OPEN ACCESS
Scholars International Journal of Biochemistry
Abbreviated Key Title: Sch Int J Biochem
ISSN 2616-8650 (Print) |ISSN 2617-3476 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com/journal/sijb/home

Original Research Article

Physicochemical Composition of Flours From Seven New Varieties of Cassava (*Manihot Esculenta* Crantz) Grown and Consumed in Côte d'Ivoire

Marise Amaco Kacou[1], Catherine Bomoh Ebah[2], Kouadio Martin Tanoh[1], Jocelyn Constant Yapi[3], Gbocho Serge Elvis Ekissi[1] and Patrice Lucien Kouame[1]
[1]Laboratory of Biochemistry and Food Technology, University Nangui Abrogoua (Abidjan, Côte d'Ivoire).
[2]CNRA (National Center for Agronomic Research), Research Station on Technology (Abidjan, Côte d'Ivoire)
[3]Department of Biochemistry and Microbiology, Agroforestry unit, University Lorougnon Guede (Daloa, Côte d'Ivoire)

***Corresponding author:** Ekissi Elvis Serge Gbocho
| **Received:** 14.03.2019 | **Accepted:** 22.03.2019 | **Published:** 31.03.2019
DOI: 10.36348/sijb.2019.v02i03.007

Abstract

Flours were prepared from seven cassava varieties (Agbablé3, Bonoua2, Bondoukou4, Boufouh3, Boufouh4, Soclopouopo3, Totoba2) evaluated for their physicochemical properties. The physicochemical parameters of the seven varieties show significant differences (p <0.05). The results showed that moisture content of flours ranged from 10.88±0.02 (Bonoua2) to 12.92±0.31% (Agbaglé3), starch from 28.71±0.34 (Socloppouopo3) to 44.06±0.56% (Totoba2) carbohydrates from 92.70 ±0.05% (Totoba2) to 94.72±0.27 (Bonoua2), organic matter from 85.3±0.27 (Totoba2) to 87.4±0.18% (Bondoukou4), and energy value from 347.56±0.03 (Agbable3) to 361.95±0.01 to kcal/100g (Bonoua2). Physicochemical parameters at low content are the protein ranging from 1.37±0.14 (Soclopouopo3 and Boufouh4) to 2.23±0.13% (Boufouh3), lipids from 0.77±0.03 (Bonoua2) to 1.29±0.11(Boufouh4), ash from 1.29±0.1(Agbablé3) to 2.62±0.01 (Soclopouopo3), fibers from 1.03±0.24 (Soclopouopo3) to 1.08±0.06% (Boufouh3 and 4) and total sugar from 1.30±0.04(Soclopouopo3)-3.35±0.05(Bonoua2). The most dominant minerals are potassium, calcium and phosphorus whose content are respectively 328±0.1 (Totoba2) to 1207 mg/100g (Bondoukou4), 82±0.01 (Boufouh4) to 338±0.26 mg/100g (Bonoua2) and from 20±0.05 (Totoba2) to 100±0.41 mg/100g (Bonoua2). From the data obtained it can be concluded that cassava varieties should not be abandoned because of poor cooking quality and high cyanogenic potential. These varieties could be used for other purposes such as starch production, glucose, adhesives, fuel alcohol, animal feed and other industrial Uses.
Keywords: Physicochemical composition, *Manihot esculenta*, flour, variety, Côte d'Ivoire.

INTRODUCTION

The cassava (*Manihot esculenta* Crantz) is a perennial of the dicotyledonous family Euphorbiaceae cultivated mainly in the tropic and sub-tropic regions of the world, over a wide range of environmental and soil conditions [1]. Cassava is a staple food in many countries of Africa, Asia, Latin America and the Caribbean. This crop has great social value and cultural identity. Therefore, cassava plays an important role in food security and nutrition being a source of income for producers, processors and trades contributing substantially to poverty alleviation [2]. The cassava is an important component in the diets of more than 800 million people around the world [3] and is the third largest carbohydrate food source within the tropical regions, after rice and corn [4]. In some countries, cassava is consumed daily and sometimes more than once a day [5]. Cassava was found to be the cheapest source of calories among all food crops [6]. It is estimated to provide over 12% of the daily per capita calorie needs for the people of SubSaharan Africa [7]. Cassava is mainly grown by small producers, who use it for self-consumption, feed animals and generate income by selling in different markets [8].

World production is estimated at 278.7 million tonnes, of which Nigeria is the world's largest producer with 54.832 million tonnes, or 20.3% of world production [7]. In Côte d'Ivoire, cassava is grown on about 4/5 of the national territory and is the major food crop after yam [9]. Farmers in Africa grow several cassava varieties included local varieties and improved ones. The proximate composition and the mineral profiles of some improved cassava roots have been assessed [10, 11]. Starch of cassava is also used in the textile, paper, metallurgy, pharmacy, and plastic industries [12]. In Côte d'Ivoire, several meals (placali, kongondé, bédèkouma, gari, etc.) were obtained from cassava roots [13]. According to the FAOSTAT [7], this food has the potential to become the raw material base for a number of processed products. However, the utilization and efficient commercialization of cassava are affected by its short shelf-life due to a rapid postharvest physiological deterioration process, which renders the root unpalatable within 48 hours of harvest and the presence of cyanogenic compounds in its roots requires treatment just after harvest [14]. One of the best ways to preserve them is to turn them into flour and / or starch [15].

Cassava flour is used for production of foods such as noodles, breakfast cereals, cookies, breads, cakes, pastries, muffins and doughnuts [16]. In order to be widely accepted by the food industry, cassava flour needs to meet the high quality requirements in terms of physicochemical characteristics, microbial safety and cyanogenic glucoside content. However, the success of completely or partially useding cassava flour in bakery and other applications could be better achieved if the cassava flour is adequately characterized in terms of its physicochemical and functional behavior.

The aim of this study was therefore to examine the physicochemical of flours from seven varieties (Bonoua2, Boufouh3, Boufouh4, Bondoukou4, Agbablé3, Soclopouopo3 and Totoba2) of cassava in order to suggest their suitable usages. It is also expected that the database obtained will served as a guide for future research.

MATERIALS AND METHODS

Raw materials

The roots of seven new improved cassava (Agbablé3, Bonoua2, Boufouh3, Boufouh4, Bondoukou4, Soclopouopo3 and Totoba2) of twelve month sold were harvested from CNRA (National Center for Agronomic Research) experimental plot (Bouake, Côte d'Ivoire). Roots were put in coolers to preserve their fresh state, they were transported to the Laboratory of Biochemistry and Food Technology of University of Nangui Abrogoua (Abidjan, Côte d'Ivoire) where study was conducted.

Flour sample preparation

Fresh roots were peeled manually and cut into small pieces with a inox knife. The pieces obtained were washed and dried in an oven at 45 °C for 48 hours. Dry pieceswere crushed and sieved to obtain the raw cassava flour that has been used for various analyzes.

Physicochemical analyses

The following analyses were conducted to characterize the flours of seven improved cassava varieties. Moisture, ash, starch, protein and lipid contents were evaluated using BIPEA [17] methods. Titratable acidity and pH were determined according to method described by Dufour *et al*. [18]. Cyanide and total sugar contents were carried out following FAO [19] and Dubois *et al*. [20] methods respectively. Total carbohydrate contents were evaluated using method described by Bertrand [21]. Caloric energy was calculated according to Atwater general factor system [7]. The system uses a single factor for each of the energy-yielding substrates (protein, fat, carbohydrate) regardless of the food in which it is found. The energy values are 4.0 kcal/g for protein, 9.0 kcal/g for fat and 4.0 kcal/g for carbohydrates. Minerals such as calcium (Ca), sodium (Na); magnesium (Mg), potassium (K), manganese (Mn), zinc (Zn), iron (Fe) and phosphorus (P) were quantified by Atomic Absorption Spectrometer (Varian AA 20, Australia) and Spectrophotometer (UV/Visible Jasco V 530i) respectively, after digestion of samples following IITA [22] method. The Ca/P ratio was evaluated by calculation.

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 functional properties of cassava flours. Means were separated according to Duncan's multiple range analysis (p#0.05), with the help of the software Statistica (StatSoft Inc, Tulsa USA Headquarters) [23].

RESULTS AND DISCUSSION

Physicochemical composition

Physicochemical composition of flours from seven improved varieties cassava is presented in table 1. Moisture content of cassava flours varied from 10.79±0.03 (Soclopouopo3) to 12.92±0.31% (Agbablé3). Moisture content of flours cassava from Soclopouopo3, Bondoukou4 and Bonoua2 varieties is statistically identical to the 5% threshold. Physicochemical composition revealed that cassava flours of seven varieties assessed had low moisture content. The moisture content of cassava flours is found to be 11-16.5 % [24]. The values recorded in this study were within this range. Besides, statistical analyses revealed that there was no significant difference ($p<0.05$) between the moisture content of the flours evaluated. Moisture content is an index of storage of the flours. Flours moisture contents (10.79±0.03 % to 12.92±0.31%) less than 14 % can resist microbial growth and contribute to best storage of the flours cassava more than six months [24]. These results were similar with the findings of Charles *et al.* [25] who reported that the moisture content of cassava flour was 9.2 to 12.3 %. Indeed, a relationship between the moisture content of foods and the proliferation of microorganisms that cause deterioration has been mentioned [26].

Protein content of flours seven varieties ranged from 1.37±0.14% (Soclopouopo3 and Boufouh3) to

2.23±0.13% (Boufouh4). Protein contents of Bondoukou4, Bonoua2, Soclopouopo3 and Boufouh3 flours are statistically identical ($p < 0.05$), as are the flours Totoba2 and Boufouh4 varieties. Crude proteins content range between 1.37 to 2.23 %. In addition, there was no significant difference ($p>0.05$) between the protein values recorded in the flours cassava, whatever the varieties. It is well-known that cassava roots from varieties have low protein content [27]. The results obtained in this study confirmed this statement. The protein value reported in some improved cassava varieties was much higher than those recorded in the present study. The proteins content was similar with the findings of Stupak *et al*. [28] on cassava (1 to 3 %) and lower compared to six flours taro from Cameroon (2.9 and 4.6 %) [29]. The variation of protein content could be due to maturation of the seeds and environmental conditions [4].

Fat content of flours ranged from 0.77±0.03 (Bonoua2) to 1.29±0.11 % (Boufouh4). Fat contents recorded in the present study varied significantly ($p<0.05$) between the flours cassava varieties. The highest value was recorded in Boufouh4 flour while the lowest one was in Bonoua2 flour variety. The relatively high fat content of flour from Boufouh 4 cultivar could be due to the presence of carotenoid compounds at relevant level than the other cultivars. Despite this significant difference, all the values of fat were low. It is well-know that cassava roots have low lipid content [26]. The fat contents of the flours seven varieties of cassava ranging from 0.77 to 1.29% are higher than those reported by Gomes *et al*. [30] and who obtained 0.1% and 0.1% at 0.4% respectively.

pH values of cassava flours varied from 5.83±0.01 (Totoba2) to 6.52±0.3 (Soclopouopo3), titratable acidity ranged from 3.3 ± 0.01 (Boufouh3) to 5.16 ± 0.02 meq/100 g (Soclopouopo3). pH values of Bonoua2 and Totoba2 flours varieties are identical ($p < 0.05$) . The pH was higher in cassava flours and ranged between 5.83 and 6.52, which was acceptable according to the quality requirements [31]. The pH is a good quality indicator for cassava flour since flour with a pH of 4 or less will have a characteristic sour aroma and taste due to fermentation, which is not desirable for use in bakery products [31]. The analyses of variance showed that the pH values of cassava roots varied significantly ($p<0.05$) from a cultivar to another. Despite the significant difference between the pH values, all of the roots assessed were low-acid foods (pH>4.5).

Ash content of flours varied from 1.29 ± 0.15 (Agbablé3) to 2.62±0.08 % (Soclopouo3). Ash content of the different flours cassava varieties (1.29±0.15 to 2.62±0.08 %) may be considered as good sources of minerals compared to cereals and tubers values (2–10 %) [3]. The ash content of improved cassava variety was found to be 0.92-2.6 % on dry matter basis [11]. In this study, the values recorded were close to this range.

Total sugar contents of cassava flours ranged from 1.3 ± 0.04 (Soclopouopo3) to 3.35 ± 0.05% (Bonoua2), cyanide contents varied from 0.096 ± 0.04 (Boufouh3) to 0.152 ± 0.06 mg/100g (Bondoukou4). The total sugar content of flours cassava varied significantly ($p<0.05$) from a flour to a flour. The lowest value belongs to flour of Soclopouopo3 variety this result would be due bitter taste of this variety of cassava. Unfortunately, all the values of total sugar were low. The total sugar contents recorded in this study were much lower than those reported by Assemand *et al.* [32]. These authors found in the fruits plantain agnrin, values ranging from 4.92 to 29.97 % on fresh matter basis.

The crudes fibers content varied from1.03±0.24 (Soclopouopo3) to 1.08±0.06 % (Boufouh3 and 4) in the flours seven cassava varieties would be advantageous for their active role in the regulation of intestinal transit [33, 34]. These contents are low compared to the roots cassava studied by Ebuehi *et al*. [30]. All the values of fibers content were low; therefore, the consumption of the flours cassava can know may be advantageous since high fibers content of foods help in digestion, prevention of colon cancer and in the treatment of diseases such as obesity, diabetes and gastrointestinal disorders [35].

According to the cyanide contents of flours cassava evaluated, the analysis of variance revealed that there was no significant difference ($p<0.05$) between the values recorded. The cyanide content of flours cassava were lowest (less than 50 mg/kg) is an indication of non-toxicity. This kind of flours could be used either in Child's food preparation that needs slight transformation, or in of foods such as breakfast cereals, cookies, breads, cakes, pastries production. The cyanide content was significantly reduced compared to cyanide content in fresh roots (4.72±0.008 and 9.45±0.033 mg/100g). These results show that the transformation of roots into flour is a technique that significantly reduces the rate of toxicity of cassava.

Carbohydrate contents of cassava flours varied from 92.7±0.05 (Totoba2) to 94.72±0.27% (Bonoua2). The cassava varieties flours recorded highest carbohydrate contents. Despite the significant difference ($p<0.05$), all the values of carbohydrate in the flours seven cassava varieties were high. The high levels of carbohydrate could explain the high-energy values recorded in the flours, whatever the variety. Then, flours from the seven varieties are energizing foods. Indeed, about one kilogram of the roots from the seven cultivars could cover the recommended daily energy value for adult, which is 3050 kcal [3].

Starch contents ranged from 28.71±0.34 (Soclopouopo3) to 44.06±0.56 % (Totoba2). Energy values varied from 347.56±0.029 (Agbablé3) to 361.95± 0.01 kcal/100 g (Bonoua2). The starch content of the flours cassava is found to be 15-30 % on dry matter basis [36]. In this study, the starch contents of flours from the seven cassava varieties assessed were within this range. In addition, statistical analysis revealed that there was significant difference ($p<0.05$) between the starch content of the flours seven cultivars. Therefore, the roots are starchy products. Due to their high starch content, the roots from the seven improved cassava varieties could be used at small-scale in starch production [37].

Energy value of the flours cassava range between 347.56±0.03 (Agbablé 3) to 361.95±0.01 Kcal/100g (Bonoua2) is agreed with general observation do on the roots which have low energy values [38] due to their low fat content and relatively high level of moisture [39]. With these energies values, flours from seven cassava varieties could be used as energy in the flour poridge for infanys and children [40].

Table-1: Physicochemical composiion of flours from seven varieties of cassava (*Manihot esculenta* Crantz)

Composition (%)	Cassava Varieties						
	Agbablé3	Bondou-kou4	Bonoua2	Soclo-pouopo3	Boufouh4	Boufouh3	Totoba2
Moisture	12.92±0.31[d]	10.91±0.09[a]	10.88±0.02[a]	10.79±0.03[a]	10.96±0.04[b]	11.88±0.08[c]	12.40±0.1[d]
Carbohydrate	94.3±0.81[ab]	94.11±0.29[ab]	94.72±0.27[ab]	94.03±0.04[a]	93.09±0.12[b]	93.7±0.43[a]	92.7±0.05[b]
Fat	0.85±0.09[ac]	1.1±0.03[b]	0.77±0.03[c]	0.95±0.07[a]	1.29±0.11[d]	0.99±0.08[ab]	1.10±0.08[a]
Protein	2.14±0.44[b]	1.51±0.22[a]	1.55±0.44[a]	1.37±0.14[a]	2.23±0.13[b]	1.37±0.14[a]	2.19±0.07[b]
Ash	1.29±0.1[a]	1.69±0.21[b]	1.66±0.06[b]	2.62±0.08[c]	1.71±0.09[b]	2.26±0.3[c]	2.3±0.24[c]
Fibers	1.42±0.27[ab]	1.59±0.28[ab]	1.3±0.28[bc]	1.03±0.24[c]	1.68±0.06[a]	1.68±0.06[a]	1.71±0.06[a]
Organic matter	85.79±0.25[ab]	87.40±0.18[c]	87.36±0.11[c]	86.59±0.05[b]	87.33±0.06[bc]	85.86±0.56[a]	85.3±0.27[a]
Total sugars	1.80±0.04[c]	2.68±0.021 [e]	3.35±0.05[f]	1.30±0.04[b]	2.55±0.08 [d]	2.06±0.04[a]	2.10±0.03[a]
Reducing sugars	1.09±0.16 [ab]	0.91±0.14[a]	1.04±0.10[a]	0.98±0.09[a]	1.48±0.13[c]	1.28±0.07[b]	1.14±0.09 [ab]
Starch	35.85 ±1.31[b]	38.49 ±1.10[a]	38.50 ±0.19[a]	28.71 ±0.34[c]	40.48 ±0.88[a]	36.03 ±1.70[b]	44.06 ±0.56[d]
Cyanide (mg/100g)	0.103±0.02[a]	0.152±0.05[b]	0.101±0.02[a]	0.109±0.04[a]	0.102±0.03[a]	0.096±0.04[a]	0.100±0.02[a]
Acidity (méq)	5.00±0.01[c]	3.66±0.02[a]	4.16±0.05[b]	5.16±0.017[c]	3.5±0.02[a]	3.3±0.01[d]	4.16±0.124[b]
pH	6.14±0.01[c]	6.10±0.02[b]	5.84±0.02[a]	6.44±0.01[f]	6.33±0.02[e]	6.52±0.03[d]	5.83±0.01[a]
Energy (Kcal/100 g)	347.56 ±0.03[a]	350.57 ±0.03[b]	361.95 ±0.01[c]	350.76 ±0.81[b]	347.99 ±0.01[a]	348.10 ±0.04[a]	347.84 ±0.05[a]

Tabulated values are means of triplicate determinations ± Standard Deviation (SD), Values with different letters in each row are significantly different ($p<0.05$)

Mineral composition

Mineral composition investigated of flours from seven varieties of cassava is presented in Table 2. Minerals are considered to be essential in human nutrition [41]. They help in the maintenance of acid-base balance, to physiological stimulation and blood clotting [42]. The results showed that the flours cassava represent a potential source in mineral, notably in potassium, calcium and phosphorus.

Potassium is the most abundant mineral in cassava flours. The potassium content of flours varied from 328±0.1 (Totoba2) to 1207±0.22 (Bondoukou4). The potassium content is higher compared to the range (250–302 mg/100g) of various species of roots cassava fresh [43, 44].

Calcium is the major component of bone, assists in teeth development, necessary for blood coagulation and for the integrity of intracellular cement substances [45]. The content of Calcium varied of 82 to 338 ppm. This result is in the range (136 to 369 mg / 100g) described by Charles *et al*. [46] on cassava flour.

Seven varieties flours are poor in iron, nevertheless the variety Bondoukou4 is the least poor followed by the variety Boufouh4. Phosphorus contents ranged between 20±0.05 (Totoba2) to 100±0.41 (Bonoua2) ppm are higher than phosphorus content of Ossinum gratissimum (13.8mg/100g) [47]. Phosphorus is an important mineral that aids the absorption of calcium which is required for growth, maintenance of bones, teeth and muscles [48]. As a result, the flours cassava could be recommended for feeding to children and lactating women. These results confirm earlier report that cassava has been recognized as a suitable crop for micronutrient intervention in Africa [49].

The Ca/P ratio of cassava flours varied from 1.01 ± 0.01 (Soclopouopo3) to 13.15±0.23 (Totoba2). The Ca/P ratios of cassava flours were close to 0.7, which is the optimal value for the absorption of the both minerals [50]. It is a clear indication that the minerals in flours cassava are well-balanced.

Table-2: Mineral composition of flours from seven varieties of cassava (*Manihot esculenta* Crantz)

Minerals ((ppm)	Cassava varieties						
	Agbablé3	Bondoukou4	Bonoua2	Soclopouopo3	Boufouh4	Boufouh3	Totoba2
P	90±0.41^{a}	80±0.25^{e}	100±0.41^{f}	90±0.55^{a}	60±0.20^{d}	40±0.40^{c}	20±0.05^{b}
K	992±1.00^{d}	1207±0.22^{g}	1048±0.06^{e}	1081±0.22^{f}	735±0.05^{c}	720±0.28^{b}	328±0.1^{a}
Ca	282±0.05^{f}	162±0.2^{d}	338±0.26^{g}	91±0.05^{b}	82±0.01^{a}	94±0.06^{c}	263±0.02^{e}
Mg	40±0.02^{e}	45±0.01^{g}	44±0.1^{f}	34±0.05^{a}	37±0.04^{s}	35±0.05^{b}	38±0.02^{d}
Fe	0.003±0.0^{b}	0.011±0.0^{g}	0.008±0.0^{e}	0.007±0.0^{d}	0.009±0.0^{f}	0.005±0.0^{c}	0.002±0.0^{a}
Mn	3.14±0.05^{b}	3.75±0.05^{g}	3.69±0.05^{f}	3.62±0.05^{e}	3.61±0.05^{d}	3.35±0.05^{c}	3.125±0.0^{a}
Na	1.65±0.00^{a}	1.56±0.0^{a}	1.18±0.0^{d}	1.03±0.01^{bc}	7.91±0.05^{c}	1.41±0.19^{a}	1.014±0.0^{b}
Zn	0.00±0.0^{a}	0.00±0.0^{a}	0.00±0.0^{a}	0.24±0.0^{c}	0.25±0.01^{d}	0.03±0.0^{b}	0,000±0.0^{a}
Ca/P	3.13^{a}±0.01	2.03^{b}±0.09	3.38^{c}±0.01	1.01^{d}±0.04	1.37^{b}±0.02	2.35^{a}±0.04	13.15^{f}±0.23

Tabulated values are means of triplicate determinations ± Standard Deviation (SD), Values with different letters in each row are significantly different ($p<0.05$)

CONCLUSION

Flours extracted from seven cassava varieties collected in Côte d'Ivoire exhibit differences in their physicochemical properties. The present study has clearly showed that flours cassava had high carbohydrate, starch, energy, potassium, calcium and phosphorus contents and were poor in moisture contents whatever the variety. The low moisture content which makes them store for a long time. The relatively high starch content of these flours makes them potential alternative sources of carbohydrate. Bonoua2 flour is richer in carbohydrates, starch, energy and phosphorus while Agbagble3 and Bondoukou4 are rich in calcium and potassium respectively.

ACKNOWLEDGEMENTS

This work was supported by Ph.D. grant to the first author. The authors thank Biocatalysis and Bioprocessing Laboratory of Nangui Abrogoua University (Abidjan, Côte d'Ivoire) for its technical assistance and CNRA (National Center for Agricultural Research) for biological material (seven varieties of cassava).

REFERENCES

1. Perera, P. I. P., Ordoñez, C. A., Lopez-Lavalle, L. B., & Dedicova, B. (2014). A milestone in the doubled haploid pathway of cassava. *Protoplasma*. *251*(1), 233-246.
2. FAO, I. (2000). The global cassava development strategy and implementation plan, V. 1. In *Proceedings of the validation forum on the global cassava development strategy*.
3. Bricas, N., & Daviron, B. (2008). De la hausse des prix au retour du «productionnisme» agricole: les enjeux du sommet sur la sécurité alimentaire de juin 2008 à Rome. *Hérodote*, (4), 31-39.
4. Ocloo, F. C. K., Bansa, D., Boatin, R., Adom, T., & Agbemavor, W. S. (2010). Physico-chemical, functional and pasting characteristics of flour produced from Jackfruits (Artocarpus heterophyllus) seeds. *Agriculture and Biology Journal of North America*, *1*(5), 903-908.
5. Nweke, F. I. (2004). *New challenges in the cassava transformation in Nigeria and Ghana* (Vol. 118). Intl Food Policy Res Inst.
6. Tonukari, N. J. (2004). Cassava and the future of starch. *Electronic journal of biotechnology*, *7*(1), 5-8.
7. Jachertz, R. (2012). United Nations Food and Agriculture Organization. *The Wiley-Blackwell Encyclopedia of Globalization*.
8. UNCTAD. (2015). Infocomm Commodity Profile Cassava. United Nations Conference on Trade and Development. Recuperado Retrieved from http://www.unctad.info/en/info- comm/aacp-products/commodiry-profile---cassava/
9. N'zue, B., Zohouri, P. G. & Sangare, A. (2004). Performances Agronomiques De Quelques Varietes De Manioc (*Manihot Esculenta* Crantz) Dans Trois Zones Agroclimatiques De La Cote D'ivoire, *Agronomie Africaine*. 16 (2): 1 - 7.
10. Kouassi, S., K., Mégnanou, R., M., Akpa, E., E., Djedji, C., N'zue, B., & Niamké, L. S. (2010). Physicochemical and biochemical characteristics evaluation of seven improve cassava (*Manihot esculenta* crantz) varieties of Côte d'Ivoire. *African Journal of Biotechnology*. 9(41); 6860-6866.
11. Doue, G. G., Mégnanou, R. M., Bedikou, E. M., & Niamke, L. S. (2014). Physicochemical characterization of starches from seven improved cassava varieties: Potentiality of industrial utilization. *Journal of Applied Biosciences*, *73*(1), 6002-6011.
12. Emmanuel, O., A., Clement, A., Agnes, S., B. & Chiwona-Karltun, L., (2012). Chemical composition and cyanogenic potential of traditional and high yielding CMD resistant cassava (*Manihot esculenta* Crantz) varieties, *Int Food Res J*, 19: 175-181.

13. Amani, G., Nindjin, C., N'zue, B., Tschannen, A., & Aka, D. (2007). "Potentialités de la transformation du manioc (*Manihot esculenta* Crantz) en Afrique de l'Ouest". Actes du 1er Atelier International, Abidjan, 4-7 juin, 48–79.
14. Westby, A. (2002). Cassava Utilization, Storage and Small-scale Processing. In: Cassava: Biology, Production and Utilization. Editions Belloti A.C., Thresh J.M. and Hillocks R.C. CAB International, Wallingford, Oxon, UK, 281-300.
15. Perez, E., Schultzb, F., S., & Pacheco de Delahaye, E. (2005). Caractérisation de certaines propriétés des amidons isolés de Xanthosoma Saggitifolium (tannia) et *Colocasia esculenta* (taro) Carbohydr Polym, 60:139-145.
16. Akinlonu, E., O. (2011). Nutritional and sensory qualities of novel dishes from cassava. Dissertation submitted to the Department of Nutrition and Dietetics. University of Agriculture, Abeokuta, Africa.
17. BIPEA. (1976). Bureau Inter Professionnel d'Etudes Analytiques. Recueil des méthodes d'analyses des Communautés Européennes. Gennevillier.
18. Dufour, D., Larsonneur, S., Alarçon, F., Brabet, C., & Chuzel, G. (1996). Improving the breadmaking potential of cassava sour starch. In D. Dufour, G. M. O'Brien & R. Best (Eds), *Cassava Flour and Starch: Progress in Research and Development* (pp. 133-142). Cali, Colombia: CIAT.
19. FAO. (1956). Acide cyanhydrique. Dosage par la méthode alcaline de titrage du manioc. In Food and Agriculture Organization of United Nations (Ed.), *Traitement du Manioc* (pp. 84-85). Rome; Italie : FAO.
20. Dubois, M., Gilles, K.A., Hamilton, J., K., Rebers, P., A. & Smith, F. (1956). Colorimetric method for determination of sugars and related substances. Anal. Chem. *28*, 350–356.
21. Bertrand, G. (1913). Dosage de sucres. In Dunod & Pinat (Eds.), *Guide pours les Manipulations de Chimie Biologie* (p. 20). Paris, France.
22. IITA. (1981). Analyses des Prélèvements Pédologiques et Végétaux (Manuel N°1). Ibadan: IITA.
23. Duncan, D., B. (1955). Multiple range andMultiple F-tests, Biometrics. 11, 1-42.
24. Shittu, T., A., Sanni, L., O., Awonorin, S.O., Maziya-Dixon, B., & Dixon, A. (2007). Use of multivariate techniques in studying the flour making properties of some CMD resistant cassava clones. Food Chemistry. 101: 1606– 1615.
25. Charles, A., L., Sriroth, K., & Huang, T.C. (2005). Proximate composition, mineral contents, hydrogen cyanide andphytic acid of 5 cassava genotypes. Food Chemistry. 92: 615–20.
26. Ladeira, T., Souza, H., & Pena, R. (2013). Characterization of the roots and starches of three cassava cultivars. *International Journal of Agricultural Science Research*. 2(1), 012-020.
27. Nassar, N., & Ortiz, R. (2010). Breeding cassava to feed poor. *Scientific American*, 78-84.
28. Stupak, M., Vandeschuren, H., Gruissem, W., & Zhang, P. (2006). Biotechnological approaches to Cassava protein improvement. Trends Food Sci Tech. 17: 634-41.
29. Aboubakar, N., Y., N., Scher, J., & Mbofung, C., M., F. (2008). Physico-chimique, propriétés thermiques et microstructure de six variétés de farines et d'amidons de taro (*Colocasia esculenta* L. Schott). J Food Eng, 86 : 294-305.
30. Ebuehi O.A.T, Babalola O. Ahmed Z .2005. Phytochemical, nutritive and anti-nutritive composition of cassava (Manihot esculenta L) tubers and leaves. *Nigerian Food Journal* 23: 40-46.
31. Apea-Bah, F., B., Oduro, I., Ellis, W., O. & Safo-Katanka, O. (2011). Factor analysis and age at harvest effect on the quality of flour from four cassava varieties. World Journal of Dairy Food
32. Assemand, E., Camara, F., Kouamé, F., Konan, V., & Kouamé, L., P. (2012). Caractérisation biochimique et évaluation sensorielle des fruits de plantain Agnrin. Journal of Applied Biosciences, 60: 4438– 4447.
33. Jenkin, D., J., Jenkin, A., L., Wolever, T., M., S, Rao, A.,V., & Thompson, L., U. (1986). Fibre and starchy foods: function and implication in disease. *American Journal of Gastroenterology*, 81: 920-930.
34. Mensah, J., K., Okoli, R., I., Ohaju-Obodo, J., O. & Eifediyi, K. (2008). Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. *Afr. J. Biotechnol*., 7: 2304-2309.
35. Saldanha, L., G. (1995). Fibre in the diet of U.S. Children: results of national surveys. Pediat., 96: 994-996. Science. 6:43–54.
36. Bradshaw, J., E. (2010). Root and tuber crops. New York: Springer. Doue, G. G., Megnanou, R. M., Bedikou, E. M. & Niamke, L. S. 2014. Physicochemical characterization of starches from seven improved cassava varieties: Potentiality of industrial utilization. *Journal of Applied Biosciences*, 73, 6002– 6011.
37. Koko, A., C., Kouame, K., B., Anvoh, Y., B, Amani, N., G. & Assidjo, N., E. (2014). Comparative study on physicochemical characteristics of cassava roots from three local cultivars in côte d'ivoire. European Scientific Journal, 10 (33): 418-432.
38. Lintas, C. (1992). Nutritional aspects of fruits and vegetable consumption. Options Meditérraneennes, 19: 79-87.
39. Gnonlonfin, G., J., B., Koudande, D., O., Sanni, A., & Brimer, L. (2011). Farmers' perceptions on characteristics of cassava (Manihot esculenta Crantz) varieties used for chips production in rural areas in Benin, West Africa. Int J Biol Chem Sci. 5: 870– 879.

40. Butte, N., F. (1996). Energy requirements of infnats. *Europen Journal of Clinical Nutrition*, 50 :24-36.
41. Valvi, S. R., & Rathod. V.S. (2011). Mineral composition of some wild edible fruits from Kolhapur district. Int. J. Appl. Biol. Pharmaceut. Technol, 2:112–119.
42. Hanif, R., Z. Igbal, M. Igbal, S., Hanif, & Rasheed. M. (2006). Use of vegetables as nutritional food: role in human health. J. Agric. Biol. Sci. 1:18–20.
43. Bradbury, J., H., & Holloway, W.D., (1988). Cassava, M. esculenta. Chemistry of tropical root crops: significance for nutrition and agriculture in the Pacific. Australian Centre for International Agricultural Research, monograph nr 6, Canberra, Australia, pp. 76–104.
44. Buitrago, A., J., A., (1990). La yucca en la alimentacion animal. Centro Internacional de Agricultura Tropical, Cali, Colombia, 446 p.
45. Okala, J., C., & Okala, A., N., O. (2001). Food composition, spoilage and shelf life extension, ocjarc. Academic Publishers, Enugu, Nigeria. 54-56.
46. Charles, A., L., Sriroth, K., & Huang, T., C., (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. Food Chemistry 92: 615–20.
47. Mark, R., Church, S., Pinchen, H., & Finglas, P. (2013). Nutrient analysis of fruit and vegetables. Analytical report, 24-29.
48. Turan, M., Kordis, S., Zeyin, H., Dursan, A., & Sezen, Y. (2003). Macro and micro minerals content of some wild edible leaves consumed in eastern Anatolia. Tailors and Francis, 129-130.
49. Oyewole, O., B., & Asagbara, Y. (2003). Improving traditional Cassava processing for nutritional enhancement. *Food Nutrition Agriculture*, 32, 1721.
50. Javillier, M., Polonovski, M., Florki, N., Boulanger, P., Lemoigne, M., Roche, J., & Wurmser, R. (1967). Traité de Biochimie Générale. Paris: Masson. 320p.