are mean±standard deviation
Means not sharing a similar letter in a line are significantly different $p \leq 0.05$ as assessed by the test of Duncan

respectively for t *Dioscorea cayenensis* and *Dioscorea rotundata* after 19 weeks of storage (Trèche, 1989).

Total phenolic compounds: Total phenolic compound are shown in Table 3. The proximal parts of "Kangba" and "Bètè-Bètè" tubers showed respectively 330.11 mg/100 g dw and of 263.67 mg/100 g dw total phenolic compound at month 0. They had higher ($p \leq 0.05$) phenolic content if compared to distal parts containing 247.00 mg/100 g dw and of 222.44 mg/100 g dw respectively for "Kangba", and "Bètè-Bètè". At the end of storage period, a significant ($p \leq 0.05$) decrease was observed in the two varieties. Le lowest total phenolic compound content was 23.00 mg/100 g dw, located in distal part of "Bètè-Bètè". Medoua (2005) also observed reduction of total phenols in *Dioscorea dumetorum* from 318 to 248.4 mg/100 g dw after 56 days of storage. According to the same author, reduction of the total phenolic compounds during the storage could be bound to germination and its role in morphogenesis of the stems formed on the reserve organ that is the tuber.

Mineral composition: Monitoring of mineral composition during storage is viewed in Table 4. The highest contents of zinc was respectively 1.90 and 1.42 mg/100g dw, for proximal parts of “kangba” and distal part of “bètè-bètè”. Concerning magnesium 64.22 and 61.51 mg/100g dw were obtained also for distal parts of “kangba” and proximal part of “bètè-bètè”. Calcium distal parts were 16.05 and 27.48 mg/100g dw respectively for "Kangba", and "Bètè-Bètè" at month 0. The highest concentration of nickel was observed in proximal parts at month 4 (0.94 mg/100g dw) for “kangba”. Excepted for Ni, a significant decrease ($p \leq 0.05$) of the other minerals content occurred from the beginning to the end of storage. It could be due to their transfer towards the bud for the metabolic process entailed by germination (Coleman, 2000).

CONCLUSION

Storage proved to have effect on some biochemical parameters of different parts of "bête-bète" and "kangba". Dry matter increased in all parts of yam tuber and proximal part of "Bètè-Bètè" shows the highest content at the end of conservation period. Total and reducing sugar also increased in distal parts during storage. "Bètè-Bètè" showed the most elevated rate after six-month storage. Distal parts also exhibited the highest contents of ash. There was a homogeneous repartition of protein and lipids in the tubers of both "Kangba", and "Bètè-Bètè" that post harvest storage did not significantly ($p \leq 0.05$) affect. Storage significantly reduced total phenolic compounds, which were higher in proximal parts of the tubers. High mineral contents were represented magnesium and nickel in proximal of "kangba", zinc and calcium respectively in proximal and distal parts "Bètè-Bètè". They significantly decreased during preservation.

Except for lipids and protein this study shows that the studied parameters of yam varied in the parts of tubers from the beginning to the end of storage period. Total and reducing sugars by examples was more important in the distal part of the tubers. Storage was also found to be a good method of eliminating the phenolic compounds.

REFERENCES

Amani, N.G., F. Aboua, D. Gnakri and A. Kamenan, 1993. Study of physico-chemical properties of taro starch (*Xanthomonas sagittifalium*). Ind. Alim Agr., 110(137): 141.

Amani, N.G. and A. Kamenan, 2003. Nutritional potential and traditional technological of transformation of starchy foods in Côte d'Ivoire. Second International Workshop: Ways to improve food nutrition in West Africa: the role of food technologists and nutritionists (Ouagadougou, 23-28 November). Research Institute for Development, Wageningen University, FAO.

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association Official Analytical Chemists.Washington DC.

Attaie, H., N. Zakhia and N. Bricas, 1998. State of Knowledge and Research on Food Processing and Uses of Yam. In: Berthaud, J., N. Bricas and J.L. Marchand (Eds.), Yam, Old Plant and Crop for the Future. Proceedings of International Seminar CIRAD-INRA-ORSTOM-CORAF, 3-6 June, Montpellier, France, pp: 275-284.

Bernfeld, P., 1955. Amylase α and β. Methods Enzymology. Vol: 1, Colswick, S. and N.O. Kaplan, (Ed.), Academic Press Inc, New York, pp: 149-154.

Bourret-Cortadellas, D., 1973. Ethnobotanic Study of the Dioscorea, Yams New Caledonia. Doctorate 3rd cycle. Faculty of science, Paris, France, pp: 135.

Coleman, W.K., 2000. Physiological ageing of patato tubers: a review. Ann. Appl. Bio., 137(2): 189-19l.

Coursey, D.G., 1973. Cassava as Food: Toxicity and Technology. In: Nestel, B. and R. MacIntyre, (Eds.), Chronic Cassava Toxicity, Ottawa, Canada, IDRC, IDRC-10[e], pp: 27-36.

Degras, L., 1986. Yam: Tropical Tuber. Maisonneuve et Larose, G.P. (Ed.), Technical and Agricultural Tropical Productions. Paris, France, 36 : 408.

Diopoh, J. and A. Kamenan, 1981 Distribution of amylase, phosphorylase and acid phosphatase in some dioscoréacées (Yams) in Côte d'Ivoire. Physiol. Vég., 19: 401-405.

Doumbia, S., 1990. Development of the system post-harvest of yam and plantain. Stress Analysis of post-harvest and marketing channels. Thesis, Université de Cocody, Abidjan, Cote d'Ivoire.

Dubois, M., L.K. Mc Cowen, T.J. Schotch, P.A. Rebers and F. Smith, 1956. Colorimetric methods for determination of sugars and related substances. Anal. Chem., 2: 350-356.

Ettien, D.J.B., B. Koné, K.K.H. Kouadio, N.E. Kouadio, A. Yao-Kouamé and O. Girardin, 2009. Mineral fertilization of ferralsols for yam production in Guinean Savanna zone of West Africa: the case of traditional varieties of yam on dystric ferralsols Centre Côte d'Ivoire. J. Appl. Biosci., 23: 1394-1402.

FAO, 2006. Statistics on World Production of Roots and Tubers. FAO, Rome, Italie.

Ferguson, T.U., P.H. Haynes and J.A. Spense, 1980. Distribution of dry matter and mineral nutriments in tuber of two cultivars of *Dioscorea alata* L. Trop. Agric., 1: 61-67.

Ketiku, A.O. and V.A. Oyenuga, 1973. Preliminary report on the carbohydrate constituents of cassava roots and yam tuber. Nigeria J. Sci., 4: 25-30.

Kumar, G.N. and N.R. Knowles, 1993. Age of potato seed-tuber influences protein synthesis during sprouting. Physiol. Plant., 89(2): 262-270.

Lebot, V., R. Malapa, T. Molisale and J.L. Marchand, 2005. Physico-chemical characterisation of yam (*Dioscorea alata* L.) tubers from Vanuatu. Genet. Resour. Crop Ev., 53: 1199-1208.

Manuel, C.J., G.K. Rafael, B.P. Milagros, S.P. Arletys, M.V. Vıctor, L.T. Jorge, R.C. Aymé, G.G. Magaly and la C. de V. Jose´, 2005. Production of yam microtubers using a temporary immersion system. Plant Cell Tiss. Org., 83: 103-107.

Medoua, N.G.J.M., 2005. Nutritional and technological potential of hardened tubers of yam Dioscorea dumetorum (Kunth) pax: Thesis, University of Ngaoundere, Cameroun, pp: 210.

Ondo, O.P., C. Kevers and J. Dommes, 2009. Effects of reducing sugar concentration on in vitro tuber formation and sprouting in yam (*Dioscorea cayenensis-D. rotundata* complex). Plant Cell Tiss. Org., 99: 55-59.

Osagie, A.U., 1992. The yam tuber in storage. Benin City. (NIG): Postharvest Research Unit. Departement of Biochemistry, University of Benin, pp: 247.

Osagie, A.U. and F.I. Opute, 1981. Major lipid constituents of *Dioscorea rotundata* tuber during growth and maturation. J. Exp. Bot., 32: 737-740.

Sahoré, D., G.J. Nemlin and A. Kamenan, 2007. Changes in nutrional properties of yam (*Dioscorea* spp), plantain (*Musa* spp) and cassava (*Manihot esculenta*) during storage. Trop. Sci., 47(2): 81-88.

Swain, T. and W.E. Hillis, 1959. The phenolic constituents of *Prunes domestica* I. The quantitative analysis of phenolic constituents. J. Sci. Food Agr., 10: 63-68.

Trèche, S., 1989. Nutritional Potential of Yam (*Dioscorea* Spp.) Grown in Cameroon. Vol: I. text. Vol. II: Appendices. ORSTOM Edn., Collection Studies and Thesis , Paris, pp: 595.

Trèche, S. and P. Guion, 1979. Nutritional implications of differences in physico-chemical properties of starches from two species of yams grown in Cameroon. J. Sci. Technol., (Sci. Health), 2: 117-133.

Trèche, S., G. Gallon and A. Joseph, 1982. Changes in nutrient contents during the ripening and storage of yam tubers (*Dioscorea dumetorum* and *Dioscorea rotundata*) nutritional implications. J. Sci. Technol., (Health Sci.), 3: 69-79.