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Chemical Composition, Nutritive and Energetic Value of Plantain (*Musa* ssp.) Hybrids CRBP 14, CRBP 39, FHIA 17, FHIA 21 and Orishele Variety

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Keywords: Plantain- Musa- Hybrid- Physical characteristics- Chemical composition- Energetic value- Ivory Coast

Summary

*Chemical characteristics as well as contents in main components such as dry matter, sugars, lipids proteins and some minerals were determined in four banana hybrids CRBP 14, CRBP 39, FHIA 17, FHIA 21 and Orishele variety (used as control). Titrable acidity, pH, and calorific energy of these various cultivars of banana (*Musa *ssp.) were also determined. The results indicated that Orishele variety had the highest content of dry matter, total carbohydrate and potassium. On the other hand, CRBP 39 hybrid which had the highest total acidity was the richest in total sugars and was the most energetic. Concerning FHIA 17, it contained the highest amount of proteins, lipids, magnesium, calcium and iron.*

Résumé

Composition chimique, nutritive et valeur énergétique des hybrides CRBP 14, CRBP 39, FHIA 17 et FHIA 21 de banane (*Musa* spp.) et de la variété Orishele

Les caractéristiques chimiques ainsi que les principales composantes que sont la matière sèche, les sucres, les lipides, les protéines, et certains minéraux ont été déterminées dans les cultivars de banane CRBP 14, CRBP 39, FHIA 17, FHIA 21 et Orishele. Les travaux ont également porté sur la détermination de l'acidité titrable, le pH et l'énergie calorifique de ces différents cultivars de banane. Les résultats des analyses montrent, que la variété Orishele présente les taux les plus élevés de matière sèche, de glucides totaux et de potassium. Par contre, l'hybride CRBP 39, qui a l'acidité totale la plus élevée, est le plus riche en sucres totaux et est le plus énergétique. L'hybride FHIA 17 contient, quant à lui, les teneurs les plus élevées en protéines, lipides, magnésium, calcium et fer.

Introduction

Plantains (*Musa* ssp) are the most privileged bananas in the large family of bananas. For that, they play an important role in the economy and food security of many wet tropical regions in the world (22).

According to Ducroquet (18), plantain (1,200 000 tons/year) is the third food crops in Ivory Coast after yams (3,000 000 tons/year) and cassava (1,700 000 tons/year).

Today, most of the banana species available derived from the *Musa acuminata* (genome A) and the M*usa balbisiana* (genome B) species. Following many natural or artificial hybridations, homogenomic and allogenomic species, diploïds, triploïds and tretraploïds have been developed. Some of these species display illnesses prejudicial to a good production.

To reduce the effect of black cercosporiosis (caused by the *Mycosphaerella fijensis* Morelet fungus), one of the most spread illnesses on plantain, the International Institute of Tropical Agriculture (IITA), the Center of Regional Research on Bananas and Plantain (CRBP) and the *Fundaciòn Hondureña de Investigacion Agricola* (FHIA) have conceived hybrids partially resistant to this phytopathology.

As contribution to these agronomic trials, researchers in post-harvest technology have focused their investigations on the study of physico-chemical, biochemical properties and nutritive qualities of many of these cultivars. So, the Orishele variety has been a topic of researches by Gnakri and Kamenan (25, 26), who determined the optimal period of harvest. These results were confirmed by Collin and Dalnic (12). The chemical composition of some varieties from Nigeria and Ivory Coast were analysed respectively by Burdon *et al.* (9) and Aboua (1). Westby and Reilly (41) performed a comparative study on post-harvest characteristics (pulp / skin ratio, moisture content of the pulp and the composition in carbohydrate of the whole pulp), of many plantain cultivars among which three represent the principle variability of plantain subgroups in Africa (one variety of cooking banana resistant to the black cercosporiosis and two hybrids of plantain tetraploïd which are resistant to this pathology).

Offen and Thomas (33) observed on the *Musa paradisiaca* and *Musa sapientum* the evolution of components and the caloric energy during 60, 104 and 116 days after the appearance of the inflorescence.

For the Prata banana (*Musa* AAB, Prata subgroup) the study of the variation of chemical components, during ripening of the fruit allowed Ayub (6) to determine the optimal period of harvest of the banana stems.

N'Galani *et al.* (31) have observed the change in starch and sugars in fruits of "French Clair" and "Batard" (group AAB) plantain cultivars grown in Cameroon for a commercial purpose.

This paper presents data from comparison of some physical, chemical, nutritive and energetic properties between hybrids CRBP 14, CRBP 39, FHIA 17, FHIA 21 and Orishele variety.

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Materials and methods

Vegetal material

Banana hybrids CRBP 14, CRBP 39, FHIA 17, FHIA 21 and Orishele variety (control) were obtained from the Research Station on Fruits and Citrus Fruits of Centre National de Recherche Agronomique (CNRA) located in the village Anguededou (at 20 kilometers east of Abidjan: 5° 38' N, 4° 05' W). They were all harvested at a stage of maximal maturity when at least one ripe fruit appears on the bunch (30). Starting from the date of flowering, this stage corresponds to 67, 92, 78 and 82 days for the four hydrids CRBP 14, CRBP 39, FHIA 17 and FHIA 21 respectively. The control Orishele variety was harvested after 70 days.

Transformation process

Flour was obtained by grinding the pulp slices, after having them dried in a oven at 45 °C during 48 hours.

Analysis methods

Dry matter content was determined by desiccation in a drying oven at 105 °C during 24 hours. Reducing and total sugars were determined using the 3,5-DNS acid method (17). Starch purity was determined by the polarimetric method (8). Titrable acidity was obtained by the volumetric method with phenophtalein. pH was directly read on the pH-meter METROM E 520. Raw proteins were measured by Kjeldahl method (4) using 6.25 as conversion factor. Lipids content was determined by extraction with hexane in a Soxtherm system during 6 hours. Ashes were obtained by calcination in a muffle furnace at 550 °C during 6 hours. Minerals were determined on a VARIAN Atomic Absorption Spectrometer (Spectraa-5 Model). Starch and total carbohydrate contents as well as energetic values were determined by calculation.

Statistic methods

To measure the significance level of differences observed in the case of small samples, the Student t- test was applied (35) using the SPSS software (10.0 version).

Results

The chemical composition of the pulp of hybrids CRBP 14, CRBP 39, FHIA 17, FHIA 21 and that of the Orishele (control banana) is summarized in table 1. Apart from starch and total glucids contents as well as energetic values (values determined by calculation) all the others data are given in the form $\bar{x} \pm \sigma$ in order to take the variance into account.

The dry matter content of the five cultivars of banana varied from 42.63 (Orishele variety) to 23.96 (hybrid FHIA 17). The highest titrable acidity (3.33 meq/100 g) was observed in hybrid CRBP 39 and the lowest (1.66 meq/100 g) in hybrid FHIA 17 and in the Orishele variety. The pH values which were inversely proportional to titrable acidities and varied from 5.68 (hybrid CRBP 39) to 6.43 (Orishele variety). Lipids contents were low and the average was 0.60% of dry matter. Proteins were found in our samples in proportions varying from 2.15 to 2.70%.

The amount of total sugars which was about 3.88% in these cultivars was very low. Reducing sugars contents were very close, since the difference between the two extremes (0.59% in CRBP 14 and 0.56% in FHIA 21) is 0.03%. As for total glucids contents, values are high and very close each other. The Orishele variety and hybrid CRBP 39 with respectively 95.47 and 95.25% had the highest contents, the lowest (93.04%) was observed in hybrid FHIA 17. Concerning starch, the average content of these 5 cultivars was 81.7%. On the basis of the different contents, grouping can therefore be done. The first group concerning the highest contents (82.44 and 82.38%) was made of hybrid FHIA 21 and the Orishele variety. The second group was made of hybrids CRBP 39 and CRBP 17 with the mid values of 81.82 and 81.63%. The third group was made of one hybrid, FHIA 17, which had the lowest rate (80.55).

As for ashes, remarkable differences ($p \leq 0.05$) were noticed. In fact, a difference of more than 1% was observed between ashes content of hybrid FHIA 17 (2.94%) and those of hybrid CRBP 39 (1.93) on one hand, and between contents in ashes of hybrid FHIA 17 (2.94%) and those of the Orishele variety (1.81%) on the other hand.

Concerning energetic values of the five cultivars, the

Table 1
Chemical composition of banana hybrids and Orishele variety (control)

	CRBP 14	CRBP 39	FHIA 17	FHIA 21	Orishele
Dry matter pulp (%)	33.16 ± 0.53a	35.28 ± 0.39a	23.96 ± 0.52b	34.50 ± 0.69a	42.63 ± 0.48c
Titrable acidity (meq /100 g)	2.83 ± 0.03a	3.33 ± 2.88a	1.66 ± 2.28b	1.66 ± 2.88b	1.83 ± 0.03b
pH	5.89 ± 0.23a	5.68 ± 0.04a	6.44 ± 0.09b	6.43 ± 0.01b	6.28 ± 0.07b
Lipids*(%)	0.61 ± 0.02a	0.59 ± 0.02a	0.80 ± 0.01b	0.48 ± 0.03a	0.52 ± 0.01a
Proteins*(%)	2.70 ± 0.07a	2.19 ± 0.05b	3.17 ± 0.07c	2.14 ± 0.14a	2.58 ± 0.11b
Total sugars*(%)	3.84 ± 0.03a	4.78 ± 0.44b	3.32 ± 0.13c	3.34 ± 0.01c	4.14 ± 0.38a
Reducing sugars (%)	0.59 ± 0.06a	0.57 ± 0.05a	0.58 ± 0.06a	0.56 ± 0.04a	0.58 ± 0.05a
Total glucids*(%)	94.54a	95.25a	93.04a	94.84a	95.47a
Starch*(%)	81.63a	81.82a	80.55a	82.44a	82.38a
Ashes*(%)	2.15a	1.93a	2.94b	2.05a	1.81a
Energetic value (cal/100 g)	394.45a	395.07a	392.04a	394.38a	394.76a

*The values are expressed on dry matter basis. Data on the same line with different letters are significantly different ($p \leq 0.05$).

Table 2
Mineral contents in 100 g of pulp of banana hybrids and Orishele variety (control)

Mineral	CRBP14	CRBP39	FHIA17	FHIA21	Orishele
Potassium	226.8a	223.7a	100.2b	222.8a	244.5c
Magnesium	35.8a	39.2a	83.8b	23.9c	31.8a
Calcium	9.5a	7.6b	19.4c	6.1d	5.8d
Sodium	7.4a	0.6b	0.8b	0.6b	0.9b
Iron	0.4a	0.4a	0.7b	0.3a	0.4a

The values are averages of three determinations. Data on the same line with different letters are significantly different ($p \leq 0.05$).

difference noticed between the extreme values (395.07 cal/100 g for the Hybrid CRBP 39 and 392.04 cal/100 g for hybrid FHIA 17) is not significant ($p \geq 0.05$).

Table 2 shows the mineral contents of the five cultivars of banana. Potassium contents are practically the same (226.8; 223.6 and 222.8 mg/100 g) respectively for hybrids CRBP 14, CRBP 39 and FHIA 21. The highest content is observed in the Orishele variety (244.5 mg) and the lowest in hybrid FHIA 17.
Magnesium is present in the five cultivars but with very different contents. In fact, hybrid FHIA 17 has the highest content with 83.8 mg comparatively to the other cultivars of which contents varie between 23.9 mg (for hybrid FHIA 21) and 39.2 mg (for hybrid CRBP 39).
For calcium, the maximal content (19.4 mg) is observed once more in hybrid FHIA 17. The 4 other cultivars possess weaker quantities which go from 5.8 mg (for the Orishele variety) to 9.5 mg (for hybrid CRBP 14).
Hybrid CRPB 14 contains a high amount of sodium (7.4 mg) compared with the other cultivars of which the average content is 0.7 mg.
Quantities of iron are practically equal (0.4 mg) in all the cultivars, except hybrid FHIA 17 which shows content much more important (0.7 mg).

Discussion

Values obtained for dry matter are remarkably different ($p \leq 0.05$) from one cultivar to another. With 42.63% the Orishele variety has the highest amount. This value is consistent with those of Busson (10) who found around 37 and 43%. As for hybrids, content values rank from 23.96% (in FHIA 17) to 35.28% (in CRBP 39). These values are close to those of Dillon (16), Dadzie (14) and Cohan (11), who respectively estimated them around 33, 32 and 32,8%. Globally speaking, the variations observed are significantly different ($p \leq 0.05$).
The pH values of the five cultivars of banana varie from 5.68 to 6.44. Hybrid CRBP 39 has the lowest pH and the highest content in titrable acidity (3.33 meq/100 mg). The Orishele variety and hybrid FHIA 17 have the lowest content in titrable acidity (1.66 meq/100 mg) and correlatively they have the highest pH (6.43 and 6.44). All the results obtained for the pH as well as for titrable acidities are significantly different ($p \leq 0.05$). These values are comparable to those obtained by Dadzie (14), who noted that during the ripening of hybrids FHIA 21 and FHIA 22, pH varied respectively from 6.00 to 6.30 and from 6.00 to 6.40. According to the same author, values in titrable acidity ranked from 1.50 to 2.40 meq/100 mg in hybrid FHIA 21 and from 1.50 to 2.20 meq/100 mg in hybrid FHIA 22. Values of pH of our cultivars are rather superior to those of Ndungo (32) who observed pH ranking from 4.52 to 4.74 in the juice of five cultivars of eastern Africa height banana. But, titrable acidities values reported by this author varied from 4.8 to 6.9 meq/100 mg. They are distinctly higher than our values. These high titrable acidities could explain the exclusive use of these bananas for beer production.
Lipids content of the Orishele variety (0.48%) is significantly ($p \leq 0.05$) lower than the highest value (0.80%) observed in hybrid FHIA 17. Gnakri (25) found 0.4% lipids in the pulp of Orishele plantain. This value is very close to 0.48% that we obtained in the same variety; however, it remained lower than those of hybrids under study. These weak contents (0.48%- 0.80%) indicate that plantain is a very poor lipids fruit.
Protidic fractions of samples are weak but significantly different ($p \leq 0.05$). They vary from 3.17 (in FHIA 17) to 2.14 (in Orishele). Proteins content of the five cultivars is comparable to that of cassava (2.50%), according to Sylvestre and Arraudeau (36). Similar results have been obtained by Agbo and Soumanou (5).
Total sugars content of the five cultivars of plantain varies from 4.78% (in hybrid CRBP 39) to 3.32% (in hybrid FHIA 17). These values are similar to those of Aboua (1). Belalcàzar *et al.* (7) reported in the clone "Dominico harton" amounts of total sugars of 0.75% and of 23.7% respectively in the green and the ripe fruit. In the Orishele variety, Agbo *et al.* (5) noticed amounts of total sugars ranking from 0.1 to 20.4% according to the mode and duration of conservation in greenlife stage. Differences observed in our values which are consistent with all these results are not significant ($p \geq 0.05$).
Contents in reducting sugars of our samples vary from 0.56 to 0.59%. These values, which are not statisticaly different ($p \geq 0.05$), are comparable to those of Belalcàzar *et al.* (7) who found 0.53% of reducing sugars in the green fruit of the clone "Dominico harton". On fruits harvested the same day, Agbo *et al*. (5) have registered reducing sugars contents of 0.7% and 0.6% in the Orishele plantain and the cultivar "Affoto" plantain (corn).
Amounts of total glucids we obtained (94% as average) in the five cultivars confirm that plantain is essentially a glucidic fruit. There is no difference ($p \geq 0.05$) between the sugar contents of the banana cultivars under consideration. Our values are higher than those of sweet banana (88%) found by Adrian *et al.* (3). Total glucids contents of our samples are even higher than those of cassava which were 89% according to Sylvester *et al*. (36), as well as those of sweet potato which varied from 86.1 to 87.1% according to Dadie and coll. (13).
In the high contents of total glucids, which are not statisticaly different ($p \geq 0.05$), starch takes up an important place with amounts varying between 80.55% (in hybrid FHIA 17) and 82.44% (in hybrid FHIA 21). These results are similar to those of many other authors (1, 19, 25, 29, 28).
Ashes contents vary from 1.81% in the Orishele variety to 2.94% in hybrid FHIA 17. These statisticaly different ($p \leq 0.05$) results are consistent with those of Welford-Abbey and Omuaru (40). However, they are higher than those found by FAO (21) which was 1% in plantain.
Energetic values of our samples varied from 392.04 cal/100 g (in hybrid FHIA 17) to 395.07 cal/100 g (in CRBP 39). They are not statisticaly different ($p \geq 0.05$). These results are close to that of Du Montcel (37) who gave 145 cal/g of fresh pulp or 390 cal/100 g on dry matter basis. Therefore, our values are higher than that reported by FAO (21), which was 358 cal/100 g of dry plantain or sweet banana. With such energetic values, these cultivars of banana could cover the energetic needs of a normal individual, according to Treche and Guion (39). In fact, FAO (22) indicated that daily energetic values of food intake at the world level must vary between 2187 and 3385 kilocalories. In Africa, the average consumption of plantain was estimated to 250 kg/inhabitant/year, Fouré and Du Montcel (24) giving 0.7 kg/inhabitant/day. So, plantain with more than 1000 kilocalories per day covers a large portion of energetic needs of every inhabitant.
The highest potassium content (244.5 mg/100 g of banana) is found in the Orishele variety. With 100.2 mg/100 g of hybrid FHIA 17 has the lowest content in potassium. This value is significantly low ($p \leq 0.05$) compared to those of other cultivars of which the average content is 229.5 mg/100 g of banana. Former studies reported very different contents. In fact, FAO (21) found in 100 g of sweet banana a content of 401.0 mg of potassium and 352.2 mg in plantain. Aboua (2) estimated 680.0 mg of potassium in the pulp of green banana. Although these values are different, banana can cover the daily intake (380 mg) of potassium necessary for an adult (27).

Concerning magnesium, the maximum content (83 mg/100 g of dry matter) is observed in hybrid FHIA 17 and the lowest (23.9 mg/100 g of dry matter) in hybrid FHIA 21. These values, which are significantly different at ($p \leq 0.05$), are close to that of Aboua (2), who noticed 80.0 mg in the dry matter of green plantain.

On dry matter basis, contents in calcium of the five cultivars vary significantly ($p \leq 0.05$) from 5.8 mg/100 g (for the Orishele variety) to 19.4 mg/100 g (in hybrid FHIA 17). These values are similar to those of Aboua (2) and FAO (21), who respectively indicated 6.5 mg and 19.0 mg/100 g. Plantains under study are rich in calcium compare to cocoyam, sweet potato, maize and sorghum which, contain 0.37 mg; 0.13 mg; 0.08 mg and 0.15 mg respectively (38). Zoumenou (42) noticed in cassava (*Manihot esculenta* Crantz) 3 mg of calcium/100 g.

Sodium is present in the five cultivars of banana under study in quantities ranking significantly ($p \leq 0.05$) from 0.6 mg (in hybrid CRBP 39 and hybrid FHIA 21) to 7.4 mg (in hybrid CRBP 14) in 100 g of dry matter. These values are comparable to that of FAO (21) which indicates 3.0 mg of sodium in 100 g of dry plantain.

Contents of iron of these five plantain cultivars are significantly different ($p \leq 0.05$). They varie from 0.3 mg/100 g (for hybrid FHIA 21) to 0.7 mg/100 g (for hybrid FHIA 17). These values are conform to those of many authors (21, 34, 37).

Conclusion

The comparative study of some chemical components of CRBP14, CRBP39, FHIA17, FHIA21 (banana hybrids) and the Orishele variety (control) showes some noticeable differences between these cultivars. In fact, all the hybrids have lower dry matter than the Orishele variety which, however, possesses the lowest amount of ashes. It must be underlined that a low proportion of fat, proteins, total and reducing sugars contents are found in all the cultivars. They contain high amount of starch and therefore high energetic potentials. Among the determined minerals, potassium have a higher content in all hybrids and in the Orishele variety.

More precisely, we can conclude that hybrid FHIA17 is the most appropriate variety for kid feeding. Besides its energetic value comparable to that of the other cultivars, it is the least acidic, and so, the most palatable. In addition, its higher iron content could contribute in a remarkable way to fight against anaemia caused by the iron deficiency, a pathology which is very widespread in school areas in southern Asia and sub-Saharan Africa (15). Furthermore, its high amount of calcium would efficiently contribute to bones consolidation of the squeleton.

Complementary studies on transformation aptitude of these cultivars for feeding purpose on one hand, and the properties of their starch on the other hand, could allow to better specify their sphere of applications.

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Literature

1. Aboua F., 1991, Chemical and physical changes in plantains (*Musa paradisiaca*) during ripening. Tropical Science, **31**, 2, 183-187.
2. Aboua F., 1994, Effect of home processing methods on the nutritional value of plantains in Ivory Coast. Tropical Science, 34, 274-281.
3. Adrian J. & Frangne R., 1996, Nature et propriétés de l’amidon. IAA. 17-21.
4. A.O.A.C., 1973, Official methods of analysis. Washington, D.C.
5. Agbo N.G., Soumanou M.& Yao K.A., 1996, Nouvelles techniques de conservation de la banane plantain en milieu rural avec la matière végétale locale. Sciences des aliments, 16, 607-621.
6. Ayub R.A., 1996, Determinaçao do ponto de colheita da bananeira Prata (*Musa* AAB subgrupo Prata) por intermédio de análise química. Revista Ceres, 43, 247, 227-236.
7. Belalcazar C.S., Valencia M.J.A.& Lozada Z.J.E., 1991, La planta y el fruto pp. 43-89. *In*: El cultivo del plátano (*Musa* AAB Simmonds) en el trópico-ICA, Cali (COL); CRDI, (CAN); Comite Departemental de Cafeteros del Quindio, (COL); INIBAP, International Network for the Improvement of Banana and Plantain, Montpellier (Belalcazar Carvajal, S. (ed.)) ICA, Colombia, Cali.
8. BIPEA, 1976, Bureau interprofessionnel d’études analytiques. Recueil de méthodes d’analyse des communautés européennes, 110 p.
9. Burdon J., Moore KG. & Wainwright H., 1991, The post-harvest ripening of three plantains cultivars (*Musa* spp., AAB group), Fruits, **46,** 2, 137-143.
10. Busson F., 1965, Les plantes alimentaires de l’Afrique de l’ouest. Etude botanique, biologique et chimique. Ed Leconte Marseille. Cahiers d’études et de recherches francophones/Agricultures, **7**, 6, 475-480.
11. Cohan J.-P., Abadie C., Tomekpé K. & Tchango-Tchango J., 2003, Performance agronomiques et résistance à la maladie des raies noires de l’hybride «CRBP 39», InfoMusa, 12, 1, 29-32.
12. Collin M.N. & Dalnic R., 1991, Evolution de quelques critères physico-chimiques de la banane plantain (cultivar Orishele) au cours de la maturation. Fruits, 46, 1, 13-17.
13. Dadié A., Aboua F. & Coulibaly S., 1998, Caractéristiques physico-chimiques de la farine et de l’amidon de la patate douce (*Ipomoea batatas*). I.A.A., octobre, 32-36.
14. Dadzie B.K., 1998, Post-harvest characteristics of black Sigatoka resistant banana, cooking banana and plantain hybrids pp. 5-26. *In*: Technical guidelines INIBAP 4. International Plant Genetic Resources Institute, Rome, Italy; International Network for the Improvemennt of banana and plantain, Montepellier, 75 p.
15. Dalmiya N. & Schultink W., 2003, Combating hidden hunger: the role of international agencies. Food and Nutrition Bulletin, **24**, 4 (supplement) 69-77.
16. Dillon J.C., 1989, Bananes douces et bananes plantain. Cah. Nutr. Diét. 24, 2, 6
17. Dubois M., Mc Cowen L.K., Schotch T.J., Rebers P.A. & Smith F., 1956. Anal. Chem. 28, p. 250.
18. Ducroquet H., 2002, L’agriculture ivoirienne à la loupe (I). Le professionnel agricole, 3, 10-12.
19. Duprat F., Gallant D.J., Guilbot A., Mercier C. & Robin J.P., 1980, L’amidon, pp. 231-276 *in*: les polymères végétaux. B. Monties Gauthier éditeurs. Paris.
20. Dzomeku B.M., 2001, Introduction evaluation and dissemination of FHIA hybrids in Ghana pp. 35-43, *in*: Report of the fourth Annual Steering Committee Meeting; east Legon, Accra, Ghana; 2-4 april 2001; INIBAP, MUSACO, IPGRI; 1.
21. FAO, 1972, Food composition tables for use in Africa. Rome: Food and Agriculture Organization of the United Nations.
22. FAO, 1988, Roots and tuber crops, plantain and bananas in developing countries. Challenge and opportunities. FAO plant production and protection paper, FAO, Rome, 83 p.
23. FAO, 2004, Faostat. Food balance sheets 1961-2001. FAO Rome.
24. Fouré E. & du Montcel H.T., 1999, Les productions bananières – un enjeu économique majeur pour la sécurité alimentaire. Le courrier Afrique – Caraïbes – Pacifique – Union Européenne, 176- Juillet-Août. 71-73.
25. Gnakri D., 1990, Valorisation du fruit de plantain (*Musa* spp.). 1- Caractérisation physico-chimique de l’amidon. 2- Etudes nutritionnelle, métabolique et physiologique des aliments dérivés: foutou et foufou. Thèse doctorat d’état ès Sciences naturelles (option Biochimie -nutrition), Université Nationale de Côte d’Ivoire. Abidjan, 233 p.
26. Gnakri D. & Kamenan A., 1994, Caractéristiques physicochimiques de l’amidon de plantain (*Musa* spp., AAB). Agronomie Africaine, **6**, 1, 19-25.

27. INIBAP, 2001, La banane: aliment et source de revenus. INIBAP Montpellier. 1 p.

28. Ketiku A.O., 1973, Chemical composition of unripe (green) and ripe plantain *Musa paradisiaca*. J. Sci. Food Agri. 24, 703-707.

29. Marriot J., Robinson M. & Marikari S.K., 1981, Starch and sugar transformation during the ripening of plantains and bananas. J. Sci. Food. Agri. 32, 1021-1026.

30. Mitra S.K., 1997, Postharvest physiology and storage of tropical and subtropical fruits. CAB International,Wallingford, United Kindom. 423 p.

31. Ngalani J.A., Tchango Tchango J. & Reynes M., 1999, Starch and sugar transformation during the ripening of banana and plantain cultivars grown in Cameroon. Tropical Science, 39, 115-119.

32. Ndungo M.V., 1998, Contribution à l'étude préliminaire de l'influence variétale sur certaines qualités organoleptiques de la bière de banane pp 413-419. *In*: Bananas and food security: les productions bananières: un enjeu économique majeur pour la sécurité alimentaire. Proceedings of an International symposium, Douala, Cameroon, 10-14 November 1998. INIBAP, Coopération Française, CTA, CRBP. 797 p.

33. Offem J.O. & Thomas O.O., 1993, Chemical changes in relation to mode and degree of maturation of plantain (*Musa paradisiaca*) and banana (*Musa sapientum*) fruits. Food Research International, 26, 3, 187-193.

34. Puis B.N., 1994, Bananas and their management pp. 20-27, Kagera writers and publishers co-operative society LTD. Bukoba, Tanzania, 111 p.

35. Schwartz D., Lazer P. & Papoz L., 1985, Statistique médicale et biologique 5ème édition. Flammarion Médicale Science, 211-215.

36. Sylvestre P. & Arradau M., 1983, Le manioc. Ed. GP. Maisonneuve et Larose, Paris, 1983, 262 p.

37. Tezenas Du Montcel H., 1993, Plantain bananas, *in*: The tropical agriculturalist. The Macmillan Press LTD. London. 103 p.

38. Tilahun A., Ann S. & Jens A., 2004, Advancing human nutrition without degrading land resources through modeling cropping systems in the ethiopian highlands. Food and Nutrition Bulletin, **25**, 4, 344-353.

39. Treche S. & Guion Ph., 1979, Etudes des potentialités de quelques tubercules tropicaux au Cameroun. Agron. Top. XXXIV, 2, 127-137.

40. Welford-Abbey L.I. & Omuaru V.O.T., 1998, Effect of ripening on the chemical composition of plantain peels and pulps (*Musa paradisiacal*). J. Sci. Food Agr. 45, 333-336.

41. Westby A. & Reilly P.J.A., 1992, Traditional African foods, quality and nutrition, Proceedings of a workshop; 1992/11/25-29, pp 179-185.

42. Zoumenou V., 1994, Etude physico-chimique et nutritionnelle de quelques préparations alimentaires à base de manioc, (*Manihot esculenta,* Crantz*).* Thèse de 3è Cycle ès-Sciences naturelles. Université Nationale de Côte d'Ivoire. Abidjan. 102 p.

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